Leveraging a peer-learning community and expert community members in the integration of indigenous knowledge into the learning and teaching of Grade 10 Chemistry on the rate of reactions

A thesis submitted in fulfilment of the requirements for the degree

Of

Doctor of Philosophy

(Science Education, Chemistry)

Of

Education Department

Rhodes University

By

FREDRICK SIMATAA SIMASIKU

Supervisor: Prof Kenneth Mlungisi Ngcoza

Co-supervisor: Dr. Zukiswa Nhase

February 2022

Declaration of Originality

I ***Fredrick Simataa Simasiku (613S7222)*** declare that this thesis has not been submitted for a degree in any other university apart from Rhodes University and I declare that it is my work, written in my own original words. This research strives to mobilise how western science could be contextualised in Chemistry teaching. It has only been submitted for the Degree of Doctor of Philosophy at Rhodes University. Where I have cited the words or ideas of other researchers, these have been acknowledged using complete references according to the Departmental guidelines.

Signature:  Date: February 2022

Dedication

This thesis is dedicated to my late father, *James Simasiku Chiyasa* who taught me to be a man and the spirit of Africanism (*Ubuntu*) he instilled in me. My late mother *Rosemary Neo Muhongo Simasiku* for teaching me to be a responsible child. My late brothers: *Leonard Likili Simasiku; Raymond Chiyasa Simasiku; Boniface Muhongo Simasiku; Fedelis Simunyemba Simasiku; Leonard Ndana Simasiku; Benedict Lyamine Simasiku; Matengu Simasiku* and my late sister *Imeldah Muntita Simasiku*. May your souls continue resting in peace, if I could not mention your names my spirit could be troubled by the spirit of *Ubuntu 'that connects the living and the dead together'*.

My three lovely sons, Ntelamo, Simataa, and Matengu (NTESIMA) for inspiring me to continue struggling to this level. Finally, my lovely wife Pumulo Iness Ntelamo for encouraging me to study. I love you and may God bless you all!

Acknowledgements

First and foremost, I would like to thank the Almighty God (*Mulena Mulimu*) who has been there for me throughout my entire life. The journey was long and full of sharp thorns, but he protected me for nine good years, from BEd Honours through to the PhD travelling from Ondangwa to Okahandja almost five times a year, the Namibian roads are full of road accidents but he protected me throughout. Thank you, Lord and I will keep praising your name forever.

My heartfelt gratitude goes to my supervisor Prof. Kenneth Mlungisi Ngcoza, for outstanding support over the past years and who always encouraged, motivated, and pushed me to the maximum limit of my abilities to continue the journey to go the extra mile and the sky was the limit. Prof instilled the spirit of Ubuntu in me; he always used this African proverb: *"If you want to walk fast, walk alone, and if you want to walk far, walk together*" (in Silozi translated, *Haubata kuzamaya kakuakufa, zamaya unosi, haubata kuzamaya kuya kwahule, zamaya niba banwi*). He had a lot to deal with but he was always available whenever I wanted help and he guided me through this journey. May God bless him abundantly and give him the wisdom to do the same for other students in the future.

I also want to thank my co-supervisor Dr. Zukiswa Nhase for always giving me direction on what to do when I got lost in the management and analysing of data. May God bless and give you more strength to help other students who will follow me. The African proverb in Silozi which states: *"Munwana ulimuńwi haukoni kutuba nda"* translated as "*one finger cannot crush the lice*" was fulfilled here. Your support cannot go unnoticed during this research journey.

To the Namibian National Institute of Educational Development (NIED) in Okahandja where I attended most of the contact sessions, I say thank you, for inspiring me to continue struggling to this level. Finally, your premises and support from the staff members of your institution did pave the way for me to complete my thesis. On some occasions, family members had to do without my presence over the past 10 years. I missed going home during the holidays to attend classes at NIED and left home earlier during December holidays to travel from the Zambezi region via *Ondangwa* town in the *Oshana* region to *Okahandja* town in the *Otjozondjupa* region.

To my wife, Pumulo Iness Ntelamo, you must know that I could not have done this without your support. You were patient with me. I know that at times I was neglectful, but this was for us, for our future. Thank you for your selfless and tireless support.

My three gifts from God, Ntelamo, Simataa, and Matengu, (NTESIMA) you guys were amazing; sometimes I neglected your needs because I was always busy and sometimes you went a whole week without seeing me. I have done this for you, it is not for me. This is a challenge for you to achieve or go beyond when you grow up. I remember Simataa and Matengu always used to ask me to buy a new car. I could not make them understand because they were young and always wanted me to be like Mr A or B because they had new cars. I hope you will understand when you will read this PhD thesis, why I could not afford to buy a new car as you wished.

To my colleagues, and my classmates (2013-2021) you guys were amazing, you were there for me whenever I needed you most and we have grown to be like a family to me. It was amazing to have people like you on this journey. 'We are a family!' I appreciate Mr. Liveve, we travelled together to South Africa and we helped each other during the research journey and he became a brother to me, may God bless you, doctor.

A very big thank you to the five Chemistry teachers from two secondary schools and one combined school in the Endola Circuit. To my dearest participants, Mr. Michael Fimaneka; Mr. Sebron Shitumbuleni; Mrs. Reginald Ndeshi Kambeyo; Mr. Simon Hamunyela Nauyoma, and Mr. Tomas Tala Benjamin (TB) without your help guys I would have been stuck in the mud, but you helped me by working together and you attended all the workshops as planned and sometimes the roads were not favourable to travel to and from the workshops but you always made it, for us to grow as a team. If it was not for you, I do not think that I would have completed this thesis. School principals of Grades10-12 in the Endola Circuit, thank you for allowing me to carry out my research at your schools.

The two expert community members (Mee Mukwaluvala and Mee Mukwamhani), your humbleness allowed us to carry out the research at your homes and you were amazing to us as you were there for us. I appreciate the work and knowledge you have contributed to this research and your words will live forever. Also, Mee Lucia Kamati for the role you played in preparing the lunch for the participants whenever we visited Mee Mukwaluvala's home. Your role speaks aloud for itself and participants will never forget what you did for them.

A very big thanks to Mr. Simon Vaeta for allowing me to carry out the research in the Endola Circuit, for your words of encouragement, and for motivating me to be Dokotola (Doctor) Chakapaya as he used to pronounce it. I say thank you Mister Vaeta and may God give you extra wisdom. The entire Ohangwena Education Directorate for allowing me to carry out my research in the mighty Ohangwena region.

My sincere words of gratitude also go to Dr Chrispen Mutanho and Prof Maren Seehawer for finding time to cast their critical eyes on my thesis despite their hectic schedules. To Ms Nikki Watkins for professionally editing and formatting my PhD thesis. God bless you all in abundance!

Lastly, let me thank myself for the hard work and discipline I have shown during the past nine years (2013-2021). This journey started from an Honours class and it will now end with a PhD. I showed discipline in being able to finance my study without the help of the Namibia Student Financial Assistance Fund.

Abstract

The integration of indigenous knowledge (IK) in science teaching in Namibia is part of the transformation agenda that hopes to revitalise and make science accessible and relevant to learners' everyday life experiences. However, there seems to be contradictions between the intended curriculum, the enacted curriculum and the attained curriculum. This disjuncture is exacerbated in part by the fact that science teachers seem to be struggling to be cultural knowledge brokers. It is against this backdrop that this formative interventionist study sought to leverage a peer-learning community and expert community members in the integration of IK into the learning and teaching of Grade 10 Chemistry on the rate of reactions. To achieve this, we mobilised the indigenous technologies of preserving and pounding *Mahangu* and making *Oshikundu* to mediate learning of the rate of reactions. The study was guided by the broad overarching research question:

> How does a peer-learning community and expert community members leverage the integration of indigenous knowledge into the learning and teaching of Grade 10 Chemistry on the rate of reactions?

In this study, I used two complementary paradigms, viz. the transformative research paradigm and the indigenous research paradigm. Within these paradigms, I employed a qualitative case study research design using the community of practice and participatory action research as research approaches. Five Grade 10 Chemistry teachers from three schools in the Ohangwena region were involved in this study. Data were generated through semi-structured interviews, co-analysis of curriculum documents, workshop presentations and discussions, practical demonstrations, participatory observation, lesson observation, stimulated recall interviews, and participants' reflections. Vygotsky's sociocultural theory and Shulman's Pedagogical Content Knowledge (PCK) were employed as theoretical frameworks in this study. Additionally, within PCK, Mavhunga and Rollnick's Topic-Specific Pedagogical Content Knowledge components were used as an analytical framework. I used an inductive-deductive approach to data analysis to come up with sub-themes and themes.

The main finding of this study revealed that leveraging a peer-learning community and the expert community members (ECMs) empowered the Chemistry teachers involved in this study to be cultural knowledge brokers and their understanding of how to integrate IK in their teaching improved. Both their subject matter knowledge and pedagogical content knowledge improved through co-developing and enacting exemplar lessons that integrated IK from the expert community members as well as from their own environments. A main insight of this study is that Chemistry teachers should seek opportunities to create peer-learning communities that engage with expert community members who are the custodians of the cultural heritage. The study also shows that this approach will support them to become better cultural knowledge brokers and help their learners bridge the divide between school science and what they have learnt in their homes or community.

Key Words: Chemistry; Rate of Reactions; Scientific Knowledge; Indigenous Knowledge; Peer-Learning Community; Expert Community Members; Cultural Knowledge Brokers; Sociocultural Theory, Pedagogical Content Knowledge; Topic-Specific Pedagogical Content Knowledge

Table of Contents

List of Figures

List of Tables

Abbreviations and/or Acronyms

CK:	Contextual Knowledge
CoP:	Community of Practices
CPD:	Continuing Professional Development
ECMs:	Expert Community Members
IK:	Indigenous Knowledge
LCE:	Learner Centre Education
LoLT:	Language of Learning and Teaching
LTSMs:	Learning and Teaching Support Materials
MKO:	More Knowledgeable Other
NCBE:	National Curriculum for Basic Education
NIED:	National Institute of Education Development
NMBEC:	Namibia, Ministry of Basic Education & Culture
PAR:	Participatory Action Research
PCK:	Pedagogical Content Knowledge
cPCK:	Collective Pedagogical Content Knowledge
pPCK:	Personal Pedagogical Content Knowledge
ePCK:	Enacted Pedagogical Content Knowledge
PEEOE:	Predict, Explain, Explore, Observe and Explain
PEO:	Predict, Explain, Observe

PhD: Philosophy of Doctorate

PK: Pedagogical Knowledge

PLC: Professional Learning Communities

SCT: Sociocultural Theory

SK: Scientific Knowledge

SMK: Subject Matter Knowledge

SRI: Stimulated Recall Interviews

TIMESD: Transformative Model of Education for Sustainable Development

TSPCK: Topic-Specific Pedagogical Content Knowledge

WS: Western Science

ZPD: Zone of Proximal Development

Translation of Concepts

Local names	**Western names or explanation**
Ombike	Traditional whisky
Mahangu	Pearl Millets/ *Pennisetum glaucum*
Oshikundu	Traditional fermented soft drink, commonly in *Ovamboland*
Ongudo	Dormant catalyst
Ehete	Active Catalyst/dregs
Elilo	Traditional plate
Okuxwa	Threshing
Kapali/Oshitoo	Traditional clay pot or storage or refrigerator
Oshipale	The place where Mahangu is threshed
Olupale	Traditional reception area/ fire area
Omutala	Place where *Mahangu* is sundried
Oshini	Mortar
Omushi	Pestle

Okuyela	Sieving
Okaanda	Barn/Granary/ Traditional storage
Eembe	Jackal berry/ Wild berry
Eenyandi	African Ebony
Oitungifi	Enzymes

CHAPTER ONE: SITUATING THE STUDY

> A cumulative body of knowledge and beliefs handed down through generations by cultural transmission, about the relationship of living beings with one another and with their 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. (Shizha, 2007, p. 305)

1.1 Introduction

In this chapter, I situate my research study whose focus was on mobilising indigenous knowledge (IK) that could be integrated into Chemistry learning and teaching of the rate of reactions. The study was carried out in the Endola Circuit, Ohangwena Region of Namibia. It was triggered and motivated by my master's research that found that science teachers seem to struggle to integrate IK into science teaching. Furthermore, it was motivated by the rural setup of the region and its indigenous people who possess cultural practices, which could potentially be used during Chemistry teaching in Grade 10.

I start by outlining the background of the study and giving a brief description of the Namibian curriculum. Next, I detail the IK that was taught to me by my parents and the communities in which I grew up. I also outline my positionality and reflexivity, problem statement, rationale and significance of my study, the gap this study sought to fill in Namibia, the research goal and questions. Then, I clarify the conceptual and theoretical frameworks that informed this study. The limitations of the study and the thesis outline are provided. The chapter ends with a chapter summary.

1.2 Context of the Study

The Namibian education system has four major goals documented in different documents, namely, democracy, quality, equity and access (UNICEF, 2011). It is intended, among other things, to help teachers build from what the learners already know from home as prior everyday knowledge

(Kuhlane, 2011) or indigenous knowledge (IK). It thus repositions and views the teacher as a critically reflective practitioner rather than as a passive dispenser of received knowledge (Nyambe, 2008). It is believed that these goals could be achieved in part through using learner-centred education (LCE) pedagogy as illustrated by Nyambe (2008). LCE has many goals and one of these goals allows teachers to build from the IK of learners in the classrooms, allowing science teachers and Chemistry teachers in the context of my study to use IK as the life experiences of learners (Gwekwerere, 2016). I assume that learning can be maximised if the teachers use a learner-centred approach, whereby they use the learners' life experiences and IK in the learning process. Moreover, if they develop methods in which the learners interact with each other and the teacher and reflect on the subject matter knowledge, this will allow them to be critical thinkers as proposed by the sociocultural perspective on learning (Mavuru & Ramnarain, 2020; Vygotsky, 1978).

Nyambe (2008) contended that teachers spend most of their time planning how to make teaching and learning more effective for their learners. For this to happen, however, the curriculum needs to be indigenised (Ogunniyi, 2018) and contextualised to allow science teachers to integrate IK into science classrooms (Mukwambo et al., 2014). This current study was intended to afford the Grade 10 Chemistry teachers who were involved in it an opportunity to engage with expert community members (ECMs) in practical activities.

Indigenisation of curriculum needs to be more explicit on which topics to integrate what IK (Seehawer, 2018a). Yet, the National Curriculum for Basic Education (Ministry of Education [MoE], 2018) does not shed more light on the integration of IK into the Namibian curriculum. Instead, it highlights that teachers need to include the life experiences of learners in their lessons and interact with the surrounding environment. Indeed, Hauster et al. (2009) attested that a curriculum that actively engages with indigenous people and their environment is key to creating a space to integrate IK into science teaching.

In addition, culturally inclusive pedagogies (Mhakure & Otulaja, 2017) are important steps for negotiating a place in science education where IK or cultural heritage is recognised (Hauster et al., 2009). In support of this, Otulaja et al. (2011) pointed out that the integration of IK into the South African curriculum is a welcome issue, especially in science, since teachers need to have an understanding of how to integrate it into Westernised Science (WS). For example, using homemade fractional distillation[1] might make learners more interested in doing science than teaching them theoretically.

This transformative case study was done at a time when curriculum transformation was going on in Namibia, starting in 2016 at the junior primary (Grade 1-3) level and by 2021 completed in Grade 12 (MoE, 2018). The transformation of the curriculum allows for a knowledge shift in subject content knowledge in all subjects and Chemistry was one of the subjects in Grade 10-12. Teachers were complaining about the shift in content knowledge from Grade 12 to Grades 8 and 9 that was challenging to them and learners. To alleviate these challenges, teachers have had to come up with teaching and learning methods that could help them make the subject content understandable to the learners. For instance, the use of easily available resources (Asheela et al., 2021; Shinana et al., 2021) allows for the use of IK in Chemistry teaching which could help learners to have a better understanding of concepts. This research, however, explored the use of cultural heritage in contextualising Chemistry teaching to make learning meaningful.

As alluded to earlier, meaningful learning is more likely to occur if the teachers use learners' prior experiences and knowledge which could be in the form of IK (Kambeyo, 2012; Kota, 2006). Yet, research conducted in Namibia revealed that science teachers seem to struggle to integrate IK into their science classrooms, and they seem to lack pedagogical content knowledge (PCK) (Liveve, 2017; Mukwambo, 2017). This finding resonates with what emerged from other research that many science teachers seem to struggle to integrate IK into science classrooms (Bantwini, 2010; Jacobs, 2015; Mothwa, 2011).

Research shows that when IK is integrated into science, it encourages learners to participate actively in the lessons (Liveve, 2017; Nikodemus, 2017; Sedlacek & Sedova, 2017). It is against this backdrop that LCE views learners as central to the learning process (MoE, 2018; Nyambe, 2008). Hence, LCE encourages teachers to build on learning, starting with the prior everyday

---

[1] Fractional distillation is a process that separates more than one substance at a time and it is used when boiling points are different or when mixtures are complex (e.g., ethanol and water). These can be separated since they both have different boiling points. For example, alcohol boils at approximately 78°C while water boils up to 100°C (Shifafure, 2014; Uushona, 2013).

knowledge that learners bring to the classrooms and further values the learners' life experiences as the focal point of learning and teaching (Gwekwerere, 2016).

However, Nyambe and Wilmot (2012) critiqued the way LCE was introduced in Namibia. These scholars posited that teachers were not professionally trained on how to use LCE. As a result, some teachers seem to be struggling with how it should be used in the classroom. It seems that teachers are textbook bound and are not willing to go beyond what is documented in them. This study sought to move teachers from being textbook bound to being able to mobilise IK that is applicable in science subjects for LCE to be realised. Notwithstanding these ideals, teachers need to be aware of how IK could be integrated into science lessons to avoid misinterpreting the curriculum when integrating IK.

Indeed, lack of understanding leads to misinterpretation of the curriculum. From my experience as a Physical Science teacher, for instance, I have observed that learners understand new knowledge to be taught if a good foundation from the previous grade or IK is laid for the topics they are learning. Such foundations could include concepts from indigenous technologies or practices that they can relate to, to supplement scientific knowledge documented in science textbooks. I now discuss my personal life history.

1.3 Situating Myself in the Study

> Within the context of humility and agency, decisions around learning are in essence an agreement between individuals and the spirit world. Nishnaabewin fosters and cherishes individuals with particular gifts and skills as a mechanism for growing diversity, and childhood is an excellent time for individuals to focus on those particular gifts and hone them into excellence. (Simpson, 2014, p. 10)

Similarly to Simpson (2014), my individual and spiritual world was not cherished and the gifts and skills I was born with were not brought to excellence. As an African child, it was difficult to go to school because my parents had no formal education. It was also difficult to go to school without a school uniform, barefooted during spring and winter. I remember during spring when it used to be extremely hot, we used to make shoes from cardboard and wear them so that we would not be burnt by the hot ground. During rainy seasons, my mother used to make an umbrella from sacks in order for us to go to school. For me, going to school was a hiding place so that I would not be sent to do some demanding household chores at home.

On reflection, however, the fact that I grew up in a village where norms and traditional beliefs were the order of the day helped me to grow up as a cultural boy doing all the work that needed to be done after school, during weekends and on holidays. For example, looking after cattle, milking, fetching water, looking after children, cooking, traditional dance, fetching and mixing herbs, ploughing fields, building houses, harvesting honey, woodwork, clay pottery, weaving (fishing nets), hunting, cleaning, parenthood (some of them), security and playing soccer and netball. These activities helped us to grow and respect each other. They also influenced my choice of the paradigm I used in this research, for example, the indigenous research paradigm within which the Ubuntu perspective is embedded. Moreover, soccer brought villagers together and today I can say that Ubuntu[2] was observed and taught to us from a young age – to respect each other and share what we had.

There were also some indigenous games that we used to play such as skipping rope, [3]*Muhuma*, and filling the bottle. Such games taught us how to count even before we were taught at school. Such games also united us as children, and we grew up knowing and respecting each other. To date, I am still proud that I grew up as a village boy and whenever I go home to the village I never miss going to the kraal. This is very close to my heart, and I will not be separated from it. I remember that my father used to say to us in Silozi, my mother tongue: "*Likomu kone bufumu bwa mutu yo munsu*" [Cattle are the wealth of the black person].

---

[2] Ubuntu means humanness and is an important value in many traditional African communities where relationships are at the centre of the worldview (Khupe, 2014; Ogunniyi, 2007a).

[3] *Muhuma* is a game played inside a square with two teams competing. One team should hit the other team with a netball and the other team would be required to run from one corner to the other. In each corner is a circle where you have to stand up. While running you have to count. This was a multiple of four. If you got the number wrong you had to be out even before the ball hits you.

Figure 1.1: Examining a sick cow in front of me

My social interactions with elderly indigenous people taught me many lessons in life that were culturally oriented (Lavallee, 2009). For instance, engaging in cultural activities such as ploughing the fields, use of cattle manure as a fertiliser, milking, building huts, weaving fishing nets and other cultural activities helped me to later reflect on and contextualise Mathematics and science in my teaching. Yet, my lived world was not linked to the school science subjects. For example, using cattle mature in the field was just an activity that I used to enjoy without knowing why we were adding cattle mature to the field. My indigenous understanding was not linked to westernised science (WS) to help me understand school science (Aikenhead & Jegede, 1999).

Similarly, at school, we used to be sent to bring manure to put it in our gardens without understanding what the manure was for. Even though I was taught Agriculture in Grade 8-10, the aspect of using manure was not well contextualised to help me understand the questions I was having such as why we used manure from the cattle. The teachers could not help me answer the questions that I had at that time. That made me experience cognitive dissonance between the lived world and WS (Le Grange, 2007). However, a project on sustainable development that I did with learners on how to grow vegetables and use cattle manure helped me understand and reflect on why we used to put manure in the fields and gardens.

One of the activities that I enjoyed most before, during and after my secondary schooling was milking cows. To date, I still enjoy this activity. Before school, I used to count the calves in my home language (Subia) when asked how many calves were still in the kraal. For example, the answer could be *konke* (one), *tobele* (two) or *totatwe* (three) and so on. Such counting knowledge was not linked to the knowledge that was taught at school. At school, the language was different from my home language and my grade one teacher could not build on what was known to teach the unknown. In Silozi, counting was different from what I did at home, for example, *kalikamu* was one, *totubeli* was two, *and totulalu* was three and so on. Such a gap was not closed by the teachers when teaching me how to count.

Furthermore, when I started to learn how to milk cows, I realised that I needed another skill to do it. This skill required that I observe how it was done, when it was done and then practice it. Since I was familiar with it, I used to practice the skill when given the chance. I used to enjoy milking. For the milk to come out a cow's teat needs to be held tightly with the fingers. This was taught to me by my father and my elder brothers, and I could not understand why the teat had to be held tightly. The concept of exerting pressure was not linked to the milking process. I came to understand this when I was introduced to IK in 2014 at Rhodes University. My exposure to indigenous ways of knowing, helped me to reflect and start understanding how certain topics could be introduced in science teaching and learning.

The other indigenous practice that I was exposed to from a young age was the making of a traditional beverage called *Chikotini* (seven days). My mother was one of the experts in making this traditional beverage. I used to stay close to my mother and observe the process, but I was not aware of the scientific processes taking place. Culturally, males are not allowed to be close to this process and it was only done by females, but as a young boy, I was close to my mother. The process used to take about four days to prepare. On the first day, the water was put in drums and mixed with maize flour and sorghum flour from germinated seeds. The mixture should be done in such a way that the sorghum flour and maize flour must be in the right proportions in each drum or the whole process would be spoiled. The drums were covered with a traditional mat for fermentation to take place.

Something used to make me wonder. For instance, during summer they used to prepare the beverage during the afternoon. In contrast, during winter, used to be prepared during the morning but I could not ask why, and I regret this. Nonetheless, after being exposed to IK, I could explain their understanding and knowledge that was embedded in those different time slots depending on the season. The reason behind this was that during summer, the temperature is hot, and fermentation would take place within a short time but during winter, the temperature used to be lower, and fermentation took a long to happen.

This process is called *Kukondola* (preparation) in Silozi. They needed it to ferment by the next day and this was seen by observing the bubbles of the gas (Carbon Dioxide) that were coming out or produced from drums. On the second day, a fire would be made to cook the paste. On the third day, the paste was cooled, and the fourth day was the drinking day. Such traditional alcoholic beverages could be consumed for about three days if not finished and this is where the name seven days comes from. The paste is cooled and tested by using a finger and not a thermometer. They knew what the right temperature should be before adding other ingredients. Indigenous elders have developed ways of coping with every situation. The use of a finger as the thermometer was accurate to measure the temperature before a catalyst was added. [4]*Mulungo*, which is made from germinated sorghum, was added on the third day after the cooling process was completed. To date, no research has been done to see at what temperature community elders added other ingredients and also what percentage of alcohol would still be present after seven days. These are some of the questions that triggered my interest in the integration of IK into science teaching.

My science teachers could not link IK to WS during my schooling. As alluded to earlier, they thus created cognitive dissonance in my mind (Le Grange, 2007). Aikenhead and Jegede (1999) introduced the concept of a cultural border crossing between these two worldviews. When cultural border crossing is difficult for the learners, these scholars suggest that science teachers need to take the role of ‘tour guides’ in science lessons and guide the learners by showing them the direction they have to take. Scaffolding learners through parallel and simultaneous collateral learning would require science teachers to play the role of tour guide, whereas scaffolding learners

[4] *Mulungo* is a traditional catalyst that is used during the process of making *Chikontini* (seven days).

through dependent learning to secure collateral learning might require science teachers to take the role of a 'travel agent' (Le Grange, 2007).

In 2015 when we visited Rhodes University as students, I was exposed to a practical demonstration of making [5]*Umqombothi* by Meme Nolingo, an expert community member. Similarly, that challenged my understanding of how *Chikontini* (seven days) was prepared back home in Namibia. The process and ingredients were similar to what I used to observe my mother doing when making *Chikontini* (seven days). Such hands-on practical activity exposed and challenged me to reflect on different indigenous practices that I used to do. That subsequently helped me to start to contextualise WS by starting from what the learners know to the unknown as documented in science textbooks.

To date, after being introduced to the integration of IK into science teaching, I had to contextualise it for the learners to be able to reflect and connect it to the indigenous technologies or practices done in their homes. In the context of my study, my experiences of IK are based on the context of the community I grew up in and the current context where I am working. The knowledge I gained was not connected to the scientific knowledge that I was learning in science textbooks. This IK was locally available when we were growing up and reflecting on it helped me learn how to engage with and integrate it into the science classroom to help learners have a better conceptual understanding. Teaching science and failing to make learners understand what you are explaining is the most frustrating thing a teacher can cope with in the science classroom.

Notably, the scientific explanation that lightning is caused by the discharge of electricity (Le Grange, 2007), conflicted with my deep-rooted cultural understanding that lightning is caused by witchcraft (Webb, 2013). This caused cognitive dissonance (Le Grange, 2007) in my mind and science teachers could not help me understand the concepts from both worldviews. It could be

[5] *Umqombothi* is a traditional alcoholic beverage with about 3% alcohol content made by many families in South Africa (Mutanho, 2021).

argued that they failed to become [6]cultural knowledge brokers (Aikenhead & Jegede, 1999; Cooper et al., 1999; Meyer, 2010; Wyatt et al., 2017) between my lived science and scientific knowledge.

I remember my father used to be very angry with us when it was raining and thundering with lightning. The following were not allowed to be done – running around, herding cattle, making noise, wearing a red t-shirt or shirt and paddling, touching water or playing in the water. The reason why my father used to be very angry with us was not explained. Instead, we were told that if we did those activities lightning would strike us. For me, it was another way of controlling us so we would not play in the rain. During my schooling days, the relationship between those activities and science was not fully interconnected to help me understand. The exposure to IK integration into science teaching alerted me to start questioning and understanding some of the reasons we were not allowed to do those activities during rain and thundering with lightning. The debate we used to have as scholars during our master's sessions further helped me to understand the scientific explanations behind the indigenous elders' ways of doing things. Some of those activities are scientifically proven. Wearing of red shirts and making noises are some of the cultural beliefs that we could not explain scientifically but they nonetheless stimulated a lot of discussions and arguments (Ogunniyi, 2007a).

For the science teachers to explain this they need to start from what learners know and not discredit witchcraft stories but build on that understanding of their IK into scientific explanations. Today, I feel that my science teachers were not exposed to IK during my schooling as a learner and a student at college.

During my high school years, I was introduced to the topic of reflection and refraction in Physical Science. The concepts of reflection and refraction could be more usefully taught using our IK. I grew up on the riverside where reflection was observed daily. When I used to stand in the dugout canoe, I could see my image in the water and yet this concept was not developed in me during my junior secondary schooling years. Reflection could have been best described using water and the

---

[6] Cultural knowledge brokers in this research refers to persons who help other people to navigate between the two worldviews of knowledge, between culture and science. The persons who build the bridge to allow other people to cross from one side to another side (Aikenhead & Jegede, 1999; Wyatt et al., 2017).

trees that were next to the river as their shadows could be seen in the water. Such knowledge was not developed, and my science teachers ignored it or were not aware of how to use our IK to enhance our conceptual understanding of science concepts.

John et al. (2017) postulated that when learners come across concepts of reflection and refraction in the contexts where these phenomena are involved, they may experience conceptual difficulty in applying the optics principles correctly to explain the formation of the image of a particular object. Similarly, my life experiences could not help me to understand the two concepts in Physical Science. The two worlds were not compatible during my schooling years and were treated as separate. Furthermore, when learners encounter everyday contexts where two phenomena co-exist (Ogunniyi, 2007a), they are likely to develop alternative conceptions, while they attempt to choose between the two phenomena as the cause of image formation in a certain context (John et al., 2017). Such IK was fully developed in me but lacked scientific explanations and yet it could have been used in teaching the two concepts. Similarly to Simpson's (2014) experiences highlighted in the quote below, there was a disjuncture between my home and school experiences.

> My experience of education, from kindergarten to graduate school, was one of coping with someone else's agenda, curriculum, and pedagogy…No one ever asked me what I was interested in nor did they ask for my consent to participate in their system. My experience of education was of continually being measured against a set of principles that required surrender to an assimilative colonial agenda in order to fulfil those principles. (Simpson, 2014, p. 6)

When I joined Rhodes University as a student, however, I was exposed to IK. I remember explaining to a colleague who was teaching Life Science how to teach the topic of osmosis (Nangolo, 2018) using the IK practice of the processing of drying meat and fish. The teacher subsequently used these examples and learners were able to explain how they used to do it in their own language.

1.4 My Positionality and Reflexivity

Positionality is determined by where the researcher stands in relation to the other participants involved in the research (Bourke, 2014). Furthermore, "it reflects the position that the researcher has chosen to adopt within a given research study" (Holmes, 2020, p. 2). On the other hand, reflexivity helps the researcher to be conscious of the culture, political, individual ethics, personal integrity, social values and social context of the participants so that the participants' emotions during the research process are not affected (Holmes, 2020).

Positionality has caused many setbacks in educational research because participants are often not willing to work or take part in research where the researcher is the outsider, has a higher education qualification and/or because of the position the researcher has (Holmes, 2020). Researchers tend to lack insight into how positionality and reflexivity might help or hinder the research that could impose particular methodologies and fieldwork contexts (Moser, 2008). In the context of my study, I was mindful of the fact that I was a student pursuing a PhD in science education and a school principal, and that this might hinder the interactions between myself, the teachers and community members because of power relations.

In this study, the participants were five Grade 10 Chemistry teachers and two ECMs who were experts on the preservation of *Mahangu*, pounding *Mahangu* flour by using a mortar and pestle, and practically demonstrating the making of *Oshikundu*. To mitigate the power relations or dynamics between the participants and me, I had to show respect to the research participants and ECMs. I was also mindful of the challenges that could affect the participants such as culture, class, language and geographical differences (Isaacs, 2019) and these were taken into consideration. Consistent with Ubuntu, I built a good rapport and trust by visiting the ECMs' homes. When visiting the ECMs' homes, we were given *Oshikundu* as a way of accepting our visit and also to make sure that we were humbly welcomed. My humble beginnings highlighted in Section 1.3 above helped me to achieve this.

I also visited the schools where the participants were teaching and made them feel comfortable with me. I acknowledged my position and reflexivity during the research process. I was reflexive during the workshops and practical demonstrations with both teachers and ECMs and made sure not to intimidate them. The use of the *Oshikwanyama* language (local language) during the workshops and practical demonstrations gave room for participants to be vocal on IK they had acquired.

I thus positioned myself as a co-learner and participant during workshops, participatory observations and classroom observations. Being a science teacher and researching the integration of IK into science was well appreciated by participants as we used to coordinate science activities in the Endola Circuit, for example, organising Mathematics and science fairs together. Researching the cultural heritage of the community that was connected to their ancestors made me extra cautious not to expose the cultural beliefs of Chemistry teachers and ECMs – as I was not knowledgeable about the preservation of *Mahangu*, pounding *Mahangu* flour by using a mortar and pestle and practically demonstrating the making of *Oshikundu* – as this might prevent them from giving more information.

It is recognised, however, that IK is situated in an environment where indigenous people are living. In this study, I worked with community members and Chemistry teachers on the integration of IK and emphasised their cultural norms and beliefs. In this research, it was easier as the ECMs were working in their environment (space) which reduced the power relations.

This research helped me to be a reflexive researcher who was able to adjust to the situation when the need arose. I had to reflect each day after the research process. The notebook, reflective journal and lesson observation schedule I kept with me during co-analysing curriculum documents, practical demonstrations and participatory and lesson observations, helped me to document and reflect on what had been discussed, giving me insight into what transpired during the workshops. In her research, Isaacs (2019) reckoned that the "researcher influenced the research process and the reflexivity required in managing the complex social relations that invariably arose on the research journey" (p. 124). Reflexivity allowed teachers to be open with me and I gave them the power to decide whenever the next phase of the research process would be done. Participants were allowed to enjoy their time during the research, and time was adjusted depending on the situation which contributed to their enjoyment.

The Ubuntu philosophy helped us to work together and to have mutual understanding throughout the research process. Before the Chemistry teachers signed the informed consent, I was transparent by explaining all the steps of the research process to them, the costs involved in travelling to and from the ECM's house and the number of workshops involved. Clarity was given to the participants on the issues of confidentiality, anonymity, transparency and the participant's right to withdraw if they so wished (Mutanho, 2021). However, I was extremely cautious about how I addressed the issue of "*If you are willing you can withdraw at any time*". When translating this into Silozi, my second language, – "*haulatile wakona kuzwa kanako yifi kapa yifi*", it is regarded as an insult or disrespectful to the participants.

In *Oshikwanyama,* it is translated as follows: "*Oto dulu oku ninguluka efimbo keshe*". *Ningulunga* is a word that cannot be used when talking to someone you want to be part of your research or to any elderly person. It sounds that as a researcher you do not care about them, and it shows rudeness on the participants' side. Translating this into their mother tongue would sound like the participants were not respected and needed in the research process as reiterated by Mutanho (2021) in his study. It is very rude to tell someone in this way. Therefore, the issue of withdrawing during the research process was treated with sensitivity and cautiousness so that the participants would not be offended. The signing of the informed consent (Cohen et al., 2018) focused on the research procedure being documented and had nothing to do with withdrawing during the research process. Similarly, it should be recognised that given the nature of this study, anonymity would be impossible since these Chemistry teachers and ECMs contributed valuable knowledge. Additionally, I plan to co-present with these Chemistry teachers at colloquiums and conferences, for example, the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE).

The ECMs were informed about the aim and objectives of the research before, during and after visiting the home of Mee Mukwaluvala with five Grade 10 Chemistry teachers. The aim was to learn from them – not to judge or criticise – but to work with Chemistry teachers in the community and learn from the experts of IK as we were not knowledgeable about the preservation of *Mahangu*, pounding *Mahangu* flour by using a mortar and pestle and practically demonstrating how to make *Oshikundu*. The use of a local language was permitted so that the ECMs could freely express their knowledge and experiences on the preservation and pounding of *Mahangu* and the process of making *Oshikundu*. That is, the use of a local language when sharing their cultural heritage essentially gave a *voice* to the ECMs.

Lastly, I explained to the participants that my position as a researcher and principal should not compromise their participation and their responses as I would be learning from and with them. I also safeguarded my integrity so as not to be guilty of data manipulation during the research and considered the research as my work, written in my own words. Where I drew from the literature, I referenced as required using the American Psychological Association style, 7th edition.

1.5 The Geographical Location of Namibia

The Namibian landscape consists of five geographical areas: the central plateau, the Namib Desert, the Great Escarpment, the Bushveld and the Kalahari Desert. It borders South Africa on the South, the Atlantic Ocean on the West, Angola and Zambia in the North, and Botswana and Zimbabwe on the Eastern side of the country. The Ohangwena region where this study was conducted is situated in the Northern part of Namibia. The biggest town in the region is Eenhana which was proclaimed as a town after independence. The region is under-developed, and most people live in rural areas. They thus depend on farming as their source of income. The most common crop that they grow is *Mahangu*.

The Ohangwena region has a population of approximately 245 446 people. The region has 10 circuits, 266 schools of which 13 are private, and approximately 4 112 teachers and 108 146 learners as per the 2020 regional statistics. The circuits are: Okongo, Oshikunde, Ohakafiya, Epembe, Eenhana, Ondobe, Ohangwena, Otuganga, Ongha and Endola. The research was carried out in the Endola Circuit, as most schools are in rural areas and teachers are exposed to indigenous technologies daily (see Figure 1.2).

Ohangwena Region where the Endola Circuit is located

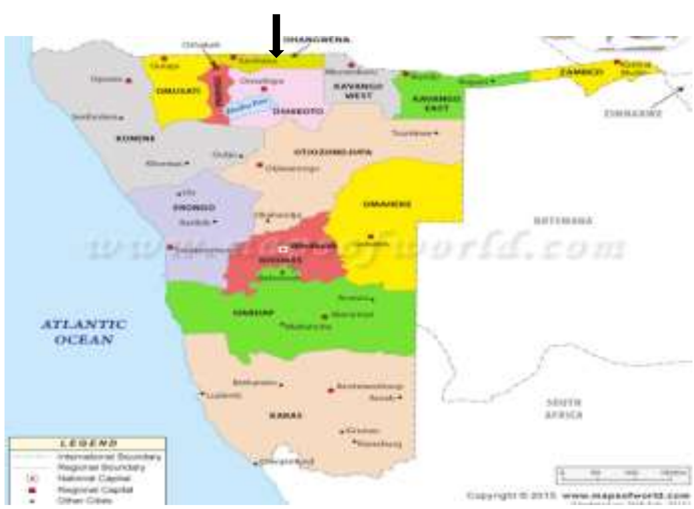


Figure 1.2: The Namibian map (www.mapsofworld.com, 2015)

1.6 Namibian National Curriculum

After independence in 1990, the educational philosophy in Namibia changed from teacher-centred education to LCE. This is documented in a range of policies by the Namibian MoE (2018) and the Namibian Ministry of Basic Education and Culture (MBEC) (1999) where teacher-centred education was based on the syllabi and textbooks. Teachers were regarded as the centre of knowledge and learners as passive receivers of knowledge. For the past years, several reforms have been made to change the education system, its curriculum, and the way content is structured in different subjects to suit the demanding and innovative world of technology. The science curriculum, for example, allows science teachers to be creative and innovative to be able to integrate the life experiences of learners from within their environments. This, therefore, creates room for IK to be integrated into science teaching. The assumption is that if the knowledge the learners bring from home into the classroom is not considered, this might affect their learning. The Namibian National Curriculum (MoE, 2018, p. 20) has the following guidelines:

- To recognise that learning involves developing values and attitudes as well as knowledge and skills;
- To promote self-awareness and an understanding of the attitudes, values, and beliefs of others in a multilingual and multicultural society; and
- To recognise that as information in its various forms becomes more accessible, learners need to develop higher cognitive skills of analysis, interpretation, and evaluation to use information effectively.

The curriculum allows teachers to integrate IK into their teaching by using easily accessible resources found in the school environment as reiterated by Asheela (2017). The revised National Curriculum for Basic Education (NCBE) (MoE, 2018) provides, through well-designed studies of theoretical and practical science, a worthwhile educational experience for all learners, whether or not they are going to study science beyond this level. In particular, it enables them to acquire sufficient understanding and knowledge to become confident citizens in a technological world; take or develop an informed interest in matters of scientific importance; recognise the usefulness and limitations of the scientific method, and appreciate its applicability in other disciplines and everyday life.

The NCBE (MoE, 2018) has core skills that learners have to acquire before the end of their educational journey. There are seven core skills in the NCBE (MoE, 2018) such as *learning to learn, personal skills, social skills, cognitive skills, communication skills, numeracy skills, and information and communication technology skills*. For my study, I chose the ones relevant to Chemistry teaching, namely, learning to learn, social skills and cognitive skills.

Table 1.1: NCBE core skills and competencies (Source: MoE (2018, p. 12)

Core Skills	Competencies
Learning to learn	Setting goals, solving problems, evaluating and reflecting on completed processes; working effectively, independently and in groups; increasingly taking responsibility for their learning and work, among others.
Social skills	Showing respect, tolerance, trustworthiness and honesty; cooperating; accepting encouragement and positive criticism; showing appreciation, among others.
Cognitive skills	Exploring, investigating, enquiring, recognising, contextualising, hypothesising, interpreting, weighing up alternatives, analysing, synthesising, evaluating, thinking creatively, and creating knowledge, among others.

Learning to learn allows learners to actively participate in the lessons by solving problems, evaluating and reflecting on completed processes, and so forth. Social skills help learners to develop social morals through showing respect, tolerance, trustworthiness and honesty, among others. Cognitive skills help learners to be able to explore, investigate, enquire, recognise, contextualise, hypothesise, interpret, weigh up alternatives, analyse, synthesise, evaluate, think creatively and create knowledge, among others. The teaching methods that teachers employ during their teaching have an impact on learners' learning. The traditional teaching methods do not help learners acquire social skills.

The teaching methods of science and learning are today widely regarded as inflexible, stereotyped and syllabus and textbook bound as highlighted by Kambeyo (2012). Teacher-centred methods regard learners as 'empty vessels' that need to be filled with scientific knowledge supplied by the teachers from syllabi and textbooks. The new curriculum discourages teachers to regard learners as 'empty vessels' and rather see them as active participants in constructing their knowledge, thus, it allows teachers to start from the known to the unknown (Kuhlane, 2011).

Nyambe (2008) indicated that LCE has many goals including one that encourages teachers to build on learning starting with learners' life experiences or prior everyday knowledge that learners bring from home to the classroom. Learner-centred education (LCE) requires learners and teachers to work together in groups. This resonates very well with professional learning communities (PLCs) (Chauraya & Brodie, 2018) and in the context of this study, Chemistry teachers and ECMs worked together and learnt from each other. Thus, PLCs need to be taken seriously for the curriculum to realise its goal of building on learners' experiences where IK is located. The experiences learners gain are through social interactions with the community and environment. It, therefore, provides teachers with an opportunity to use the learners' IK as this is embedded in their life experiences (Gwekwerere, 2016). Certainly, for the learners to acquire new knowledge, they need to build on what they already know. For instance, learners are exposed to IK in their homes and communities and other forms of knowledge. Such knowledge could be used as a starting point where appropriate in science classrooms. Indigenous concepts can be used as enabling concepts for the learners to understand WS. Ignoring this might hinder the connectedness that learners need to have to understand the new concepts from what is already known as the curriculum advocates.

The NCBE (MoE, 2018) also emphasises that schools have a special responsibility to use the curriculum guide together with various subject syllabi to identify locally relevant content within a common framework so that learners can experience their education as being meaningful to them. This curriculum is intended to allow teachers to use the IK of learners that is relevant to the topics that are taught in Chemistry classrooms. For example, it emerged from this study that learners knew about the making of *Oshikundu* and the scientific concepts involved and that teachers could use this to build on when supporting learners during the lessons. Aikenhead and Jegede (1999) referred to this as cultural border crossing. It is against this backdrop that cultural border crossing from IK to scientific knowledge and vice versa was put into practice in this study. It is recognised, however, that for this to happen, science teachers need to be empowered to become cultural knowledge brokers (Aikenhead & Jegede, 1999; Meyer, 2010; Wyatt et al., 2017). Thus, this study sought to explore and mobilise how IK could be taught in Grade 10 Chemistry classrooms by exposing the Chemistry teachers to the IK of making *Oshikundu* to contextualise the rate of reactions in the Chemistry syllabus.

One might wonder, for example, how the teachers might act when they are taken to a place or homestead where indigenous practices are carried out. This was demonstrated by Nikodemus (2017) when he exposed learners to IK by taking them on an excursion to observe how indigenous people make *Oshikundu*. Similarly, Shinana (2019) worked with Life Science teachers on enzymes using *Oshikundu*. My study sought to close the gap that Nikodemus (2017) and Shinana (2019) left by involving Chemistry teachers in a peer-learning community and being taught by the ECMs to become cultural knowledge brokers. That is, the Chemistry teachers were involved in a peer-learning community with EMCs to contextualise the topic of the rate of reactions by making *Oshikundu*.

For instance, in her study, Kuhlane (2011) found that "learners manipulated the resources to understand the concepts or to shift their understanding of these concepts (from known to unknown)" (p. 77). Literally, in this case, 'known' referred to IK that learners were familiar with from their homes or the communities around them and 'unknown' was the WS that learners had to learn as it was documented and had to be assessed. An increase in learners' participation was observed when the IK of learners was integrated into the science classroom as illustrated by Nikodemus (2017). The Chemistry teachers showed improvement in their conceptual understanding when the IK of ECMs was used to teach science topics and they became cultural knowledge brokers (Cooper et al., 1999; Meyer, 2010; Wyatt et al., 2017). The understanding was observed when learners were given the chance to present the lesson on the topic of fractional distillation. Learners were confident and showed their understanding of the topic, using IK.

Furthermore, after attending the practical demonstrations by the ECMs, the Chemistry teachers seemed to be confident and knowledgeable about the integration of IK into science classrooms. Translating WS to IK or vice versa requires science teachers to be knowledgeable about both IK and WS. Thus, documenting IK is inevitable in overcoming the challenges created by WS in our education system and society.

1.7 Statement of the Problem

As I have experienced over the past 17 years of my teaching experience, teaching Physical Science (Chemistry & Physics) in under-resourced rural schools in Namibia is a challenge. For instance, I have been struggling to get learners to have a better understanding of science concepts, especially when hands-on practical activities are required (Asheela et al., 2021). On reflection, this has been compounded in part by the fact that I was not aware of how IK could be integrated into science teaching. As a result, learners become disoriented and experience cognitive dissonance (Le Grange, 2007) when science is not relevant to their everyday lives (Gwekwerere, 2016). To ameliorate this, science teachers need to act as cultural knowledge brokers (Aikenhead & Jegede, 1999; Wyatt et al., 2017) when learners transverse between scientific knowledge and IK to avoid cognitive dissonance (Le Grange, 2007). Moreover, the professional development workshops conducted by senior education officers could not solve the problem, even though in theory, the MoE's curriculum (2018) encourages teachers to use learners' experiences and the resources in the environment where their schools are located. It could be argued that the professional development seems to lack the contextualisation of WS to make it relevant to the learners' life experiences (Gwekwerere, 2016) that could help science teachers to integrate IK.

Furthermore, it has been argued that learning is reinforced through contextualising and using IK that learners bring from their homes and communities into the classrooms (Gwekwerere, 2016; Kibirige & van Rooyen, 2006; Klein, 2011). In light of this and building on the seminal work of Vygotsky (1978), Mavuru and Ramnarain (2020) emphasised the importance of taking into consideration learners' diverse sociocultural backgrounds during teaching and learning. The paradox in the Namibian context, however, is that while the curriculum encourages teachers to integrate learners' prior everyday knowledge into their lessons, in practice, IK has been largely ignored in the school science curriculum and textbooks. It is against this backdrop that this study sought to mobilise the IK practices of community members on preserving *Mahangu*, pounding *Mahangu* to make flour and making *Oshikundu* as examples of how IK could be integrated to contextualise Chemistry lessons and rate of reactions in particular.

Essentially, this study also sought to explore the use of cultural heritage embedded in indigenous practices or technologies from the community to make science accessible to indigenous learners. This was achieved through the use of a peer-learning community and expert community members (ECMs) in integrating IK into Chemistry learning and teaching. The practical demonstrations and explanations by the ECMs were intended to enable the Chemistry teachers involved in this study to become cultural knowledge brokers (Meyer, 2010; Wyatt et al., 2017) who would then be able to support their learners to transverse between their lived world and the science world. Such knowledge was later used in Chemistry teaching and learning. The Chemistry teachers were thus involved in a peer-learning community (Tosey, 1999; Tosey & Gregory, 1998) to understand how IK could be integrated into teaching Chemistry. The ECMs guided teachers on indigenous technologies or practices of preservation and pounding *Mahangu* and making *Oshikundu* to teach rate of reactions in Grade 10. Hence, similarly to Seehawer's (2021) study conducted in South Africa, a participatory action research (PAR) approach was used. Central to PAR is active participation by actors and this is consistent with an indigenous research paradigm (Chilisa, 2012; Pidgeon, 2019, Wilson, 2003) which I used to understand the phenomenon under research. Wilson (2003) and Pidgeon (2019) indicated that the indigenous research paradigm is research that follows the indigenous research process that involves indigenous people, culture, language and knowledge. Indeed, this research followed the indigenous research paradigm to engage ECMs in a peer-learning community to help the Chemistry teachers to become cultural knowledge brokers (Aikenhead & Jegede, 1999; Wyatt et al., 2017).

1.8 Purpose and Significance of the Study

The purpose of this study was to explore how Grade 10 Chemistry teachers and ECMs could mobilise indigenous technologies as an example of how to integrate IK to contextualise Chemistry lessons. It was hoped that this research would achieve the following in Namibia:

- The study might help to improve the teaching pedagogy of the participating Chemistry teachers in their Chemistry lessons, after mobilising and contextualising the cultural heritage of local people in science lessons.

- It might inform Chemistry teachers on the potential use of IK as learners' life experiences that learners bring from home or community to classes.
- It might help Chemistry teachers to work *with* and *in* communities, to value and tap into their cultural heritage to contextualise Chemistry lessons.
- It might also help teachers to co-develop exemplar lessons that integrate IK and improve the PCK of the participating teachers in their science lessons after the practical demonstrations and workshops by ECMs and me.
- It might also help to close the gap between policymakers and policy implementers on the views to contextualise WS and inform senior education officers on how teachers could be empowered on how to integrate IK into their science teaching.
- It might also create the platform for other research on peer-learning communities of teachers on the integration of IK in particular.
- It might also inform textbook writers on the integration of IK into Chemistry lessons which could be helpful to teachers and learners during science lessons. It might inform the curriculum designers on the importance of integrating IK into the Chemistry curriculum.
- Lastly, it might also inform institutions of higher learning on how pre-service teachers could be trained for them to become cultural knowledge brokers and be able to integrate IK into science lessons by the time they start teaching.

1.9 Research Goal and Questions

The main goal of my study was to explore leveraging a peer-learning community and expert community members in the integration of indigenous knowledge into the learning and teaching of Grade 10 Chemistry on the rate of reactions. It was guided by the following broad overarching research question:

> How do a peer-learning community and expert community members leverage the integration of indigenous knowledge into the learning and teaching of Grade 10 Chemistry on the rate of reactions?

To achieve this goal and broad overarching research question, the following research sub-questions were addressed:

1. What are Grade 10 Chemistry teachers' experiences, and pedagogical insights on the use of IK in Chemistry learning and teaching before they were engaged in a peer-learning community and with the ECMs?

2. (a) What lessons can Grade 10 Chemistry teachers learn (or not) in their peer-learning community when co-analysing the Chemistry curriculum documents?

   (b) How do Grade 10 Chemistry teachers interact, participate, and learn (or not) during the ECMs' practical demonstrations and explanations on the preservation and pounding of *Mahangu* flour and making of *Oshikundu*?

3. How does a peer-learning community enable and/or constrain Grade 10 Chemistry teachers in using the IK of the ECMs on the preservation and pounding of *Mahangu* and making of *Oshikundu* and other indigenous practices to co-develop exemplar Chemistry lessons?

4. How do the Grade 10 Chemistry teachers selected from the peer-learning community mediate learning of the co-developed exemplar lessons in their Chemistry classrooms?

5. How do discussions and group reflections in the peer-learning community influence (or not) Grade 10 Chemistry teachers' understanding of integrating IK from the ECMs?

1.10 Theoretical Frameworks

In this study, I used Vygotsky's (1978) sociocultural theory (SCT) and Shulman's (1986) pedagogical content knowledge (PCK) to analyse the data. The two complementary theories were deemed appropriate in understanding the integration of IK. The tenets of SCT helped us to work together during practical demonstrations and participatory observation in the context of the ECMs' demonstrations. It helped us to mobilise IK embedded in the indigenous technologies of making *Oshikundu* to teach the rate of reactions. The constructs of SCT were observed in how it helped Chemistry teachers to work with ECMs during practical demonstrations and participatory observation.

For example, regarding culture and language, the ECMs were dressed in traditional attire and used *Oshikwanyama* to communicate with the teachers. In social interactions, the ECMs and Chemistry teachers were engaged in practical demonstrations by learning and trying out what the ECMs were doing. Mediation of learning had to do with the ECMs explaining the indigenous ways of making *Oshikundu* although they seemed to not be aware that scientific knowledge is embedded in these indigenous technologies; this is what Taylor and Cameron (2016) refer to as 'know what', 'know how' (the former) and 'know why' (the latter). Regarding the zone of proximal development (ZPD), the Chemistry teachers were able to explain the scientific processes comprehensively after the demonstration was done. Notably, is that before the practical demonstrations, some of the Chemistry teachers were not sure how to integrate IK. After attending the practical demonstrations, however, they were able to contextualise the Chemistry concepts using indigenous technologies observed during the practical demonstrations. I discuss each framework briefly below.

1.10.1 Sociocultural theory

Vygotsky's (1978) SCT suggests that we learn first through person-to-person interaction and then as individuals through an internalisation process that leads to deep understanding (Blake & Pope, 2008). Vygotsky's (1978) SCT introduces four key concepts, viz. the culture of learning, social interaction, zone of proximal development (ZPD) and mediation of learning in the classroom context. The ZPD allows teachers to move learners from one knowledge zone to another zone through scaffolding using IK. The presence of the ZPD and scaffolding in science classrooms nurtured by social interaction between learners, teachers and community members is the secret to effective learning (Vygotsky, 1978). The use of IK in the science classroom in this study made PCK suitable (Shulman, 1986).

1.10.2 Pedagogical content knowledge

Shulman (1986) introduced the concept of PCK as a distinctive body of knowledge for teaching that is an acknowledgement of the importance of the transformation of subject matter knowledge into subject matter knowledge for teaching. PCK refers to teachers' interpretations and transformation of subject matter knowledge with the view to facilitate meaningful learning (Shulman, 1986). A growing number of scholars have worked on the PCK concept (Geddis et al., 1993; Grossman, 1990; Hashweh, 2005; Loughran et al., 2006; Magnusson et al., 1999; Marks, 1990; van Driel et al., 1998) since its inception in 1986.

When a teacher integrates IK into science lessons, the knowledge areas must be connected to ensure that the learners understand the science concepts. In this regard, PCK helped me to analyse how the teachers used all three PCK knowledge domains as introduced by Shulman (1986) and elaborated on by Grossman (1990). Grossman introduced four general areas of teacher knowledge that form the professional knowledge of teaching. These are general pedagogical knowledge, subject matter knowledge, PCK and knowledge of context used in PLCs. The historical elements of PLCs (Chauraya & Brodie, 2018) are addressed in this study through the use of a community of practice (CoP) (Lave & Wenger, 1991; Wenger, 1998). The four elements that were later reduced to three fit well into the two theoretical frameworks. Subject matter knowledge and PCK are knowledge of context as the knowledge that teachers were situated in this research. These are situated in PCK, and knowledge of context is situated in sociocultural theory (Vygotsky, 1978). We learn through social interactions with other people and the environment we find ourselves in.

1.11 Thesis Outline

This thesis consists of 10 chapters, and I outline these below.

Chapter One: This chapter outlines the study. I introduced the research topic, the context of the study and the purpose and significance of the study. In the introduction, my personal life story about IK has been underpinned by professional development. Positionality and reflexivity were also discussed, and the study's background was outlined in this chapter. The location where the study was carried out, curriculum changes, the significance of the research and research questions were provided in this chapter. Lastly, the definitions of key concepts used in the thesis were explained.

Chapter Two: This chapter discusses the literature relevant to my study. I look at the conceptual framework that was relevant to my study. I discuss food preservation, preservation of *Mahangu* contextualising WS in different topics in science (Chemistry and Physics), specifically rate of reactions. The conceptual framework discusses concepts such as the science curriculum in Namibia, contextualising the science curriculum, preparation of *Oshikundu* in teaching rate of reactions in the Namibian context. I also discuss rate of reactions in Chemistry curriculum, nature of science and IK. Decolonising of Chemistry curriculum, Africanisation of the science curriculum, hands-on practical demonstration and visualisation in Chemistry are also discussed in this chapter. Practical demonstrations in Chemistry and visualisation in science are also discussed as well as the use of IK in teaching science concepts and how it could be integrated. Furthermore, criticism of integration of IK into science teaching, cross-fertilisation of ideas in science classrooms, Chemistry teachers' peer-learning communities, and understanding of IK. Finally, the chapter concludes with the chapter summary.

Chapter Three: This chapter discusses the theoretical frameworks. The tenets of the sociocultural theory discussed are those from Vygotsky (1978), especially the tenets of Vygotsky's SCT. I also discuss PCK as a theoretical framework, with topic-specific pedagogical content knowledge (TSPCK) as an analytical framework to analyse the data. I further extend TSPCK to realms of PCK such as cPCK, pPCK, and ePCK. Within ePCK I looked at the existing forms of ePCK as ePCK for planning ($ePCK_P$), ePCK for teaching ($ePCK_T$) and ePCK for reflecting ($ePCK_R$). I conclude with the chapter summary.

Chapter Four: This chapter narrates the methodology, paradigms and research design used in my study. In this chapter, I reveal my study as a qualitative case study that incorporates transformative research paradigm and indigenous research paradigms. Within the indigenous research paradigm, I focused on the Ubuntu perspective. Community of practices (CoPs) and PAR were used as research approaches to generate data in this chapter. It also clarified the methods used to gather data to answer my research questions. The methods of data generation techniques were divided into seven phases. I used semi-structured interviews, co-analysing of curriculum documents, participatory observation, lesson observation, stimulated recall interviews (SRIs), and reflection to generate the data needed for my research topic and these procedures are detailed in this chapter. I also describe the sampling techniques used to select the participants for my study. Data analysis, being inductive-deductive, is discussed in this chapter. The explanation of how data were generated from the instruments and analysed forms part of the chapter.

The chapter concludes with a description of the triangulation methods used to validate the data and the ethical considerations with its tenets. It also highlights some limitations that occurred during the data generation process and concludes with a chapter summary.

Chapter Five: I present the data generated using semi-structured interviews. Data analysis, interpretation, and discussion of the semi-structured interviews were done in this chapter: Baseline study from five Chemistry teachers was analysed using the SCT. The data situated the understanding of teachers on the integration of IK before they attended the workshops.

Chapter Six: I present the data generated from three workshops with the participants when co-analysing curriculum documents. Data were generated from the NCBE document, Chemistry syllabus, Chemistry textbooks, Physical Science examination papers and examiners' reports. Data analysis, interpretation, and discussion of the findings from co-analysing documents were presented in this chapter using theoretical frameworks and supported by the literature.

Chapter Seven: Data from practical demonstrations and participatory observations are presented and analysed in this chapter. This chapter is the core of this study, Chemistry teachers were involved in practical demonstration with ECMs, and they became cultural knowledge brokers after were involved in professional learning communities. The data presented and analysed involved preservation of *Mahangu*, pounding of *Mahangu* and making of *Oshikundu* to contextualise Chemistry teaching of rate of reactions.

Chapter Eight: This chapter I presented, analysis, interpretation, and discussion data from co-developed exemplar lessons, lesson observations, and SRIs. This chapter afforded me an opportunity to see how the Chemistry teachers used the knowledge gained during practical observation and peer-learning communities that took place in Chapter Six when we co-analysed the NCBE on how it integrates IK into Chemistry teaching and learning. In this chapter, it was evident that the Chemistry teachers acquired knowledge and indigenous pedagogies to be able to contextualise WS. Four lessons were taught and analysed that allowed the Chemistry teachers to contextualise fractional distillation and rate of reactions topics. I critically analysed and categorised data using the theoretical frameworks and literature.

Chapter Nine: This chapter presents the findings that emerged from the data generated from the reflexive space that was done after the research process to come up with the mind maps and concept maps. After practical demonstration with ECMs, the Chemistry teachers were involved in reflexive space to draw the mind maps and concepts map. This helped the Chemistry teachers to reflect on the data that emerged during those activities and were analysed, interpreted and discussed in this chapter.

Chapter Ten: This chapter, I summarised the findings of my study. The implication of the study was also discussed in this chapter. My research journey, experiences, and reflections are presented in this chapter. Additionally, the chapter presents some recommendations for further research. The chapter concludes with a summary of the findings based on each research question.

1.12 Chapter Summary

In this chapter, I situated my study by looking at the background of the study in the Namibian context, and where the study took place in the Ohangwena region. The chapter also addressed the goal, research questions, and the significance of the study. The next chapter describes the literature review relevant to my study on the integration of IK in Chemistry classrooms.

CHAPTER TWO: LITERATURE SYNTHESIS

> Humans are agents that can influence their contexts, rather than just react to them, in a relationship of ongoing reciprocal causality in which the emphasis is on the complex, dynamic interaction, practiced and how it is resourced, constrained and bounded by contextual factors, including power relations and discourse and further by the material conditions and culture of social interaction between the two world views. (Brodie, 2021, p. 561)

2.1 Introduction

A literature synthesis is a review of a body of knowledge comprised of what has been found as well as methodological contributions. The literature review gives the researcher an idea of what has been researched and what needs to be further researched, that is, identifying the gaps to be researched (O'Leary, 2014).

In this study, I took the Chemistry teachers to the community to experience practical demonstrations on preserving *Mahangu,* pounding of *Mahangu* and the making of *Oshikundu* to contextualise Chemistry teaching. The notion that indigenous elders are not knowledgeable about scientific knowledge and the lack of teachers' interest in integrating IK into their lessons were the reasons for this research being conducted. The study sought to address the cognitive dissonance (Le Grange, 2007) experienced by learners during Chemistry learning and teaching and to enable Chemistry teachers to be cultural knowledge brokers (Aikenhead & Jegede, 1999; Wyatt et al., 2017). The lived world of the learners and westernised science seems to be separated by the way Chemistry teaching and learning is presented to the learners without considering their life experiences (Gwekwerere, 2016). Hence, Chemistry teachers need to be cultural knowledge brokers between the lived world of learners and their science classrooms.

In light of this, this study mobilised, explored, and expanded on how IK could be integrated into Chemistry classrooms. In this chapter, I discuss the preservation of food, the Chemistry curriculum in Namibia, nature of science and IK. I also look at community elders, who I call ECMs in this research. I further explain how WS could be contextualised in the mediation of learning Chemistry, looking at the rate of reactions. I also address the issue of contextualising the Chemistry curriculum in Namibia and the Africanisation of science curriculum is discussed looking at school science. This chapter also addresses hands-on practical activities and visualisation, criticism of integration of IK into science teaching, and cross-fertilisation of ideas in science classrooms. Lastly, I discuss the Chemistry teachers' PLCs which I refer to it in this thesis as peer-learning communities. Throughout the thesis I distinguish the two by writing peer-learning communities in full. I conclude the chapter with a chapter summary.

2.2 Food Preservation

Indigenous people have developed diverse ways of preserving seeds and other foods over the centuries. There are different methods used as preservation measures to make the seeds and food last longer than the fresh ones. Without refrigerators, indigenous people have been able to preserve food to be used for weeks or months to come. In my view, some of these preservation methods highlighted below could be used to teach science concepts or topics such as the rate of reactions, osmosis and forms of preservation foods.

2.2.1 Preservation of seeds

The use of IK to teach the rate of reactions in our curriculum might help learners to understand how westernised knowledge (WS) and IK are interconnected. For instance, the Shona people of Zimbabwe used to preserve seeds after the harvest; farmers, especially women who had acquired skills in identifying good seed varieties, would collect grain and maize cobs that they would tie and hang inside their kitchens (Mapara, 2009). Mukwambo et al. (2014) pointed out that indigenous people used to preserve seeds by hanging them on the rafters in their kitchens where smoke from the firewood covered them naturally with soot which contains creosote. According to these scholars, creosote coated the outside of the maize to preserve it to last longer and also acted as an antiseptic, this ensured the seeds were free from contamination and prevented them from being destroyed by insects. The creosote coated the maize, making it hard so that maize lice could not attack it.

Furthermore, food crops such as maize, *Mahangu*, sorghum, beans and groundnuts used to be sundried before being stored to increase their shelf-life span to about six months (Agea et al., 2008). This practice was common for most indigenous people, and it was believed to be the best method of preserving food or seeds. In the Zambezi region, after drying, the maize crops and seeds are kept in locally made storage containers (*Sishete* in *Silozi or Okaanda* in *Oshikwanyama*).

If this IK is not preserved, then African people are bound to suffer from the so-called westernised knowledge. I have observed that the maize cobs, sorghum, and millet that used to be preserved traditionally are not preserved by hanging anymore and so the IK ways of preserving them in kitchens or huts are no longer practised. Admittedly, IK is not stagnant but evolves with the changing world and can adapt to changes, and engagement of people from different community on how maize is preserved in societies and the dominance of scientific/westernised knowledge. It is worrisome that our IK is slowly dying out and if we do not document it, WS will continue to dominate it (Ogunniyi, 2007a).

2.2.2 Preservation of *Mahangu*

Mahangu is one of the staple foods in Northern Namibia. "*Mahangu* is the main crop of the northern Communal Areas, specifically of the North Central Regions, Kavango and the western part of Caprivi, where it is grown under rain-fed conditions" (Mallet & du Plessis, 2001, p. 16). *Mahang*u and sorghum used to be ploughed between October and January when the rains normally fell. Depending on which months the rain fell more, the community members would know that ploughing could start. In the past, people used hoes to till the soil and plant different seeds. *Mahangu* and sorghum are some of the seeds that the *Oshiwambo* people plant every year. Different types of *Mahangu* are planted across the continent. In Namibia, pearl millet (*Pennisetum glaucum*), bulrush millet, cattail millet, and candle millet are also used as synonyms for pearl millet known as *Mahangu*, commonly planted in Northern Namibia (Mallet & du Plessis, 2001). However, pearl millet should not be confused with the other millets, such as finger millet (*Eleusine coracana*), foxtail millet (*Setaria italica*), common or Proso millet (*Panicum miliaceum*), and fonio (*Digitaria exilis*) of West Africa, all of which are not grown in Namibia (Mallet & du Plessis, 2001). I could not find any research on how the preservation of *Mahangu* is done in Namibia.

Indigenous people are blessed with diverse types of food products and also possess diverse IK for preservation and storage (Asogwa et al., 2017). IK prides itself on including different methods of preservation, ranging from drying, fermentation, germination, and soaking which are commonly used in preserving food. Added to this, Asogwa et al. (2017) averred that indigenous methods of food preservation include sun drying, soaking, fermentation, and germination. *Mahangu* is preserved in different ways depending on the cultural knowledge and IK of the community. This research was carried out in *Ovamboland* (consisting of four regions, *Oshikoto, Omusati, Oshana,* and *Ohangwena*), so the methods explained here reflect those of people living in the Northern and north-eastern parts of Namibia, specifically in *Ohangwena*. The *Aowambo* people have a transcultural language and their culture is interconnected to each other (see Section 1.5).

Mahangu undergoes several processes before the final preservation. After ploughing, Mahangu could take two to three months to be ready to be harvested. The place called *Omutala*[7] has to be prepared. After harvesting the *Mahangu,* it has to be sundried at the *Omutala*. Sun drying is one of the oldest methods of preserving food, even before WS dominated Africa (Asogwa et al., 2017). The heads of *Mahangu* are placed in large harvesting [8]*Oshimbale* and taken away for further drying at the *Omutala* before threshing. Communities reduce the spoilage of *Mahangu* by not leaving it for a long time in the field when it is ready to be harvested as leaving the crop in the field too long may result in higher losses due to birds, other field pests, and increased insect infestation (Mallet & du Plessis, 2001).

After harvesting, the *Mahangu* heads are sundried at the *Omutala*, most often on a raised wooden platform near the fields, with a 24/7 watch for birds, chickens, goats, and other grain-eating animals (Mallet & du Plessis, 2001). This is to reduce the moisture and to be completely dried.

---

[7] *Omutala* is the area made from poles, tree branches and grasses raised 1 meter from the ground used to sun-dry *Mahangu* before threshing.

[8] *Oshimbale* is a traditional plate that is weaved from palm leaves

The *Omutala* in most cases is made near some shade, as members of the community have to stay there during the day to watch for pests. Mallet and du Plessis (2001) found that drying can take a few weeks (to get the grain moisture content down to 10% or so) or a month for the dry process to be completed. This is the cheapest method of preserving *Mahangu* done by local communities. It also depends on the season. If it is raining, for instance, it will prolong the drying process as *Mahangu* has to be dry before the threshing process. At the *Omutala*, air circulation is allowed as the place is made from sticks, branches, and grass that also allows water to go through. Furthermore, Mallet and du Plessis (2001) showed that "drying on the threshing floor has also been reported, but the use of an elevated platform has the following advantages: contamination is minimised, with proper construction they can be made rodent-proof, and in the event of an end of season rain shower crop damage is minimised by quick re-drying due to the improved aeration" (p. 10). Drying at the threshing ground has disadvantages, as *Mahangu* will be exposed to ants and if the rains continue, this might spoil it. Thus, communities in the Northern part of Namibia opt to sun-dry *Mahangu* at the *Omutala* for quick-drying and to reduce spoilage.

When *Mahangu* is completely dry, the threshing process has to begin. *Mahangu* has to be separated from the chaff. Mallet and du Plessis (2001, p. 14) stated that:

> Threshing is the detachment of kernels from the rest of the head (or panicle). For *Mahangu* it also involves removing the chaff, which is carried out by winnowing, to obtain a clean grain. Threshing is very important in the small-holder post-harvest operations for on-farm grain storage and marketing.

Threshing can be done on a small scale using the pestle and hitting it with sticks. Threshing is most often carried out in or near the crop fields at the [9]*Oshipale* (Mallet & du Plessis, 2001). This area has to be plastered so that the *Mahangu* grains are not mixed with the sandy soil. The *Oshipale* is a drying place, which is often enclosed with wooden poles and/or thorny bush branches (Mallet & du Plessis, 2001).

---

[9] *Oshipale* is the place where Mahangu is threshed

Women can do the threshing process, and they often sing when threshing to inform the neighbours to come to join them. Herein lies the importance of Ubuntu in rural communities whereby people willingly support one another. Manual threshing and winnowing are typically the work of household women, but men and children often join the family working team (Mallet & du Plessis, 2001). Communities use the wind to winnow for separating *Mahangu* grains from kernel and chaff after threshing. After threshing, the *Mahangu* grains are kept at the traditionally made *Okaanda*/granary/barn for safekeeping away from birds and grain-eating animals. The *Okaanda* is made from weaved small tree branches using the Makalani palm (*Hypbaene petersiana*) leaves in the shape of a sphere. To prevent pests from further entering the *Okaanda*, it used to be plastered inside using hill soil and cattle dung mixed with water. This process can only be done by ECMs who know how to plaster. The *Okaanda* used to be plastered at the opening to prevent pests from entering and destroying the *Mahangu* with two sticks in the form of a cross that served to hold up the opening in case the *Mahangu* grains had to be taken out – it also served as the support for the roof so that it would not fall.

The seeds to be planted in the next ploughing season used to be preserved differently. The *Mahangu* preserved in the *Okaanda* in most cases was for consumption purposes. I grew up observing my parents preserving seeds for planting in the coming ploughing season differently from the rest. The best seeds used to be chosen and preserved in a clay pot called [10]*Kapali/Oshitoo*. The use of ash/*Omutoko* is commonly used to preserve seeds. The cobs of maize, *Mahangu*, sorghum and a variety of seeds used to be kept in an *Oshitoo* and mixed with ash/*Omutoko*. The ash acted as a pesticide. Indigenous people discovered that pests cannot destroy seeds that are preserved using ashes. This method was commonly used in most communities in the Northern and north-eastern parts of Namibia. Integrating the IK of the community in science subjects helps learners and teachers to cross-fertilise ideas between IK and WS. Teachers will be able to contextualise WS in their teaching. Thus, to enhance the conceptual understanding of learners by building from their existing knowledge from home, communities, or environment, learners have to cross-fertilise ideas between the two worldviews.

---

[10] *Kapali/Oshitoo* is a traditional clay pot made from clay soil that has to go through several process to make it strong. It is made to keep water to be cold as a refrigerator and to preserve seed and also it is used to prepare *Oshikundu.*

2.3 Chemistry Curriculum in Namibia

The Chemistry curriculum in Namibia is influenced by a colonial power that ruled the country for many years. Education systems in sub-Saharan Africa have been disadvantaged by westernised science (WS). In many African countries, however, opponents of the integration of IK in science education and its values, argue that IK refers to the historical and ancient knowledge practices of African people as illogical, outdated, and no longer relevant in today's world of science education curriculum (Mhakure & Mushaikwa, 2014). Instead, IK is embedded in both historical and current practices which are unique to people in a specific geographical area and still sustain the majority of rural populations in Africa (Mhakure & Mushaikwa, 2014). The Chemistry curriculum is influenced by LCE. Nyambe (2008) alluded that LCE as a democratic pedagogy views the learner as someone highly motivated to acquire knowledge and further participate not only in the teaching and learning process but also in decision making on how the curriculum should be implemented. Furthermore, in LCE, the learner is viewed as a knowledge inquirer, and should be critical and pose questions during the lessons for better understanding the learning task at hand (Nyambe, 2008). In learner-centred pedagogy, they construct knowledge by using available resources, either provided by the teacher or that come from home. The learner-centred science curriculum seeks to begin with learners' life experiences and interests to use them to lead learners toward what is less familiar and not yet understood in science classrooms.

Despite this, not all IK has been perceived and neglected in science classroom. Some examples are still used by science teachers during their teaching by mentioning them as gatekeeping concepts. In the area where this study was conducted, for instance, most of the societies still practice their indigenous technologies and they regard this as their knowledge and cultural heritage (Cocks et al., 2012). The curriculum that allows learners to integrate their IK with science knowledge is what Aikenhead and Jegede (1999) called 'cultural border crossing'. Cultural border crossing helps science teachers during the lessons to connect science knowledge from both world views. The 'pedagogical culture workers' make the culture of science teachers accessible during the lessons to all their learners (Aikenhead & Jegede, 1999). If learners are not afforded an opportunity to traverse this properly can cause cognitive dissonance (Le Grange, 2007). Hence, there is a need to empower science teachers to be cultural knowledge brokers (Wyatt et al., 2017).

The NCBE (MoE, 2018) allows teachers to start from learners' life experiences (Gwekwerere, 2016) to avoid cognitive dissonance experienced by learners during learning.

The characteristics of a knowledge-based society are the effective and wise use of existing knowledge and the creation of new knowledge, sharing and using knowledge effectively through a dynamic information infrastructure (MoE, 2018). A curriculum that actively engages with indigenous people and their ontologies is the key to actualising ontological as the creation of such spaces forms an important mechanism for effusing IK into science lessons (Hauster et al., 2009). The NCBE (MoE, 2018) suggests that the teachers include life experiences and existing knowledge of learners as reiterated by Gwekwerere (2016), where IK might be embedded. The curriculum that gives guidelines to the teachers on how IK should be tapped into makes it easier for such a curriculum to be fully implemented by teachers. In addition, an inclusive curriculum is a crucial step for negotiating a place in science education where IK heritage is empowered and not further harmed (Hauster et al., 2009).

Hays (2009) indicated that learners learn best when their IK and life experiences are considered and presented in the language and context that is relevant to them. For example, during practical demonstration on the process of making *Oshikundu*, expert community members explained in the local language (*Oshikwanyama*), as the more knowledgeable others (MKO), this allowed the Chemistry teachers to learn (Stott, 2016). Chemistry teachers become cultural knowledge brokers (Aikenhead & Jegede, 1999; Cooper et al., 1999; Meyer, 2010; Wyatt et al., 2017) after practical demonstration. The integration of IK into Chemistry teaching might engender a sense of pride from both Chemistry teachers and ECMs and they could become adept at critical thinking by linking every topic in science to what they do and know from home.

2.3.1 Preparation of *Oshikundu* in teaching rate of reactions in the Namibian context

The preparation of the homemade drink *Oshikundu* involves different scientific processes. *Oshikundu* (also known as *Ontaku* in other dialects of *Oshiwambo*) is a cereal fermented beverage made from water, pearl millet bran, pearl millet (*Pennisetum glaucum*) locally known as *Mahangu,* and malted sorghum (*sorghum bicolour*) flour (Embashu et al., 2013). In this research, I used *Oshikundu* as it is called in the *Oshikwanyama* language. *Oshikundu* is an *Oshiwambo* word derived from *Oshikundifa*, which means "*greeting in Oshikwanyama"* (Embashu et al., 2015). Culturally, *Oshikundu* is given to a visitor before the conversation starts and it is known as breaking the ice (Embashu et al., 2013; 2015). *Oshikundu* has a heterogeneous composition and is brown with a short shelf-life span of less than a day (Embashu & Natanga, 2019). Hence, *Oshikundu* is made through the process of fermentation within six hours and is non-alcoholic (Embashu & Natanga, 2019; Embashu et al., 2013), but if left for a day it will become alcoholic. Children are not allowed to drink *Oshikundu* that has fermented for a long time because of the level of alcohol in it. First, the sorghum or millet seeds need to be put in water for them to germinate (finger millet or sorghum). The germinated seeds are dried and crushed using a mortar and pestle and then sieved by hand or machine. The *Mahangu* flour after being sieved is ready to be used.

There are two different types of catalysts made from sorghum, *Ehete* (catalyst) from the residue/dregs of *Oshikundu* that sediment at the bottom of the container and *Ongudo* which is crushed *Mahangu* but not sieved (Embashu & Natanga, 2019). The knowledge of brewing *Oshikundu* has been adapted and has evolved as this knowledge has been passed on orally and practically from generation to generation through practical experiences (Embashu et al., 2013). In the study done by Embashu et al. (2013), they found that women above the age of 60 years were more knowledgeable on the processing methods of making *Oshikundu* compared to their male counterparts. Ideally, the preparation of *Oshikundu* is believed to be the responsibility of the women. Thus, their knowledge is more advanced than their male counterparts. In this research, two female participants above 50 years were participants as ECMs. They demonstrated and taught Chemistry teachers on IK associated with the preservation of *Mahangu*, pounding of *Mahangu,* and making of *Oshikundu*.

After pounding, *Mahangu* flour is added to boiled water for it to be cooked and stirred until properly mixed and cooled down. It is believed that for the best results there is a need to continue stirring it until it cools down; it must not cool down by itself, if it does, it might become sour (cultural beliefs). The cooled down paste is then diluted with cold water and an estimation is made of the thickness of the *Oshikundu*. They used warm water and the temperature is always measured by the use of a finger (Embashu & Nantanga, 2019). For *Oshikundu* to be ready within a reasonable time, *Ehete* is added to make it ferment or the residue/dregs from the leftover *Oshikundu* are added to speed up the process of fermentation (Embashu & Nantanga, 2019; Shinana, 2019). During wintertime, *Oshikundu* is put in the sun and during the night it will be put next to the fireplace for it to ferment within a short period (Embashu et al., 2013; Embashu & Natanga, 2019). This is done to speed up the fermenting process as enzymes need a favourable temperature for them to work. The sorghum flour and the residue from the already made *Oshikundu* catalyse to speed up the fermentation process, using the dormant catalyst (*Ongudo*) and active catalyst (*Ehete/residue*) that are added into Oshikundu. *Oshikundu* undergoes several scientific processes that are relevant to the topic of the rate of reactions. With this common understanding, scientific processes are involved during the preparation of *Oshikundu.*

Using *Oshikundu* to teach the rate of reactions in Chemistry would allow learners to contextualise different concepts in the lessons. Learners might be conscious of their IK during the lessons and might be able to explain processes that involve scientific concepts. For example, the use of fine particles allows the rate of reaction to be faster than using the big particles, therefore, the *Mahangu* used to be crushed and sieved to make sure that only small particles pass through the sieve. This increases the rate of reaction and indigenous people have developed these skills to allow them to be able to make *Oshikundu* within six hours. Rates of reactions are understood to be a measure of the number of collisions taking place in a single unit of time, in this case, the more particles the more the collisions. This allows the reaction to be faster and the process to be ready within given hours. "The preparation technique of *Oshikundu* highlighted factors that affect the rates of reactions, such as increasing the surface area by crushing *Mahangu* and sorghum flour, using hot water (temperature), the addition of water or *Ehete* (concentration), and *Ehete/Ongudo* as a catalyst" (Nikodemus, 2017, p. 35).

The next concept that could be taught using *Oshikundu* is fermentation, which is the process when particles are colliding when *Oshikundu* starts to ferment, this is observable when bubbles are produced as the fermentation process releases Carbon Dioxide (CO_2) (Nandjedi, 2022). The CO_2 could be collected and tested by using limewater and a lighting splint.

The reaction from the formation of *Oshikundu* could be used to teach the balancing of the equation in anaerobic respiration. A microorganism called yeast is added to the solution. The IK uses *Ehete* (Nikodemus, 2017; Shinana, 2019) as the yeast/enzymes and it used to be added to make the process faster. The yeast uses the sugar for energy during anaerobic respiration (respiration without oxygen), and so the sugar is broken down to give CO_2 and small traces of ethanol (hence, *Oshikundu* could be regarded as a non-alcoholic beverage). Sorghum flour or *Mahangu* flour has natural sugar that needs to be broken down into simple sugar through the process of fermentation. Additionally, malted sorghum flour (*Ongudo*) added to the cooled *Mahangu* flour mixture prevents the inactivation of enzymes that are involved in fermentation (Embashu et al., 2013).

Mahangu flour + *Ehete* → Oshikundu + Carbon Dioxide

↓

Glucose + yeast → ethanol + Carbon Dioxide

↓

$$C_6H_{12}O_{6(aq)} \longrightarrow 2C_2H_5OH_{(l)} + 2CO_{2(g)}$$

The malting of the sorghum's enzyme amylase is activated to break down the starch in *Ongudo* into simple sugar; this can also contribute to the flavour of *Oshikundu* (Embashu et al., 2013). Chemistry teachers need to connect the ideas of learners between WS and IK for them to be able to learn and master the content using indigenous technologies. I now discuss how IK could be used to teach the rate of reactions.

2.3.2 Rate of reactions in the Chemistry curriculum

Rate of reactions is one of the topics that is taught in Chemistry Grades 10 and 11. The NCBE (MoE, 2018) avows that under Natural Science where Chemistry is part of the learning areas that:

> Learners use methods and skills to develop simple scientific models based on existing and new information and communicate their investigations, analyses and conclusions using scientific and mathematical language, theories, laws and principles. They apply and generalise scientific knowledge to everyday situations, understand the value and vulnerability of the natural environment, as well as actions that affect the environment negatively, and know how these can be countered. (p. 29)

The excerpt above stresses that learners doing Natural Science are expected to build on their existing knowledge to be able to investigate, analyse, and make conclusions about what they are learning. The existing knowledge learners have is their prior everyday knowledge (Kuhlane, 2011; Roschelle, 1995). The rate of reactions is one of the topics that could be taught using learners' prior everyday knowledge of making *Oshikundu*. Learners regard the rate of reactions as one of the most difficult topics in Chemistry and they fail to understand the speed of reactions (Nikodemus, 2017). The complexity of the topic is because the topic is taught theoretically due to the lack of resources in most schools in Namibia. Without practical investigations, the rate of reactions becomes a complex topic to teach to the learners using materials that are not readily available in learners' life experiences. The examiner's report 2018 claims that most learners were not able to answer questions on kinetic/collision theory (rate of reactions). It stated that most learners fairly answered the question.

> The examiners revealed that learners could not understand the collision theory (rate of reactions) during examination. Most candidates could not use comparative words and therefore losing marks unnecessarily. (Examiner's Report, 2018)

The excerpt from this examiner's report shows that learners had a lack of conceptual understanding of the topic of the rate of reactions. They used incorrect concepts to explain the collision theory when the reaction is taking place.

The study carried out in Thailand by Supasorn and Promarak (2015) when implementing the 5E inquiry in school science to enhance the conceptual understanding of learners in Grade 11, found that the rate of reactions was one of the topics in Chemistry where learners struggled to make meaning during the lessons. The concept involves many calculations and factors that affect the rate of reactions. Supasorn and Promarak (2015) further found that the rate of reaction topic was causing problems for the learners such as their inability to define the rate of reaction; misunderstanding, misapplying or misinterpreting the relationship between the rate of reaction and its influencing factors; and a lack of understanding on how activation energy and enthalpy relate to the rate of reaction. This made it difficult for learners to differentiate between reactants and products in the reaction. Learners had a different understanding of the scientific concepts and that made the topic more difficult for them. Similarly, the examiner's report (2018) stated that learners used different concepts that were not correct and showed misinterpretation of concepts.

Furthermore, Chairam et al. (2009) found that Chemical kinetics was an extremely important topic for learners wishing to do Chemistry at institutions of higher learning. The topic addresses questions such as: How fast do chemical reactions go and what factors influence the rate of a chemical reaction?

The rate of reactions could be taught using IK that occurs in the local environment where learners are from. To address this, Nikodemus (2017) reverberated that, learners were actively involved in the lessons when their IK of making *Oshikundu* was used to teach the topic on the rate of reactions. Learners' voices were heard during practical activities of making *Oshikundu*. As a consequence, many learners could understand the concepts without assistance and opportunities for carrying out activities in a laboratory (Chairam et al., 2009). In Namibia, with the shortage of laboratories, out-of-school activities help learners to engage with science concepts through the local practical activities that are done by the community. This research, however, took teachers to the local community to engage with practical demonstrations and participatory observation on the preservation of *Mahangu*, pounding of *Mahangu*, and making of *Oshikundu*. The aim was to mobilise IK and contextualise Chemistry content.

The rate of reactions should be taught by describing, in terms of collision theory, the effects of concentration, pressure, particle size (surface area), catalysts (including inorganic or organic), temperature, and light. These factors that affect the rate of reactions are similar to the ones observed in the practical activities that used to be done by community members when making *Oshikundu*. Learners are familiar with the way *Oshikundu* is prepared at home. Engaging them in daily practical activities done at home to teach factors affecting the rate of reactions enhances their conceptual understanding. Most westernised books ignore the use of locally available materials that are found in the communities where learners come from. For example, the commonly used example in Chemistry textbooks when teaching particle sizes (surface area) is shown below:

Particle size (Surface area)

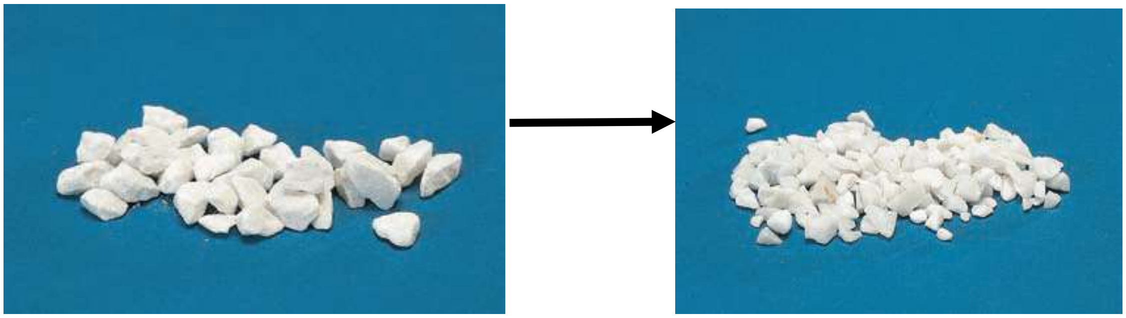


Figure 2.1: Large chips and small chips used in westernised Chemistry textbooks

Figure 2.1 above illustrates that increasing the surface area by breaking larger chips into small chips will make the reaction faster and increase the collision between reactants. The experiment shows that the reaction will be completed first on the small chips, given that the mass of the chips is the same. This does not support the understanding of learners that they have from home. The use of *Mahangu* grains and flour might replace the use of chips that are not locally available in most secondary school laboratories. The use of marble chips is more practical in western countries that are developed, but in Africa, we still need to use African epistemology. Thus, locally available resources/materials that can replace westernised materials need to be unearthed to be used in practical activities.

The study done by Yalçınkayaa et al. (2012) affirmed that most of the learners when asked to explain the factor of temperature, tend to implement Le Chatelier's principle to the rate of reactions concepts (Chani et al., 2018). In this case, learners used the concepts they understood to explain temperature on the rate of reactions. Nikodemus (2017) echoed that, learners do better on a topic if they have prior everyday knowledge and are engaged in practical activities. Several research done in Namibia found that engaging learners in practical activities using easily available resources enhances conceptual understanding (Asheela et al., 2021; Kambeyo, 2012; Liveve, 2022; Shifafure, 2014). For example, using *Oshikundu* to teach the rate of reactions could help learners to engage in classroom talk, as a result, enhancing their conceptual understanding. *Oshikundu* undergoes the process of fermentation that involves all the factors that affect the rate of reactions.

The use of *Oshikundu* to teach the rate of reactions helps learners to be critical thinkers and to further research the factors that affect the rate of reactions. One critique against using IK is that it lacks terminologies that can be used in science classrooms. What does the nature of science look like then?

2.4 Nature of Science

The nature of science (NOS) is referred to as the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge (Abd-El-Khalick et al., 1997). The NOS that is taught in schools is based on scientific explanations and facts that are atomised. To enhance science in the United Kingdom, the British Association for the Advancement of Science (BAAS) was established in 1831 in York, the most central city in the three Kingdoms (Withers et al., 2008). The aim was to advance scientific knowledge (western) to be more explicit and well understood by a larger community of researchers. Eurocentric science was a collection of rational perceptions of reality and was authorised by this scientific body called BAAS (Mukwambo, 2013). The BAAS body dealt with the Eurocentric knowledge system. In 1884, BAAS started holding meetings overseas to promote scientific knowledge and its dominance started in the 19^{th} century. The first handbook for the BAAS was written in 1859. With the influence of BAAS, in 1848, the American Association for the Advancement of Science was established with the prime function of promoting the cultivation of science across the United States of America and giving systematic direction to scientific research and procuring resources for its members (Aikenhead, 2003).

As alluded to earlier, the worldview in which scientific knowledge is anchored is based on atomised facts. In his study, Mukwambo (2013) indicated that in the parameter time, a small spherical ball was tied on a string and hung and then allowed to swing forward and backwards. This was taken as a presentation of an instrument to measure time and from there the clock was formed. Essentially, scientific knowledge is based on empirical data that reveal the practical work to manifest evidence and prove the evidence.

Scientific knowledge used experiments to prove if facts were correct or not. Scientific knowledge is foregrounded in empirical observation and experiments to prove the facts correct and this allows for improvement of the knowledge. Science books document the facts that are proven by experiments and there is still room for further research to correct the earlier assumptions or mistakes. The advancement of scientific knowledge played a role in how sub-Saharan Africa and the world perceived this knowledge. Scientific knowledge taught in schools has gone through revisions and every time new knowledge emerges and new evidence bridges the gaps in the knowledge. For example, the theory of dispersion of white light into its component colours discovered by Isaac Newtown in 1665 was an astonishing scientific investigation of its time. Newton had to prove this to the world for it to be accepted as the truth and not just a hypothesis written on paper.

There has been a shift from western knowledge to scientific knowledge, I used the two interchangeably. This study used both western/westernised knowledge and scientific knowledge interchangeably to refer to the knowledge that is documented in science textbooks. To make the connection between scientific knowledge and IK, the NCBE (MoE, 2018) allows teachers to teach learners using the resources from the environment. The connection between IK and scientific knowledge is not always smooth and it brings cognitive dissonance (Le Grange, 2007) in the minds of the learners. Science teachers need to permeate the gap between the two knowledge to avoid cognitive dissonance that can be caused by two worldviews. Cognitive dissonance can influence how learners accept the IK as scientific knowledge with regard to documented science knowledge. Hence, Chemistry teachers need to be empowered to become cultural knowledge brokers (Cooper et al., 1999; Meyer, 2010; Wyatt et al., 2017) when IK is integrated into Chemistry teaching. This might allow learners to traverse between the two knowledge worldviews which are regarded as not compatible.

To make the two compatible, the NCBE allows teachers to use learners' life experiences in their teaching (Gwekwerere, 2016). In this regard, the science curriculum needs to be Africanised and decolonised as proposed by scholars such as Mukwambo et al. (2014), Ogunniyi (2018), Seehawer (2018a) and others. The epistemological way of knowing in western knowledge is based on studying things that are documented to discover new trends of knowledge. This allows for further research and through further research, new knowledge is created. Simonds and Christopher (2013) indicated that western ways of knowing are based on breaking everything into small pieces and looking at them as small pieces. That allows western knowledge to discover and keep on improving by learning from the previous knowledge and building from what is known to the unknown.

2.5 Nature of Indigenous Knowledge

Indigenous knowledge (IK) is the knowledge that is embedded in the culture of people who live in the same area and have the same social, economic, technological, and scientific threads of a people developed and refined over time (Jones & Hunter, 2003). This indicates that IK can change with time, technologies, and the economy of the country. IK can be referred to as indigenous technical knowledge, ethno ecology, local knowledge, folk knowledge, traditional knowledge, traditional environmental knowledge, people's science, rural people knowledge and is the knowledge that is unique to a culture or society (Nyika, 2017). IK could have different names in various parts of the world and could mean the same thing. Looking at these definitions indicates that IK is unique knowledge woven into a certain culture and cannot be shared with other cultures. This knowledge is influenced by geographical and environmental factors which have an impact on the way of living for certain communities.

It is argued that IK differs from place to place but the way it is transmitted remains similar. Indigenous knowledge (IK) is transmitted orally from one generation to the next and usually in the form of storytelling. In this study, IK was used to illustrate the knowledge that community members or indigenous people possess that is associated with the practical activities they do on a daily basis. For example, how indigenous people make *Oshikundu* using different ingredients as indigenous technologies.

Indigenous knowledge (IK) is becoming more universal because it is not stagnant, it can adapt, change and interface with this new changing world. Indigenous people from diverse cultures and backgrounds meet and share their knowledge, but it still has its roots in the specific culture where it originated. In this regard, Dziva et al. (2011) contended that IK is not static, but it evolves and changes as it develops. Furthermore, it is influenced by both internal and external circumstances and interaction with other knowledge systems. IK is the body of knowledge that belongs to a certain community (Klein, 2011; Mapara, 2009; Mhakure & Mushaikwa, 2014).

According to Dziva et al. (2011), IK is an all-inclusive knowledge that includes indigenous technologies and practices that have been done and are still used by indigenous and local people for existence, survival, and adaption in a variety of environments. It has been widely recognised as part of the curriculum (Mhakure & Mushaikwa, 2014), but its implementation in science lessons still seems to be a challenge to teachers because most schools in Namibia are multicultural schools with learners from different cultures (Nyamakuti, 2021). As a result, their IKs differ from each other, and it could be a challenge for the teachers to teach or use examples of the IK of some learners and ignore others. Different cultures have different IK which is influenced or depends on different factors such as climatic conditions, geographical location, cultural artefacts, beliefs, environment, and other factors. Additionally, IK has pros and cons when integrated into science lessons.

Based on my experience as a Physical Science teacher, now Chemistry and Physics, I have learnt that for learners to grasp new subject matter knowledge more easily, IK examples need to be part of the lessons and if this IK foundation is ignored, the topic will not be anchored in the minds of the learners. Learning is also enriched by hands-on practical activities that are done based on the learners' prior everyday knowledge. Such hands-on practical activities could be in the form of indigenous practices or technologies that exist in the communities. Thus, working with community elders has the potential to help close the gap that exists between indigenous knowledge and WS. Indigenous people use their observation and their connectedness with the environment to prove their facts correct. Indigenous ways of knowing are holistic and do not allow small pieces to be broken as that destroys the *Ubuntu*. Simonds and Christopher (2013) proffered that IK does not allow small pieces of knowledge to be broken down as that will destroy this way of knowing. Instead, knowledge is created when people share their experiences and wisdom and the connectivity they have with the environment. Moreover, in contrast to the NOS, beliefs, religion and spirituality influence the ways of knowing within the *Ubuntu* perspective. Seehawer et al. (2015) indicates that:

> IK it develops in people's local livelihoods and is shaped according to their specific environment. However, indigenous knowledge is not necessarily in opposition of Western knowledge: In many cases, it is just a different way of knowing the same thing. Spirituality can be part of the knowledge, for example, when knowledge is received through spirits or ancestors. Indigenous knowledge is broad: It incorporates systems of knowledge such as farming systems (how to grow crops, how to preserve foods, control pests, etcetera.); there is also indigenous knowledge in music, in art etc. Indigenous knowledge can be part of everyday knowledge that the learners bring to the classroom from their homes and communities. (p. 6)

However, this research was not intended to compare indigenous and western ways of knowing as such, rather it was conducted to see how the two worldviews that are different, could be taught simultaneously without necessarily comparing them. Similarly, Onwu and Mufundirwa (2020) affirmed that their study was not about "comparing perspectives between IK and scientific ways of knowing, rather it was about an understanding of how science and indigenous technologies/practices can co-exist where they share commonalities and be beneficially used to facilitate relevant science teaching for more meaningful learning" (p. 230). Even though IK and WS have different ways of knowing, this study was aimed at leveraging a peer-learning community and ECMs in integrating indigenous knowledge into Grade 10 Chemistry learning and teaching of rate of reactions. Thus, working with community/indigenous elders was inevitable in my study.

2.6 Community Elders

Indigenous knowledge (IK) is defined by scholars as rural people's knowledge or traditional knowledge and is associated with indigenous people (Jones & Hunter, 2003; Nyika, 2017). Indigenous elders are the custodians of indigenous knowledge that has its foundation in the environment where people live. For instance, in his study, Kakambi (2020) worked with indigenous elders on basketry and weaving to contextualise WS in the topic of chemical and physical changes. Notably, indigenous elders are called different names such as indigenous people, folk people, local people, community people, holders of IK (de Beer & Mentz, 2016) and many others. Lavallee (2009) indicated that "indigenous elders are an important part of Aboriginal culture because of the traditional knowledge that they impart and they carry the traditional teachings, the ceremonies, and the stories of all our relations" (p. 27).

In this study, indigenous elders are called ECMs and are custodians of the cultural heritage. To Vygotsky (1978), they are the more knowledgeable others (MKOs). Hence, indigenous elders have the potential to support the education system in different ways that allow them to be part of children's education (Klein, 2011; Mateus & Ngcoza, 2019). They can thus empower teachers to be confident cultural knowledge brokers when integrating IK into their science classrooms (Aikenhead & Jegede, 1999; Wyatt et al., 2017).

Working with indigenous elders meant this research was placed within the indigenous research paradigm. Under the indigenous research paradigm, I used the Ubuntu perspective which connected the ECMs and Chemistry teachers to work together during practical demonstrations on preservation and pounding of *Mahangu* and the making of *Oshikundu*. Ubuntu has connotations that mean 'I am a person through other people' or 'human-ness' (Keane et al., 2016; Khupe, 2014; Ogunniyi, 2007a). Without the Ubuntu of indigenous elders this study would not have been possible. For Chemistry teachers to contextualise their lessons they need to work with indigenous elders by inviting them to the classroom to explain certain aspects that are practised in the local environment (Kakambi, 2020; Klein, 2011; Mateus & Ngcoza, 2019). Doing this would allow science teachers and ECMs to work together in science classrooms. Science teachers could become cultural knowledge brokers (Aikenhead & Jegede, 1999; Cooper, 2014; Wyatt et al., 2017) when indigenous elders are invited to the classroom to explain indigenous ways of doing things that could be used to explain or contextualise topics in Chemistry. Working with the ECMs in this study allowed learning to take place in an out-of-school context (Braund & Reiss, 2006; Luehmann, 2009; Rennie et al., 2003).

To date, indigenous elders have been involved in different research (Kakambi, 2020; Lavallee, 2009; Liveve, 2022; Nikodemus, 2017; Shinana, 2019) that is changing the ideology and perspectives of current researchers to work with indigenous people as the custodians of different IK that is useful in teaching science subjects. Klein (2011) signposted that "indigenous people are usually defined by characteristics that relate to the identity of a particular people in a particular area, and which distinguish them culturally from other people" (p. 82). This culturally oriented research worked with the ECMs on preservation of *Mahangu*, pounding of *Mahangu* and making *Oshikundu* which are part of the identity of the *Aawambo* speaking people in the Northern part of

Namibia (see Section 4.3.4). This allowed me to research IK that could be taught by contextualising the topic of rate of reactions in Chemistry classrooms. Similarly, Liveve (2022) worked with a cultural youth group on contextualising sound and waves in Physics classrooms. Therefore, the indigenous research paradigm enabled the relevancy of the study by working with the ECMs on IK using indigenous artefacts.

Traditionally, *Oshikundu* used to be prepared in the [11]*Oshitoo*. The *Oshitoo* is made from clay soil mixed with water and the indigenous elders (ECMs) used to make them. This was where *Oshikundu, Ontaku and Omalondu* used to be prepared before the western way of using a bucket that had the same useful functions replaced the *Oshitoo.* Lending support, Mateus and Ngcoza (2019) indicated that the *Oshitoo* are also used as containers for *Oshiwambo* traditionally brewed drinks such as *Ontaku* and O*malodu.* Observing how the *Oshitoo* is made, it so amazing that someone might wonder if it was made by a machine or by hands. Indigenous elders are so creative and knowledgeable about different aspect of Mathematics, engineering and climate change. Making the *Oshitoo* is an engineering skill that indigenous elders are knowledgeable about. After the *Oshitoo* is made, it is heated to make it strong. It is believed that heating the *Oshitoo* makes it strong, and water cannot leak from it. The process of making the *Oshitoo* involves scientific explanations. Sadly, the interest in making this amazing artefact is slowly fading because of westernised ways of doing things (Mateus & Ngcoza, 2019). It could be argued that this is akin to the death of a cultural practice with a high potential to mediate learning of science (Mateus & Ngcoza, 2019). Thus, decolonising the Chemistry curriculum in Namibia calls for researchers to work together with elderly people in understanding the IK that they used to practice.

2.7 Decolonising the Chemistry Curriculum in Namibia

The Namibian Chemistry curriculum does not explicitly give science teachers instructions on how to indigenise the curriculum during science lessons. That is, the science curriculum seems to be too scientific and does not connect to the environment where the learners come from. In less-resourced schools in rural areas in Namibia, it seems difficult for the science teachers to teach the

[11] *Oshitoo* is traditional storage made from clay soil that is heated to make it strong

scientific processes that require practical demonstrations. This type of teaching allows the teachers to use rote learning by explaining some of the processes that they do not even understand or have never come across. The curriculum should give science teachers the knowledge on how to integrate the life experiences of learners and their local environment when teaching science. The context in which science teachers teach Chemistry does not address the IK that learners are familiar with at home. Drawing from Smith (2008) cited in Chilisa (2012) aver that decolonisation is the process that:

> It involves the restoration and development of cultural practices, thinking patterns, beliefs and values that were suppressed but are still relevant and necessary to the survival and birth of new ideas, thinking, techniques and lifestyle that contribute to the advancements and empowerment of the historically oppressed and of former colonized non-western societies (Seehawer, 2021, p. 37 cited Chilisa, 2012)

In understanding this, it helped me to work within the mind frame of decolonising Chemistry curricula by working with Chemistry teachers and ECMs. Chemistry teachers need to become cultural knowledge brokers (Cooper, 2014; Cooper et al., 1999; Wyatt et al., 2017) between the learners' own environment and science they are doing at school (Chang, 2020). Furthermore, extending on Aikenhead and Jegede (1999), Chang (2020) proposed that cultural knowledge brokers (teachers) should build bridges that link or connect the western science and the knowledge learners learn from their homes or community. When teachers build the bridge to allow learners to traverse between the two worldviews, they help learners not to experience cognitive dissonance (Le Grange, 2007). Doing this allows learners to view their life experiences as part of scientific knowledge as reiterated by Gwekwerere (2016) and others.

In this study, Chemistry teachers were taken to the ECMs' houses to learn about preservation and pounding of Mahangu as well as the making of *Oshikundu*. The purpose for that was to expose them on how to contextualise WS which seems to be dominant in Namibian schools (Ogunniyi, 2007a). Put differently, they were afforded an opportunity to be cultural knowledge brokers (Cooper et al., 1999; Wyatt et al., 2017). The out-of-school context (Luehmann, 2009) was therefore intended to enable them to see the link between scientific knowledge and IK. That is, it was hoped that they would become cultural knowledge brokers through participating in practical demonstrations and participatory observation of how the preparation of *Oshikundu* could be linked to the topic of the rate of reactions. Chemistry teachers during the lessons subsequently used the knowledge (IK) from the ECMs to enhance the understanding of learners.

The classroom setup represents the scientific knowledge that allows teachers to ignore IK. Indigenising the science curriculum will allow teachers to voice their thoughts and use materials that are relevant to the topic under review. It is not limited to indigenous people, but encompasses all learners and science teachers, for the benefit of our academic integrity and social viability. The NCBE (MoE, 2018) emphasises that:

> The goal of basic education is to empower learners to actively participate in making Namibian society a knowledge-based society. A knowledge-based society is globalisation by the effective and wise use of existing knowledge and the creation of new knowledge; the effective sharing and using of knowledge (p. 5). (My emphasis)

The NCBE is clear on the integration of IK as existing knowledge of learners. Several studies done in Namibia (Liveve, 2022; Mukwambo, 2017; Nikodemus, 2017) on the integration of IK revealed that indigenous knowledge has the potential to be integrated into science teaching. Research shows that learners' performance after the teachers integrated IK showed significant improvement in learners' achievements in the diagnostic test (Liveve, 2017; Nikodemus, 2017; Shifafure, 2015). The significant improvement was the result of teachers moving from the westernised teaching methods to indigenous teaching methods by including indigenous technologies to enhance the conceptual understanding of learners. To emphasise this, the NCBE (MoE, 2018, p. 41) illustrates that:

> Teaching which does not build on that experience and learning will limit the learners' thinking, and the learners will not see the connection between the world outside school and what is taught and learnt in school. Teaching should always begin with helping the learners realise what they might already know about something, by eliciting ideas or questions they might have about it, and by relating what they are learning to the environment within and around the school. (My emphasis)

Analysing this excerpt from the NCBE (MoE, 2018) indicates that the curriculum is advocating for the integration of IK into all subjects and Chemistry is one of the subjects that has a lot of local content in it. Science should build from what learners knows to contextualise western science. Roschelle (1995) affirmed that to help learners make the most of the new knowledge, teachers need to understand how prior everyday knowledge affects their learning in the classroom. Learning can only take place when learners can re-contextualise, re-prioritise, and refine the parts of the new knowledge to be learnt (Roschelle, 1995). Teachers must be able to re-contextualise Chemistry content to make learners familiar with it and then re-prioritise the relevant knowledge, and later refine the knowledge. The process of contextualise-prioritise-refine (C-P-R) can help teachers to avoid misconceptions that might be brought by the learners to the classroom and allows teachers to be ready to integrate IK into Chemistry lessons without any doubts.

The Chemistry curriculum concerns not only what is taught, but how it is taught, which gives rise to an understanding of decolonisation that addresses how academic knowledge is experienced. Chemistry teachers need to be involved in PLCs on how IK could be integrated with WS to avoid the conflict between the two worldviews of knowledge banks. A PLC would allow teachers to become equipped with the knowledge on how contextualised science curriculum could be taught in science classrooms. Decolonising the Chemistry curriculum would provide every school learner with a high-quality education that enables them to engage in the world of scientific knowledge with confidence and competence (Jansen, 2017). The teaching of Chemistry should be context embedded to allow teachers and learners to connect IK with scientific knowledge and be culturally sensitivity.

However, the opposers of the decolonisation of the science curriculum oppose it as they feel that it poses special challenges, as it is believed that science is objective and universal (Raja, 2001). Adding to this, Le Grange et al. (2020) indicated that despite the hard work done in South Africa, decolonisation is still at an infancy stage as nothing had been done to develop African languages as a medium of instruction at higher institutions. This might hinder the way IK is approached in science classrooms. Indigenous knowledge (IK) has been dominated by scientific knowledge in what Le Grange terms *epestemicide* (replace existing knowledge) (Ngcoza, 2019), *linguicide* (displace the language of people and impose another language), and *culturecide* (replace the culture of the people) (Le Grange et al., 2020). This has affected the contextualisation of the science curriculum, particularly in sub-Saharan Africa. I have given examples of how science could be taught by integrating the IK of the learners and communities. This research contextualises Chemistry on the topic of the rate of reactions using the making of *Oshikundu*. The topic could be taught using the preparation of *Oshikundu* to affect the factors involved in the rate of reactions.

Decolonising the science curriculum would allow teachers to be trained and that will result in science being taught using indigenous languages and locally available materials. If the government wants to decolonise the curriculum for science subjects it should start with contextualising and understanding the importance of IK and what it brings to science classrooms. Drawing on Smith (1999), Chilisa (2012) identified seven elements of decolonising curriculum to integrate IK: *deconstruction and reconstruction, self-determination and social justice, ethics, language, internationalisation of indigenous experiences, history and critique.* The seven elements are explained below*:*

- *Deconstruction and reconstruction* concerns discarding what has been wrongly written, and "interrogating distortions of people's life experiences, negative labelling, deficit theorizing, genetically deficient or culturally deficient models that pathologized the indigenous people and retelling the stories of the past and envisioning the future" (Chilisa 2012, p. 17).
- *Self-determination and social justice* relate to the struggle by those who have been marginalised by the Western academy and is about seeking legitimacy for knowledge that is embedded in their own histories, experiences and ways of viewing reality and way of doing things.
- *Ethics* relates to the formulation, legislation and dissemination of ethical issues related to the protection of IK systems.
- *Language* concerns the importance of teaching and learning in indigenous languages as part of the anti-imperialist struggle; IK is embedded in indigenous language. This is where IK is overpowered by western knowledge and Africans need to develop their languages and write books in their own language.
- *Internationalisation of indigenous experiences* relates to international scholars sharing common experiences, issues and struggles of indigenous peoples in global and local spaces through research.
- *History*, in this instance, involves a study of the past to recover the history, culture and languages of indigenous people and to use it to inform the present.

- *Critique* concerns a critical appraisal of the imperial model of the academy that "continues to deny the indigenous people and historically marginalised other space to communicate from their own frames of reference" (Chilisa, 2012, p. 19).

Pete (2015, pp. 2–7) illustrated 100 ways to indigenise and decolonise academic programmes and courses. I chose the relevant ones that addressed the decolonising of the science curriculum.

- "Develop plans to recruit and retain indigenous graduates in science fields; this will allow them to implement the decolonised science curriculum;
- Recognise and respect elders and knowledge holders who fulfil important roles in the decolonisation of the science curriculum;
- Develop and sustain pragmatic approaches to the inclusion of IK that will respond to the decolonised science curriculum;
- Institute policy response on integrating IK that would respond to what is lacking in the science curriculum at the moment;
- Invite indigenous scholars to present to learners in the science classroom; and
- Learners and teachers should be IK experts and contextualising the science curriculum will make them IK researchers".

Decolonising the Chemistry curriculum requires that teachers are empowered so that they can maintain the status quo of the education system of the country. Boisselle (2016) articulated that decolonise science and science education might be possible through practices that are primarily contextually respectful and responsive. Adding to this, Sayed et al. (2017) affirmed that decolonisation of science curriculum allows teachers to expose learners to IK that is inclusive and pertinent in the science classroom. Co-analysing the science curriculum exposed science teachers in this study to the role of IK in Chemistry teaching. In the context of my study, decolonisation of the science curriculum means teaching science facts by using IK. It refers to IK as the gatekeeping knowledge during science teaching on the rate of reactions and bringing out the hidden knowledge of indigenous people from context to content and using it as the starting point in the science classroom.

Decolonising the Chemistry curriculum helped teachers to work with ECMs to teach science, and also allows science teachers to engage in PLCs to inculcate IK in Chemistry teaching. Additionally, Mukwambo et al. (2014) called for the Africanisation of the school science curriculum.

2.8 Africanisation of the School Science Curriculum

Africanisation of science curriculum has become a common topic in African research to localise the science curriculum by integrating IK of indigenous people to make SK accessible and relevant to the learners (Gwekwerere, 2016; Mukwambo et al., 2014). In the context of my study, Africanisation refers to the use of IK from other African cultures to contextualise Chemistry teaching and learning. For example, using the making of *Oshikundu* to explain rate of reactions in different cultures where *Oshikundu* is not made. The science curriculum should be relevant to the learners' prior everyday knowledge. Gwekwerere (2016) illustrated that the relevance of the science curriculum should be based on the learners' life experiences and learning should start from what the learners know to the unknown in science classrooms. This means that the SK of learners has to develop from what is known from IK to WS. The science curriculum that allows teachers to build on learners' life experiences when teaching addresses relevant SK. Gwekwerere (2016) asserted that "to ensure the development of locally relevant SK, Chemistry subject taught in African schools must be relevant and applicable to the African context" (p. 33). The science curriculum should address the context in which the subject is to be taught.

In Namibia, for example, the curriculum allows the teachers to use relevant resources (MoE, 2018) from the environment to teach the concepts in Chemistry. This allows teachers to address the curriculum from the context to the content using easily available resources. By doing this, teachers are avoiding cognitive dissonance faced by learners in their science classrooms (Le Grange, 2007). Science teachers should be able to link western knowledge and IK by acting as the cultural knowledge brokers (Chang, 2020; Wyatt et al., 2017) by building a strong foundation from IK to explain scientific knowledge. In this research, however, the topic of the rate of reactions was taught using the making of *Oshikundu,* which was relevant to the context of the learners. Mukwambo et al. (2014) called for the Africanisation of the science curriculum in African schools, specifically in South Africa and Namibia. The context in which the science curriculum is taught should be made relevant to the learners. Furthermore, Gwekwerere (2016) indicated that "*learners' sociocultural worldviews affect the way they learn and African worldviews impact African learners' way of learning*" (p. 33). This is the reality in the African context where the curriculum taught addresses what is happening in other learners' cultures, which undermines IK, and that affects how they perceive science. The curriculum that ignores the context in which it is taught brings many challenges to African learners' worldviews and real-life experiences.

Tapping into the knowledge that belongs to African people, the Africanisation of science curriculum can bring back the lost knowledge that was neglected during colonial times and which is still neglected in school curriculum today. To this, Louw (2010) asserted that Africanisation involves understanding the common legacy, history, and postcolonial experience, through which we are connected within the broader African experience and can establish curricula that bind us together.

In the light of these foregoing arguments, in most cases, science teachers teach things that they have never come across in their real-life while there are similar local examples that could help learners understand the concepts better. For example, Mukwambo (2017) indicated that in teaching pressure using local examples that are common in the Zambezi region, he observed that local people when they cross the Zambezi River, go where the river is widest because the pressure at that point is lower compared to the area where the river is narrow, or it is curving. That is, the water in the narrow area is spinning and the canoe can capsize very easily. The pressure is extremely high where the river is narrow and that will cause the water to spin around and move with great force. Local people call the area where the water is spinning [12]"*Falibu*" and it is known to the local people that it is dangerous to cross the river where the water is spinning. Asking learners where they cross the river when the water is flowing would therefore help to connect what the learners know from home to science classrooms. Thus, the Africanisation of the science curriculum calls upon indigenous people to be the custodians of IK in science classrooms.

---

[12] *Falibu* is the narrow area in the river where flowing water is spinning at a high speed due to pressure.

It seems that we teach what belongs to different cultures (western culture) and as Africans, we tend to neglect our own culture. Westernised Science (WS) has dominated IK through the use of the English language as the language of learning and teaching (LoLT), and this needs to be reversed and a curriculum developer must start contextualising the curriculum that could be taught using local languages.

Le Grange (2007) warned science teachers to be aware of the interaction between their culture and westernised knowledge because it could complicate the learning process in science classrooms. According to Le Grange (2007), cognitive conflict exists in most African learners as long as they are taught science that is far from IK practices. As alluded to earlier, to avoid cognitive dissonance, learners need to be taken to out-of-school contexts to experience the real knowledge that is embedded in their cultures. Science teachers need to be aware of what IK conflicts with scientific knowledge and how that dissonance could be solved to make learners understand the concepts or facts from both worldviews. This calls for teachers, educators, and curriculum policymakers who embrace the western perspective of what constitutes valid knowledge are likely to discern indigenous values, knowledge, and methods of teaching or may embrace it superficially, enabling the dominance of western values to take precedence (Owuor, 2007).

Indigenous knowledge (IK) is rich in the conservation of resources, farming practices, sustainable development and exploitation of resources, and the use of medicinal plants that could be used to teach Chemistry. The ongoing global debate on the integration of IK in westernised classrooms has been received with mixed feelings.

Additionally, the ongoing global focus on knowledge commodification promotes competition, contradictions, and dilemmas for educators and teachers in the implementation of the integration of IK into the curriculum (Owuor, 2007). At the same time, the interface between the science curriculum and IK is rarely a focus for most educators and policymakers in Africa (Owuor, 2007). Unfortunately, the transfer of IK from everyday life to science classrooms is not always valued or recognised by science teachers and they regard it as unproven or old-time knowledge that does not exist (Angaama et al., 2016), and it is, therefore, necessary for teacher education programmes at African universities to rethink the ways of preparing student teachers for effective integration of multiple forms of knowledge when designing and implementing the teacher education curriculum (Owuor, 2007).

For Africa to reach its goal and Namibia in particular of decolonising the science curriculum, it needs to start teaching science using locally available resources in the community. African universities need to embark on Africanising their curricula before African schools adopt them into their classrooms. Chemistry teachers are professionally trained by institutions of higher learning that implement their curricula that do not speak to the learners who are taught them. The context in which universities train teachers does not help them to include IK of local communities in their science classrooms. Thus, Le Grange (2016) called for decolonising curricula that will integrate IK of local communities where the curricula are taught.

In Figure 2.2 below, an ECM demonstrates how a fire would be made before the arrival of Europeans. This knowledge cannot be argued against, and it has been proven that friction can produce fire. This is the authentic prior everyday knowledge that a teacher can use to contextualise teaching during the situated cognition approach in science (Mukwambo, 2017). Science teachers need to be taken on excursions for them to observe, see, and touch. This will allow them to become experts on IK around the community. In his PhD, Mukwambo (2017) advocated the integration of IK in the science curriculum for the teachers to be able to integrate it into their science classrooms. Taking teachers on excursions to learn from communities will help them to contextualise WS. It coheres with Figure 2.2 that learning can only take place through observation and engagement in practical activities that are done in the communities to explain science concepts.

Figure 2.2: The hand drill technique used for making fire with two adults demonstrating adopted from Mukwambo (2017, p. 128)

Figure 2.2 shows that IK can be passed on to the young ones through observation and practice when the elderly make fires using the drilling technique. This is referred to as experiential learning. In the other picture, an ECM is making fire using the drilling technique by demonstrating to the university lecturer how to contextualise the topic of friction. This allowed the lecturer to take the topic of friction from context to content and explain it using a practical demonstration based on the knowledge and skills acquired from the community member. Similar to Kakambi's (2020) study, a young one who was well vested with the needed skills helped a parent make baskets. This allowed knowledge and skills to be transmitted from the parents to their children through observation and practically engaging in the activities. That made them knowledgeable about IK when they grew up. IK can be passed from generation to generation orally, through observation, and by engaging in practical activities as observed in Kakambi's (2020) study.

African universities need to decolonise the existing dominant western epistemologies. This would make school science more relevant to the learners (Gwekwerere, 2016), particularly at the formative stage and also provide the much-required relationship with the children's culture and physical environment (Zengeya-Makuku et al., 2013). Tapping into IK in the science curriculum at the university level might enrich the school curriculum, as teachers will be able to integrate this IK into their science teaching. This would also allow science teachers to form PLCs to help each other inculcate IK in science lessons.

2.9 Hands-on Practical Activities and Visualisation in Chemistry

Chemistry is one of the subjects that allows learners to use their mind-on, hands-on, and words-on (to improve the science language) to improve their understanding of Chemistry (Asheela et al., 2021). Kidman (2011) believed that hands-on practical activities allow learners to exercise their minds by conducting simple experiments relating to areas of learners' interest. Learners learn best when they see, touch, and talk about what they are learning. Chemistry teachers might grasp this knowledge and transform it from indigenous SK to western SK in the classrooms.

Millar (2009) exhorted that practically encouraging learners to pursue their own enquiries taps into their natural curiosity. Abrahams and Millar (2008) stated that there is also evidence that learners find hands-on practical activities relatively useful and enjoyable when linked to their indigenous technologies compared with other science teaching and learning activities. Using the cultural heritage of community members in Chemistry teaching allows teachers to explore the scientific processes happening at home and in communities to engage learners in hands-on practical activities.

Moreover, science hands-on practical activities should encourage the development of analytical and critical skills and encourage interest in science (Ottander & Grelsson, 2006). However, teaching science without hands-on practical activities is like a body without a soul (Millar, 2009). Millar (2009) argued that because science education is about the physical world, it is natural that this will involve acts of showing as well as telling. In this research, the ECMs explained the indigenous scientific process of making *Oshikundu* to Chemistry teachers, who used the knowledge gained during a practical demonstration to enhance learners' understanding. Ignoring practical work or demonstrations in science and concentrating just on the theories, might destroy the cognitive thinking skills of learners. Hands-on practical activities can help science teachers to avoid cognitive dissonance (Le Grange, 2007) by allowing learners to observe the practices that are done at home to explain scientific facts. For example, the use of *Oshikundu* to explain the rate of reactions in Chemistry lessons might help learners to assimilate (Le Grange, 2007) and visualise (Arcavi, 2003) the science embedded in the making of *Oshikundu*.

According to Woodley (2009), most practitioners would agree that good quality practical work can engage learners, help them to develop important skills, understand the process of scientific investigation, and develop their understanding of concepts. This is, Hodson (1990) situated that practical activities allow learners' knowledge to development from concrete situations to abstract ideas and can be the vehicle for the arousal of curiosity and appreciation of aesthetic aspects of the subjects. Engaging community members in practical demonstrations might arouse the curiosity of learners, as community members are the custodians of IK. Woodley (2009) further indicated that effective practical activities enable learners to build a bridge between what they can see and handle (hands-on) and scientific ideas that account for observation (minds-on). Making these connections is challenging, so practical activities that make these links explicit are more likely to be successful. For us to move away from rote learning in the science classrooms, learners need to be encouraged to take learning as their own and this can only be achieved if Chemistry teachers move away from theories to practical science teaching.

Akbar (2012) echoed that the added value of practical work is that it enhances motivation and stimulates excitement by providing unusual objects and events, a contrast with the usual learning experience of sitting still and listening or doing exercises. Moreover, the laboratory is said to be a place where personal experience can be linked to a scientific way with the real world. Learners' personal experiences are either their direct observation of a phenomenon or through hands-on manipulation done by the teachers or their recollection of past experiences gained from home.

Learners learn best by doing, touching, and seeing what is happening in the classroom. Shinana et al. (2021) reiterated that science teachers should introduce predict-explain-explore-observe-explain (PEEOE) when teaching science. Science practical work is essential to creating a learning situation that encourages and challenges learners to develop inquiry-based skills. Learners who are exposed to science practical's might become critical thinkers and might develop science concepts with ease because their minds-on, hands-on, and words-on will be connected to the experiment.

Conversely, practical work has disadvantages. Teachers inevitably develop their perceptions and attitudes towards practical work; those perceptions, in turn, interact with curriculum demands. These attitudes may influence the activities they provide to learners, how they organise and manage their classrooms, what roles they adopt, the way they use equipment and materials, and the criteria they use in assessing the success of practical work (Abrahams & Saglam, 2010). Learners feel threatened when the data they have collected is not consistent with the intended conclusion (Millar, 2009) of what was expected from them. Teachers always direct the results of the practical demonstration to the required answer in the textbook, even though the results might be different from what is in the textbook. Learners are easily distracted by other things during practical work and may lose concentration. This suggests that visualisation is critical during Chemistry lessons.

Visualisation has been dominated by Mathematics researchers and very few have imagined it in science education. Visualisation is the study of "transformation from data to visual representations to facilitate the effective and efficient cognitive process in performing tasks involving data" (Chen et al., p. 6). Teaching Chemistry using visualisation helps learners to grasp more knowledge since most schools in Namibia have no laboratories and science equipment. Visualisation happens in the minds of the learners when teachers explain the process involved in fractional distillation, for example, by using indigenous artefacts. Teaching science using real objects helps learners and teachers visualise the processes involved. The study sought to mobilise community members' cultural heritage on the preservation of *Mahangu*, pounding *Mahangu* to make flour and making *Oshikundu* by visualising the Chemistry topic on the rate of reactions and other topics that could be taught using IK.

Unlike in Mathematics where visualisation is dominant. In science, when teaching the rate of reactions using cultural artefacts in science, for example, making *Oshikundu*, might allow learners to visualise how their parents used to make it and what used to happen when they needed the process to go faster. During this process, science teachers need to act as cultural knowledge brokers (Cooper et al., 1999; Wyatt et al., 2017) by taking the learners' minds from the western science classroom setup to the context they use when making *Oshikundu*. The symbolic representation might allow learners to have a better understanding of the topic. Drawing on the artefacts indigenous people use when making *Oshikundu* in science classrooms, might create learning opportunities for the learners. Arcavi (2003) postulated that people have been using images or symbols for recording information and communication since the cave-painting era. Furthermore, visualisation is a product and a process of creation, interpretation, and reflection using pictures and images to gain a better understanding of the concepts (Arcavi, 2003). Using the process of preserving *Mahangu*, pounding *Mahangu* to make flour, and making *Oshikundu* symbolises the rate of reactions used in factories might help teachers and learners to visualise the processes when visiting the production sites. Similarly, Siseho (2013) advocated for teachers to use visual objects to help them to enhance learners' and teachers' understanding of the concepts to be taught.

As I alluded to earlier, most schools in Namibia do not have science laboratories to help science teachers to teach science using practical examples. Therefore, they tend to do it theoretically and this reduces the visual aspect of science lessons. Visualisation is enacted in the process (such as that involved in rate or reactions) when teachers teach learners science concepts using diagrams and symbols. In this study, I was interested in how teachers might visualise the process of making *Oshikundu* when comparing it to the topic of the rate of reactions that takes place in factories. Moreover, visualisation could improve the participation of learners in science classrooms and the engagement between the teachers and learners might be improved.

Asheela et al. (2021) and Shinana et al. (2021) suggested that science could be taught using the PEEOE approach to enhance teaching and learning during the 'hands-on', 'minds-on' and 'words-on' practical activities. A study conducted by Kibirige et al. (2014) revealed that the Predict-Observe-Explain (POE) approach was able to enhance learners' performance in science subjects and thus, resulted in teachers' confidence. Using POE strategies, learners were able to overcome their initial misconceptions and visualise the process by looking at the diagrams and improving their understanding.

Vygotsky (1978) claimed that the secret of effective learning lies in the social interactions between two or more people with various levels of skills and knowledge (Christmas et al., 2013). This calls for CoPs, as community members are more knowledgeable about IK and indigenous practices that occur in their environment. This involved taking teachers on an excursion to the house of an ECM so that the ECMs could workshop the teachers on how they prepare *Oshikundu*. This made the workshop more interesting to both the researcher and the participants. Without the help of the more knowledgeable ECMs, teachers would not have been able to scaffold themselves to the highest level of knowledge acquisition. Scaffolding implies an expert active stance towards the continual revision of the scaffolding in response to the emerging capabilities of the learner, and the learner's errors or limited capabilities being a signal for the adult to upgrade the scaffolding needed (Christmas et al., 2013).

Seehawer (2018) postulated that through collaboration with science teachers, parents, communities, elders, traditional healers, teacher educators, local authorities, universities, and curriculum designers, integration strategies can be explored, and solutions could be found to integrate IK into science classrooms. We have to move our classrooms from the western setup that does not recognise the integration of IK to the IK setup that allows science teachers to interweave IK in science classrooms. Seehawer (2018) posited that the traditional classroom setup does not support the integration of IK, as most IK is practical, and learners need to be taken on excursions to observe cultural activities done in the communities. There are other scientific explanations linked to many activities happening in communities. Even though IK seems to be useful in Chemistry teaching, it is always criticised by those who oppose IK.

2.10 Criticism of Integration of IK in Science Teaching

The opposers of the integration of IK in science classrooms argue that IK and science knowledge cannot work together as they are both dominant in their domains (Cobern & Loving, 2001). They argue that IK and science knowledge are immiscible, that SK is universal, and IK is context dependent. Lack of documentation makes indigenous science inferior to western science. The domain of IK needs to be brought to the fore so that it can be documented like WS. Although teachers may acknowledge and respect their learners' IK, this does not mean that they should not expose factual errors. Teachers should always scrutinise the IK that learners might have and correct any mistakes (Kibirige & van Rooyen, 2006). Most local concepts are not yet developed in the language of learning and teaching (LoLT).

According to Mukwambo et al. (2014), illustrated that some of the science facts are not explicit in most African indigenous languages, but the Africanisation of the school science curriculum calls upon the teachers and learners to attach scientific explanations to IK. Moreover, Mukwambo et al. (2014) argued that even though are some concepts not readily available in the local language, they discovered that some concepts are more advanced in the local language but not yet readily found in science textbooks. These concepts might be related to science concepts, yet they do not mean the same. Science teachers need to have advanced knowledge about IK for them to be able to incorporate it into the syllabus. Science teachers are, however, heavily influenced by the science curriculum and often do not see the need for IK in school science.

Contextualising the science curriculum gives teachers the room to explore their indigenous language in the science classroom and how useful it could be. This is where the complexity of IK is highlighted, as indigenous terminologies are not found in English and this can create problems for WS textbooks when including IK, which makes it easier for them to avoid integration as it is not scientific. De Beer and Mothwa (2013) found that teachers integrate IK in Life Science superficially, fearing that learners have different IK and also fearing that it is against the religious beliefs of some learners. Adding to this, Horsthemke and Schafer (2007) indicated that one of the challenges associated with IK is epistemological and indigenous pedagogy that has not yet been established in the African context. The revitalisation of indigenous pedagogy has to start with documentation of IK that has scientific explanations. In the case of this study, the making of *Oshikundu* has many scientific explanations that are linked to western epistemology. Indigenous epistemology has to be used in the case where the topic could be explained using local examples that occur in the local community. Indigenous knowledge (IK) was and still is associated with so-called negative concepts like ‘African’, ‘irrelevant’, ‘exotic’, ‘backwards’, ‘culturally alienating’, and ‘old-fashioned knowledge’ (Horsthemke & Schafer, 2007) that does not embrace the current technology. These negative concepts have more toxic to how African teachers value their IK in Chemistry teaching.

The other challenge is Chemistry textbooks that are a hindrance to the successful integration of IK into science lessons because they document only scientific knowledge. Teachers rely on science textbooks and accept it as factual knowledge (Shizha, 2007). This is the problem in Namibia; since IK is not documented it is difficult for teachers to incorporate it into their science lessons because they are not that knowledgeable about it. There is a lack of continuous professional development that helps teachers to integrate IK. Within South Africa, this has been further exacerbated by the lack of attention given by the national schooling curriculum to IK. The Curriculum 2005 (C2005), launched by the African National Congress, is primarily focused on Western-based SK and gives very little acknowledgement to the fact that this knowledge is given in a cultural framework that is primarily based on indigenous epistemology (Cocks et al., 2012). Cronje et al. (2015, p. 320) illustrated the following challenges to the inclusion of IK in science lessons:

- “Science teachers struggle to integrate IK into their science lessons because the curriculum is not explicit on how to integrate it.
- Teachers were not exposed to training on how to integrate IK since they were trained in so-called ‘western science’, thus universities need to start decolonising the curriculum to value IK.
- IK has a lack of instructional methods and PCK.
- Science teachers fear that they will be teaching pseudoscience when integrating IK into WS.
- Some of the IK has not been scientifically proven and is not based on scientific methods.
- Lack of literature or textbooks that include IK that should be used in all schools in the country”.

These might be some of the challenges that teachers have when about to integrate IK into science lessons. Physical Science teachers might be concerned that IK will not be examined during the examinations, therefore it might be a waste of time to include it in science lessons. This resonates with Nyika (2017), where teachers indicated that they teach what is examinable, and IK is rarely examined in the external final examinations. This challenge designates why teachers are not infusing IK into science teaching and learning.

The integration of IK could affect the learners since it is not documented in their textbooks and learners who are not from the environment could be affected as they would not be able to connect the IK to western science. This suggests that IK is culturally embedded and environmentally oriented. Dziva et al. (2011) explained that IK does not make any distinction between science facts on mind and matter. According to Cronje et al. (2015), the challenge of integrating IK is a lack of epistemology and PCK. That is, teachers have not been exposed to IK epistemology, since were trained in western science and hence, they struggle to integrate IK into science classrooms. This research thus, calls for professional development for Chemistry teachers on the integration of IK practice in science lessons. This research might alleviate some of the cons associated with IK in the science classroom. Although IK might have some challenges in the science classroom, it can bring about the active engagement of learners when integrated into the science classroom.

There are counterarguments against the integration of IK in science lessons. For instance, Cobern and Loving (2001), Hodson (2009), and Horsthemke and Schafer (2007) critiqued the integration of IK and WS arguing that they are two worldviews from different domains and therefore they cannot intertwine. Both worldviews are strong in their domain, and it is difficult for them to work together (Cobern & Loving, 2001). In contrast to Horsthemke and Schafer (2007), however, Cobern and Loving (2001), as well as Hodson (2009), are for the plurality of knowledges. The plurality of knowledges involves different knowledge systems that could be used in science classrooms.

Similarly, some proponents of the integration of IK in science lessons such as Afonso-Nhelevilo (2013), Keane et al. (2016), Mhakure and Otulaja (2017), and Ogunniyi (2007a) cautioned against the romanticising of IK. These scholars proposed that any misconceptions embedded in indigenous practices need to be corrected. Roschelle (1995) called for IK to go through three steps before being introduced in the science classroom, to clear the misconceptions that are attached to it. The topics need to be re-contextualised-re-prioritised-refined (C-P-R) before the concepts are integrated into science (Roschelle, 1995). This might add value to IK and more indigenous concepts could emerge through this process.

2.11 Cross-fertilisation of Ideas in Science Classrooms

Learning can be the result of the interweaving of IK, prior everyday knowledge, and subject matter knowledge in the science lesson. The knowledge from home (IK) and western science content cross-fertilises each other and where they agree, the learner masters the subject content and where they disagree, the content is examined and re-learnt. Comparatively, Dziva et al. (2011) posited that the differences between scientific and IK continue to create barriers to meaningful teaching and collaboration between scientific knowledge and indigenous knowledge. Learners always face the challenges of cross-fertilising their IK with scientific or western science. Le Grange (2007) illustrated that there is a risk of destroying learners' cognitive development, if their indigenous worldviews are not interpreted correctly in science teaching and learning.

Moreover, science teachers need to work with both worldviews as they complement each other and are both superior in their domains. Comparing the IK worldview and the westernised knowledge worldview might expand the gap between them, and learners will not be able to connect the two forms of knowledge. Comparing the two worldviews will result in what Le Grange (2007) called cognitive dissonance/conflict. The diagram below attempts to show what happens during the lessons when prior everyday knowledge, IK, and WS are integrated into one science lesson. The section where the three are interwoven is called indigenous western prior everyday knowledge where the knowledge has cross-fertilised each other and the result would be that learners understand the concepts. For the learners to master the content, teachers need to build on what the learners already know and make the connection between WS, prior everyday knowledge, and IK.

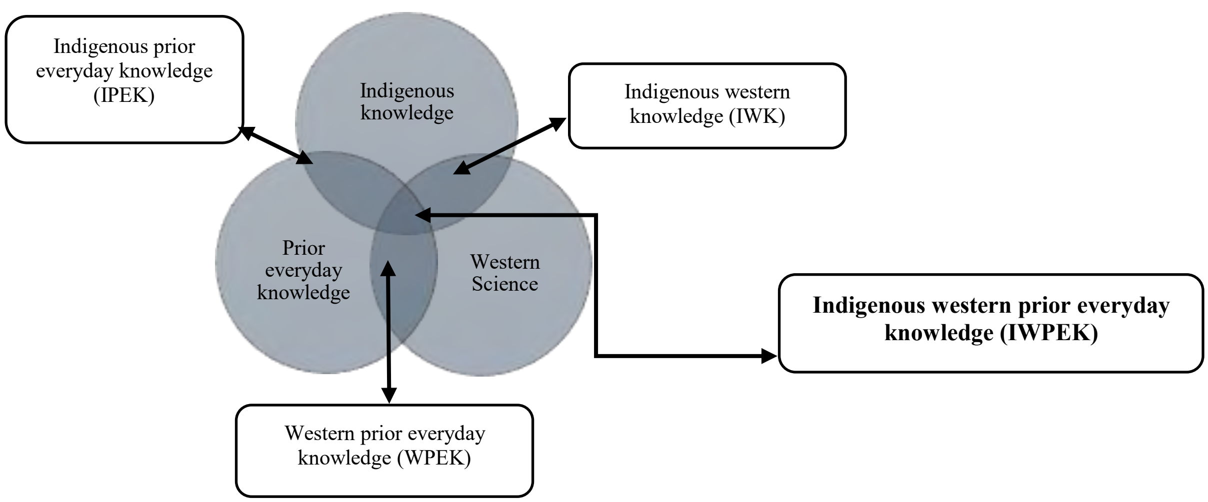


Figure 2.3: Cross-fertilisation framework and its knowledge zones (adapted from Mukwambo et al., 2014, p. 3)

The cross-fertilisation framework and its knowledge zones were adapted from Mukwambo et al. (2014) and modified to name the knowledge zones. The intersections between knowledge zones were not mentioned and so this took the framework a step further by naming the knowledge zones between IK, WS and PEK. The central focus is the knowledge zone where all three circles intersect, and it is known as indigenous western prior everyday knowledge. Mastering the content requires Chemistry teachers to use the three circles to represent the different knowledge zones that learners have in their minds or different knowledge zones in the mind of the learners. The three knowledge zones in the minds of learners during science lessons are western science (engraved in textbooks), prior everyday knowledge (assimilated from home), and IK (learnt from the communities). The sections where the circles intersect represent the knowledge zones that match and cross-fertilise each other, while the knowledge zone outside represents the knowledge that does not have a link to either one of the two. The fourth knowledge zone where all three circles intersect represents the indigenous western prior everyday knowledge during the lessons and this is called cross-fertilisation of ideas. Cross-fertilisation of ideas is when the knowledge worldviews are intertwined and cannot be separated. Briefly, the traditional process of making *Oshikundu* and the process of making whisky in factories might use the same process. These two different knowledge zones are intertwined and any of the examples can be used to explain the other processes depending on the environment.

Mukwambo (2017) indicated that although prior everyday knowledge and life experiences of learners have been found to be more useful in science classrooms, little has been done to integrate them into the actual teaching and learning of science. Furthermore, for learning to take place, learners need to use their life experiences and connect the knowledge learnt to their IK and prior everyday knowledge. Indigenous knowledge, prior everyday knowledge and scientific knowledge are interwoven and cannot be separated; therefore, the teacher needs only to reconnect the science content to the IK of the learners in science teaching. Mukwambo et al. (2014) argued that learning becomes effective when teachers' and learners' IK and cultural resources are connected in the teaching and learning of the science topic of rate of reactions.

Moreover, when science teachers come into contact with scientific facts, it might trigger their experiences and link them to their existing knowledge (IK), and they can make meaning from the concepts in the local language before being translated back into the LoLT. This calls for cross-fertilisation of ideas to be brought in to help the learners to understand the concepts in their local language and fertilise them, before translating them into the science language and making meaning for understanding. For non-western learners, the interaction between the two worldviews (IK and WS) characterises much of their school experiences, complicating the learning process and potentially resulting in a cognitive conflict called cognitive dissonance/perturbation (Le Grange, 2007). Cognitive dissonance is when a learner has two versions of the truth about something, and this makes it difficult for the learners to leave their beliefs and concentrate on the science being taught. The figure above illustrates when the two worldviews overlap in the mind of non-western learners, and this results in indigenous western prior everyday knowledge. It is crucial for science teachers working in any context to be familiar with indigenous technologies used in that community, as IK is context dependent. Effective teaching might depend on the understanding of IK and teachers' ability to manage classroom discourses related to this matter to reduce the conflicts (Le Grange, 2007). Every unfamiliar word introduced to the learners could bring about conflict. The solution to this conflict could be resolved by introducing Jegede's (1995) theory of collateral learning. To solve these problems, learners and teachers in a science classroom need to work toward cross-fertilising the ideas from both worldviews.

Jegede's (1995) theory of collateral learning identifies four types of collateral learning that help learners and science teachers in science classrooms. They are parallel, simultaneous, dependent, and secured collateral learning. For the learners not to experience dissonance/perturbation in Chemistry lessons, when teaching the topic of the rate of reactions, Chemistry teachers need to integrate all four collateral learning types in their teaching and understand exactly what is happening to the learners.

Building from Jegede (1995), parallel collateral learning is when learners acquire and maintain opposing schemata about science concepts and ideas in their long-term memory when learning new science facts. The facts can be easily linked to IK that the learners know from home. Simultaneous collateral learning is when the science facts or knowledge to be embedded in the long-term memory of the learners need to be processed over an extended period. This means that the teachers have to explain the facts repeatedly for the learners to be able to understand them and keep them in their long-term memory. Dependent collateral learning is when schemata from one worldview presented challenge those of other worldviews enabling the learner to modify existing schemata. During this process, learners get trapped and confused as to which knowledge to believe and perceive as facts. Secured collateral learning is when learners acquire knowledge or an intellectual skill through a gradual and incremental process rather than a single event. Learners have to resolve what they might experience as cognitive conflict or mental dissonance in their knowledge that are embedded in their long-term memory (Le Grange, 2007).

This collateral learning (Ogunniyi, 2007a) helps the Chemistry teacher to integrate IK into science lessons. To this point, the use of learners' indigenous knowledge as underpinned by the SCT is not visible in most science classrooms and teachers need to undergo PLCs for them to be able to integrate IK. Even though research has been done on teaching Chemistry with IK, it still poses some challenges to both learners and teachers. Science needs to be taught using available resources in the community. Additionally, to avoid conflict in the minds of the learners, science needs to be accessible to them in and outside science classrooms.

Instead of teaching abstract content to the learners, Chemistry teachers have to build from what the learners know from home as their prior everyday knowledge. For instance, IK could be used to make learners contextualise Chemistry by bringing forth the knowledge they use to engage at home. For example (Kakambi, 2020; Kudumo, 2020; Liveve, 2022; Nikodemus, 2017) all embarked on different research that change the conceptions and depositions of science teachers toward the integration of IK.

Without quality professional learning communities, teachers will continue to struggle to interpret the curriculum when integrating the IK that they gained from the local community. There will always be a gap between what the learners are taught at school and what is happening in the community. This research intended to close the gap by training Chemistry teachers to be able to locate IK in their science lessons. Peer-learning communities helped science teachers to learn from each and the ECMs. I now discuss professional learning communities.

2.12 Chemistry Teachers' Professional Learning Communities

Hord (1997) defined a professional learning community (PLC) as extending classroom practice into the community, bringing community personnel into the classroom to enhance the curriculum, and learning tasks for learners or engaging learners, teachers, and community members simultaneously in learning. This calls for PLCs to incorporate terms such as learning, development, socialisation, growth, improvement, implementation of something new or different, cognitive and effective change, and self-study (Tam, 2015). It was hoped in this study that the Chemistry teachers' cognition and cultural knowledge brokerage might improve after the workshops run by the ECMs on the preservation of *Mahangu*, pounding of *Mahangu* to make flour, and the making of *Oshikundu*. The knowledge of teachers is about teaching, learning, subject matter, curricula, materials, instructional activities, culture and beliefs (Tam, 2015).

The term PLC refers to teachers critically interrogating their practices in ongoing, reflecting, and collaborative ways to promote and enhance learner learning (Brodie, 2013). It is difficult for teachers to change their practices and beliefs and PLCs with other teachers and communities can transform their beliefs and practices into positive useful resources. A PLC allows teachers to work together in groups and engage in collective professional learning (Chauraya & Brodie, 2018). Similar to Ngcoza's (2007) research conducted in South Africa, in this study two Chemistry teachers from each school were involved in this research and this might allow them to continue with PLCs at the school level after the workshops with ECMs and other researchers. During the workshops, science teachers had an opportunity to deepen their understanding of the integration of IK into Chemistry classrooms using the knowledge acquired from the practical demonstrations on preserving *Mahangu*, pounding *Mahangu* to make flour, and making *Oshikundu*.

Essentially, the practical demonstrations afforded the Chemistry teachers and ECMs an opportunity to engage in learning in an out-of-school context (Braund & Reiss, 2006; Mayoh & Knutton, 1997). It was found that the out-of-school context allowed progressive leaning to take place because the teachers engaged in discussions in a non-threatening space (Mayoh & Knutton, 1997). Out-of-school programmes have the potential to broaden the understanding of both teachers and learners (Luehmann, 2009). Similar to Luehmann (2009), this study was aimed at broadening the Chemistry teachers' knowledge of integrating IK into science lessons through a peer-learning community and in an out-of-school learning context with the ECMs. That was in contrast to traditional learning which is mostly associated with textbooks, syllabus and lesson plans. What was unique was learning about cultural heritage from the ECMs who were regarded in this study as the MKOs as espoused by Vygotsky (1978).

Throughout my experiences and observation, in Namibia, workshops for teachers are mostly focused on the transformation of the new curriculum to equip them with subject matter knowledge, a new standard, and the latest innovations (scientific inquiry or new textbooks). However, there seem to be no workshops for science teachers on how they should mobilise learners' life experiences where IK is embedded. For instance, most workshops that I attended in my teaching career were on how to interpret the new curriculum or refresher workshops to improve the results. During such workshops, teachers were regarded as newcomers or less knowledgeable and advisory teachers as MKOs. To date, the focus has been on how to teach the content as it is in the syllabus using westernised textbooks, without integrating IK. Resultantly, most Chemistry teachers seem to regard IK as knowledge that is not useful because they have not been exposed to how to contextualise Chemistry.

Consequently, teachers seem struggle to integrate the IK of learners in science lessons or they ignore it. There is a need for PLCs that look beyond the scope of the curriculum and focus on how to integrate IK into science teaching. In this study, for instance, ECMs were the custodians of the cultural heritage and IK and could work with Chemistry teachers on the scientific concepts that are related to making *Oshikundu*. In this study, Chemistry teachers joined the PLC to share their experiences, knowledge and learn from each other. That is, the peer-learning community allowed us to build trust, love and care for each other which is associated with Ubuntu. Participants valued each other during the research process, which allowed them to share and learn from each other. Literally, the Ubuntu perspective means 'I am a person through other people and that we are interconnected' (Keane et al., 2016; Khupe, 2014; Ogunniyi, 2007a) and was displayed throughout the research process, through respect for each other, care for each other and the mutual trust between us. The trust developed helped the Chemistry teachers to start sharing resources, and subsequently develop common epistemologies on different topics.

The PLCs do not focus only on an individual teacher's learning but on collective professional learning within the context of a cohesive group that works with an ethic of interpersonal care (Brodie, 2013). In this regard, PLCs have four key successful characteristics: It has a challenging focus; it creates a productive relationship through trust; it collaborates for joint benefits which require moderate professional conflict although not personal conflict; and it engages in rigorous enquiry (Brodie, 2013). Drawing from the four characteristics of PLCs proposed by Kruse et al. (1995), Tam (2015) further explains them as five characteristics:

- Reflective dialogue refers to the extent to which teachers engage in professional dialogue about specific educational issues.

- Deprivatization of the practice of feedback of instruction means that teachers observe one another's classes to give and receive feedback.
- A collaborative activity represents a temporal measure of the extent to which teachers engage in cooperative practices.
- Shared sense of purpose refers to the degree to which the teachers agree with the school's mission and its operational principles.
- A collective focus on learners' learning indicates the mutual commitment of teachers to learners' success (p. 24).

These characteristics were used in this study to enhance the Chemistry teachers' understanding the importance of working together and with the ECMs. I thus refer to our PLC as a peer-learning community to highlight co-learning amongst ourselves. We also involved a critical friend who was responsible for probing for justification, challenging assumptions, and pushing for deeper thinking and interpretations (Tam, 2015). During the peer-learning community, three groups were involved, the researcher, five Chemistry teachers, and two ECMs. Expert community members (ECMs) facilitated how [13]*Mahangu* is preserved, pounded *Mahangu* to make flour using a mortar and pestle, and made [14]*Oshikundu*; they helped the teachers learn the scientific concepts that could be useful in Chemistry when learning about the rate of reactions. This triggered the content knowledge and PCK of teachers and the PLC allowed teachers to learn from each other by observing other lessons.

Research has shown that PLCs help teachers to improve their instructional clarity, the quality of their discourse, and their interactions with learners (Chauraya & Brodie, 2017; 2018; Tam, 2015). Tam (2015) affirmed that PLCs help teachers to overcome initial constraints and facilitate teachers' changes in knowledge creation, allowing them to acquire new knowledge. Ngcoza and Southwood (2019) found that there are different threads attached to PLCs for teachers to be able to engage in professional learning. These threads according to these scholars are *connectivity*,

---

[13] *Mahangu* is the local name for millets in *Ovamboland.*

[14] *Oshikundu* is a non-alcoholic traditional beverage which is made from fermenting three flours, namely, *Ongudo*, *Uushutu,* and *Mahangu*. It is a staple drink for many *Oshiwambo* speakers in Namibia and it is a rich source of carbohydrates, proteins, vitamins, as well as minerals. It also provides the body with water essential to preventing dehydration (Shinana, 2019).

collaboration, *dialogue*, *negotiation*, and *appreciation* and these helped teachers to engage in a transformation network with knowledgeable community members during the workshops.

The making of *Oshikundu* helped teachers and ECMs to share interests and concerns that motivated the coming together and engaging in a PLC with the view of learning (Ngcoza & Southwood, 2019). Through a PLC, teachers' collaborated on the topic they wanted to teach and on how the topic could be taught. Research has shown that PLCs allow teachers to learn from each other. This study, however, used ECMs who worked with Chemistry teachers on the rate of reactions by using indigenous technologies to enhance teachers' understanding of the topic and to allow them to integrate IK when teaching the rate of reactions. The PLC in the context of the study was based on the Chemistry teachers learning from the ECMs and collaborating on the new knowledge that emerged during the research. It involved teachers-teachers collaboration and teachers-ECM or ECMs-teachers collaboration to enhance their understanding.

This collaboration made this study unique from Ngcoza and Southwood (2019) because it allowed the Chemistry teachers to collaborate amongst themselves and also for the ECMs to become part of the collaboration when we visited their homes. Working with ECMs during the research process helped the Chemistry teachers to become cultural knowledge brokers. This allowed the teachers to start seeing IK as an integral part of Chemistry lessons. Similarly, the use of the indigenous research paradigm helped us to work together and value the contributions made by the ECMs during the research process. Working with ECMs allowed the Chemistry teachers to work within the two knowledge boundaries (IK and WS) to help learners understand the concepts from both knowledge systems.

In this research, I used what Hatcher et al. (2009) call 'two-eyed seeing' approaches. I used indigenous ways of knowing to understand westernised science when teaching the topic of the rate of reactions. The ECMs helped the Chemistry teachers in understanding the knowledge levels from IK ways of knowing to westernised science that teachers were knowledgeable in. Literally, Hatcher et al. (2009) illustrate that that 'two-eyed seeing' is about "learning to see from one eye with the strengths of indigenous way of knowing and from the other eye with the strengths of western way of knowing and learning to use both of these eyes together for the benefit of the learners in science classroom" (p. 146). In this regard, Seehawer and Breidlid (2021) emphasise that there should be dialogue between these knowledges (IK and WS). Involving indigenous elders in this research allowed the research to work within the indigenous research and transformative research paradigms. Co-learning and mutual benefits helped the Chemistry teachers and ECMs to work together (Hatcher et al., 2009; Onwu & Mufundirwa, 2020).

Drawing from Korthagen's (2017) seminal work, it is acknowledged that teachers learn at different levels that involve cognition, emotional and motivational dimensions (Korthagen, 2017). For instance, during the practical demonstrations by the ECMs on making *Oshikundu*, the Chemistry teachers went through different learning experiences, and they could contextualise scientific knowledge using concepts from the making of *Oshikundu* to teach the rate of reactions, which resulted in their knowledge improving. The shifts in the Chemistry teachers' knowledge from doing things that they could not do without the help of the ECMs revealed that Vygotsky's ZPD took place.

Moreover, during co-analysing the curriculum documents, teachers were accorded opportunities for them to develop and explain concepts in their local language (*Oshikwanyama*) and this was processed in the lessons when learners were encouraged to use the local language. The practical demonstrations and participatory observation promoted the use of local language and promoted conceptual development (Eun, 2021). The Chemistry teachers demonstrated their understanding in the local language which was later translated into the LoLT.

2.13 Chapter Summary

In this chapter, I presented the literature relevant to the study that supported the integration of IK in science/Chemistry classrooms. I focused on the NOS and the understanding of IK and the indigenous elders as the custodian of IK. In this study, indigenous elders are called ECMs. This chapter also focused on the professional learning community of teachers and the role of IK in the science classroom. This chapter outlined the studies that have been done that support the integration of IK by contextualising WS/scientific knowledge and concluded with a discussion on the cross-fertilisation of ideas. I concluded the chapter with the peer-learning communities of Chemistry teachers. Chapter three focuses on the theoretical frameworks that were used to analyse the data generated using the instruments framed in Chapter Four.

CHAPTER THREE: THEORETICAL AND ANALYTICAL FRAMEWORKS

> Indigenous communities and researchers have come to realize the limitations of non-indigenous paradigms in accomplishing the goals they have set to articulate and implement research within their own indigenous frameworks. For example, research within indigenous research paradigm emerges from the relationship of an indigenous researcher with the indigenous community. The relationship is complex as nationhood, culture, and protocol of each in this relationship becomes central to informing how the research process is undertaken. (Pidgeon, 2019, p. 419)

3.1 Introduction

In this chapter, I discuss the theories used to analyse the data that were generated throughout the research process. Vygotsky's (1978) sociocultural theory (SCT) was used to analyse the data generated from a social setting when expert community members (ECMs) and Chemistry teachers were interacting during practical demonstrations. Additionally, Shulman's (1986) pedagogical content knowledge (PCK) was used to analyse the data that were generated from classroom observations.

In this chapter, I discuss the theoretical and analytical frameworks informing this study. Firstly, I discuss SCT (Vygotsky, 1978) and PCK (Shulman, 1986) as theoretical frameworks. The tenets of SCT were used as an analytical framework to analyse the data from the practical demonstrations with ECMs. Mediation of learning was used to analyse the data on how Chemistry teachers were involved with the ECMs during the practical demonstrations. Language and culture were used to analyse how they helped the Chemistry teachers learn from the ECMs. Social interaction was used to study the interactions between the Chemistry teachers and ECMs that helped them learn from each other in the PLC. Lastly, the ZPD was used to analyse the lessons taught by the teachers on how they explained using IK with scientific knowledge in the absence of the ECMs to address cognitive dissonance (Le Grange, 2007). The TSPCK was used to analyse the data that emerged from co-analysing curriculum documents, practical demonstrations, co-exemplar lessons and lesson observations with the focus on the rate of reactions. Extending on TSPCK, I also used the refined consensus model (RCM) (Carlson & Daehler, 2019) of PCK to unpack the understanding of teachers' knowledge in Chemistry teaching.

3.2 Theoretical Frameworks

The theoretical frameworks for this research were the SCT and PCK. The SCT encompasses culture and beliefs in learning. Culture and beliefs influence the way learners learn as illustrated by Vygotsky (1978). The SCT was used as a lens to look into the data generated using culture and learning, social interactions, mediation of learning and ZPD, which are tenets within the SCT. Within PCK (Shulman, 1986), Mavhunga and Rollnick's (2013) topic-specific PCK (TSPCK) components were used to analyse data generated from co-analysing national documents and lesson observations. Extending from TSPCK (Mavhunga & Rollnick, 2013), I also focused on the realms of PCK, viz. collective PCK (cPCK), personal PCK (pPCK) and enacted PCK (ePCK) (Carlson & Daehler, 2019) which were used in this research to analyse data from co-analysing curriculum documents, practical demonstrations, participatory observation, lesson observation and SRIs.

The two theories complement each other since SCT is a learning theory and PCK is a teaching theory. The SCT and PCK were used in this study to create new knowledge (see Figure 3.1 below) bearing in mind that if IK is consciously brought to the science classroom, it has the potential to enable meaningful learning of western concepts. The research, therefore, used two theories that could elicit/bring out/take note of what constitutes IK/skills/ experience that constitute IK in a science classroom.

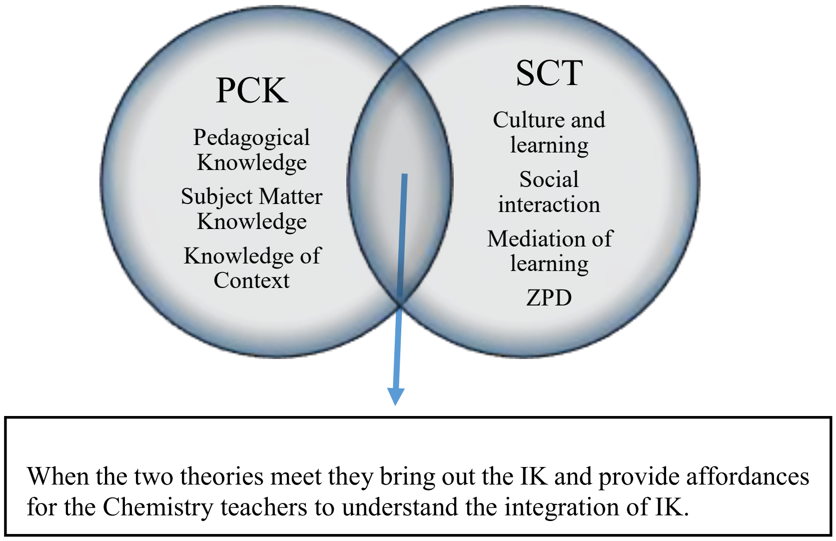


Figure 3.1: The theoretical frameworks

Figure 3.1 above allowed me to understand the two theories used in this research, that is, how they complemented each other. Pedagogical Content Knowledge (PCK) as a teaching theory looked at the knowledge Chemistry teachers have, which helped me to understand how ECMs and Chemistry teachers interacted during practical demonstrations and during lesson observations. On the other hand, SCT is a learning theory. It helped me to be able to understand how the Chemistry teachers were assimilating the knowledge from the ECMs during the practical demonstrations and participatory observations to become cultural knowledge brokers (Aikenhead & Jegede, 1999; Wyatt et al., 2017). Now I look at each theory separately and its tenets.

3.2.1 Sociocultural theory

Sociocultural theory's (SCT) submission to learning and development was first introduced and applied by Vygotsky and his collaborators in Russia in the 1920s and 1930s (Vygotsky, 1987, 1997a, 1997c, 1998, 1999) in (Vadeboncoeur & Collie, 2013). Extending from Vygotsky's (1978) seminal work, John-Steiner and Mahn (1996) indicated that SCT is based on the assumption that human activities take place in cultural contexts, and are mediated by language and other symbol systems. Furthermore, mediation is important in understanding how human mental functioning works and how it is dependent on cultural contexts, institutional backgrounds and historical settings since these settings shape and prove the cultural tools that are mastered by the individual to form this functioning (John-Steiner & Mahn, 1996).

Language plays a pivotal role in knowledge construction in SCT. This was observed during the practical demonstrations by the ECMs. Learners (teachers in the context of this study) construct knowledge in the language that is known to them and this language is embedded in the society where the learner comes from. Hence, teachers need to scaffold learners so that learners can make sense of scientific concepts. That is, teachers use language as a cultural tool to connect the IK of learners and WS. However, not all WS can be explained using indigenous language. Therefore, science teachers have to find a way to scaffold learners using language to meet the western language in science classrooms in order to close the gap between IK and WS.

Given the above, language is an essential cultural tool when science teachers scaffold learners in classrooms using LCE. Practical demonstrations were used as the agent to demonstrate scientific knowledge using indigenous technologies. This might assist learners to be able to do the tasks successfully without any delay. In this study, for instance, the ECMs used local language during their practical demonstrations. The language used helped the Chemistry teachers and ECMs to communicate during practical demonstrations and learn from each other.

Indigenous knowledge (IK) is associated with the environment in which people live. This implies that knowing our environment does not require someone to have WS or knowledge to be able to know about rain, weather and floods. This knowledge is already embedded in the people's culture and is known by the learners and only needs to be linked to WS. Moreover, culture plays a vital role in how we acquire knowledge and influences the way we acquire knowledge. Language, as embedded in culture, is a cultural tool used to acquire knowledge.

The IK of learners would be more useful when their culture, where IK is embedded, is involved in classroom teaching. In his research conducted in the Zambezi region, Mukwambo (2012) found that contextualising entails the bringing in of culturally constituted conceptual theoretical teaching and learning frameworks. Such a theoretical framework is the SCT of learning science where teachers use culturally related experiential knowledge in teaching science.

The SCT has been criticised as it focuses more on learning theory than teaching theory. To counteract the criticisms by Ameri (2020), in this study I used Vygotsky's SCT as the learning theory and mental development through the potential interactions between individuals and the surrounding environment. The SCT does not only show how adults and peers influence individual learning but also how cultural beliefs and attitudes affect how learning takes place (Ameri, 2020). I used SCT to analyse the data generated in this research.

The constructs underlying Vygotsky's SCT used to analyse the data were culture and learning that precede development; mediation of learning that is central to learning; language that is the main vehicle (cultural tool) of thought; and social interaction which is the basis of learning and development. Learning is a process of apprenticeship and internalisation in which skills and knowledge are transformed from the social into the cognitive plane and the ZPD is the primary activity space in which learning occurs (Shabani, 2016).

The SCT was used in my study as a learning theory to bring out the essence of the ECMs' knowledge during the practical demonstration on making *Oshikundu* to contextualise the rate of reactions. It also helped me to analyse how the Chemistry teachers learnt from the ECMs during the practical demonstrations on preservation of *Mahangu*, pounding of Mahangu and making *Oshikundu*. The constructs of SCT such as mediation of learning, culture and language, social interaction and ZPD were used to analyse the data from the practical demonstrations and lesson observation. The research was grounded in this theory as the Chemistry teachers were able to learn from each other and also learn from the ECMs. The mutual benefit, however, was that the ECMs learnt from the teachers during the practical demonstrations as they explained the scientific concepts embedded in the indigenous technologies or practices of preserving and pounding *Mahangu* as well as the making of *Oshikundu*.

Culture and language were the foundations of the knowledge that emerged during the practical demonstrations, and the ECMs used the local language (*Oshikwanyama*) and did the practical demonstrations dressed in their traditional attire (without being asked to do so). This illustrates that culture and language cannot be separated. Social interaction was one of the constructs that afforded the Chemistry teachers and ECMs an opportunity to interact using the *Oshikwanyama* language as a cultural tool to communicate. For instance, the Chemistry teachers were free to ask and engage with the practical demonstrations with the ECMs. During the practical demonstrations, the Chemistry teachers' knowledge shifted and they could explain facts/concepts that they were not aware of before they were engaged in this study. That is, the ECMs helped the Chemistry teachers understand and explain facts from an indigenous point of view. To help the Chemistry teachers and ECMs work together, I used two research approaches. I used the CoP and PAR. The two research approaches helped me to understand how SCT constructs were useful during the practical demonstrations. The CoP helped me understand how the constructs of SCT were more useful in my study and PAR helped me to understand the practical demonstrations that took place at Mee Mukwaluvala's home on the preservation of *Mahangu*, pounding of *Mahangu* and making of *Oshikundu*. The core constructs of SCT were used as an analytical framework in this study.

3.2.1.1 Mediation of learning

Mediation according to Vygotsky (1978) refers to "the part played by other significant people in the learners' lives, people who enhance their learning by selecting and shaping the learning experience presented to them" (Turuk, 2008, p. 250). Furthermore, Vygotsky stressed that effective learning is nurtured by social interactions between people with various levels of skills and knowledge (Vygotsky, 1978). Adding to this, "mediation is the process whereby an individual connects to and learns from the surrounding social and cultural environment" (Boblett, 2012, p. 4).

Furthermore, mediation forms the basis of how the community manages to communicate and how the members of the community come to understand the meaning and values of experiences (IK) (Boblett, 2012). In this research, however, mediation happened in two phases; the first mediation phase took place between the ECMs on the topic used as an exemplar (rate of reactions) with Grade 10 Chemistry teachers. The second mediation phase took place in the classroom setting where the Chemistry teachers presented the co-developed exemplar lessons on topics that integrated IK. The engagement in which learners collaborated during mediation reflected that mediation is an interactive, collaborative social practice in which problem-solving is accomplished, remarkably similar to the collaborative interaction described in scaffolding (Boblett, 2012).

Language plays a particularly important role in Vygotsky's (1978) mediation of learning. This allowed the ECMs to use the *Oshikwanyama* language as the symbol that enabled Chemistry teachers to understand and interact with each other during the practical demonstrations and science lessons with learners. During practical demonstrations and participatory observation, the ECMs used the local language (*Oshikwanyama*) that they were fluent in and that helped them to communicate and impart the knowledge they acquired from their forefathers to the Chemistry teachers. Using the local language and the IK that is applied in Chemistry to the topic of rate of reactions, allowed teachers to mediate teaching using the knowledge acquired from the home and community and integrate it into scientific concepts. There was a chain of thought linking IK to scientific knowledge and it required science teachers to use the local language in science classroom (Probyn, 2009). Probyn (2009) indicated that during mediation of learning, science teachers could code-switch from scientific language to the local language to allow learners to have a better understanding of scientific concepts. It is believed that learners think in their vernacular language first before translating the concepts into the LoLT and responding to the questions. This process accommodates teachers in the use of local languages in science lessons to make the thinking and translating quicker. If teachers ignore the local languages then barriers are created and learners will struggle to close the gaps on their own.

Bruner (1978) describes scaffolding as a cognitive support given by the teachers to learners to help them solve tasks that they would not able to solve working on their own (Fernandez et al., 2001). Scaffolding has its origin in the analysis of adult and child interactions as introduced by Wood et al. (1976). Teachers scaffold learners during mediation of learning and this allows the cross-fertilisation of ideas between IK and WS during practical demonstrations, workshops and science lessons. Turuk (2008) accentuated that "Vygotsky encourages teachers not to concentrate too much on teaching concrete facts but to also push their learners into an abstract world as a means to assist them to develop multiple skills that will enable them to deal with complex learning tasks" (p. 256). That is, during the science lessons learners should be moved from textbook concrete knowledge into the worldview of IK. The use of IK-based encounters allows teachers to have indigenous pedagogical content knowledge (Mukwambo, 2017) with it roots embedded in PCK.

Mukwambo et al. (2014) argued that learners are loaded with scientific concepts from their home backgrounds that should be taken advantage of. In this way, IK can serve as prior knowledge (Roschelle, 1995; Williams & Lombrozo, 2010) for the learners and the teachers need to build on the foundation that is already there. Even before studying scientific knowledge, and most African learners have accumulated IK about their environment (classification of plants and animals, weather conditions, soil types, seasonal changes, tracking games, various methods of conservation, finding water sources, cure of many diseases) that school science, with its compartmentalised disciplines, has tended to displace rather than accommodate (Ogunniyi & Ogawa, 2008).

There is a need, therefore, to promote the use of IK in science lessons for the learners to have better conceptual understanding. This can be done by recognising indigenous and local communities as custodians of IK and practices while promoting effective protection of traditional knowledge (Mapara, 2009). This knowledge could be useful to the learners in the Chemistry classrooms; thus, IK has to be taught with the involvement of ECMs to be more effective and teachers have to be cultural knowledge brokers between IK and WS (Meyer, 2010). Teachers as cultural knowledge brokers need to facilitate the creation, sharing and the use of IK (Meyer, 2010). This includes how knowledge is created in science classrooms and how the sharing of such knowledge could help learners to traverse between the lived world and science world views. Science teachers as cultural knowledge brokers should be able to know how and know why such IK has to be taught in science classrooms (Meyer, 2010).

Figure 3.2 below illustrates what happens in science classrooms when the teachers scaffold learners after practical demonstrations with ECMs using IK in their classrooms.

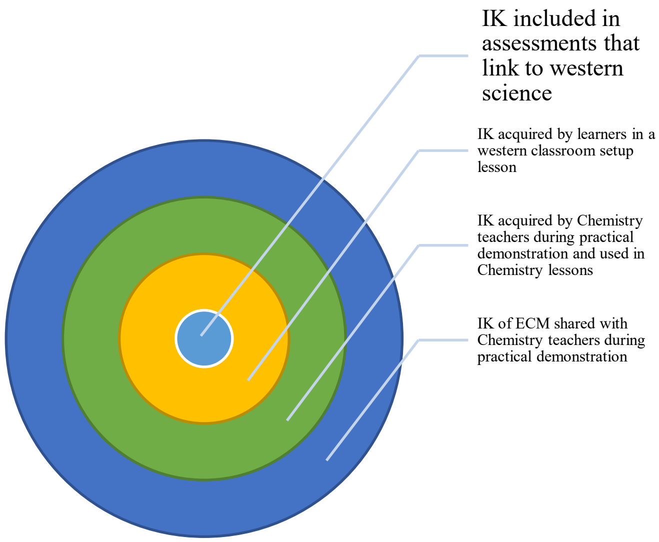


Figure 3.2: The knowledge disparity from the community members to the learners (adapted from Mukwambo, 2017, p. 60)

Mukwambo (2017) used this diagram to explain three levels of reality. I adapted it and modified it to explain the knowledge disparity from the practical demonstrations and participatory observation done by the ECMs to the knowledge the learners will contextualise and use during examinations. Thus, Figure 3.2 elaborates on the knowledge the ECMs explained during the practical demonstrations and participatory observation as the outer shell that includes other shells. The second knowledge zone was the knowledge the Chemistry teachers gained during the practical demonstrations and the peer-learning community. This was the knowledge the Chemistry teachers used to integrate IK in their classrooms. The next knowledge zone represented the knowledge the learners gained/acquired during the lessons. This knowledge allowed learners to learn it and it agreed with scientific knowledge. Cognitive dissonance (Le Grange, 2007) could be observed during the lessons when scientific knowledge and IK conflicted each other (Ogunniyi, 2007a). The Chemistry teachers had to be aware of such conflicts and how to resolve them. The shells indicated here represent the knowledge when scientific knowledge and IK agreed and accommodated each other and Ogunniyi (2007a) refers to this as the equipollent cognitive state. The inner shell represents the knowledge used in assessments or examinations that could be linked to IK.

Indigenous people are loaded with different indigenous practices or knowledge that could be used in Chemistry classrooms. As illustrated by Figure 3.2, indigenous people can share knowledge with science teachers to enhance their understanding of various aspects of IK. The quality of social interactions between the teacher and learners is seen as crucial when scaffolding learners' knowledge using IK (Shabani et al., 2010). The quality of teaching depended on the quality of the peer-learning community science teachers were exposed to during the practical demonstrations and workshops attended in this research.

3.2.1.2 Culture and language

Vygotsky (1978) argued that learning and cognitive development are culturally and socially based. In other words, learning is a social process rather than an individual one, and it occurs during social interactions with a knowledgeable other (Hammond & Gibbons, 2005). Using IK allows Chemistry teachers to connect the emergent needs of learners to their environment and this makes it easy to learn them. Children 'learn better' if the information is presented to them in a language and context that they can relate to and if their areas of competence are valued rather than denigrated. Thus, Chemistry teachers need to use the culture of the knowledge learners have from home using the tool (language) learners understand better.

For the learners to move from one knowledge level to another knowledge level, the teacher needs to scaffold them between the two knowledge levels. Peer-learning communities have a potential to help science teachers connect the culture of learners to their learning. Learning is influenced by the cultures of the learners that have experiential activities embedded in the culture of the community members. Using culture as the bridging instrument in Chemistry lessons allows learners to reflect on the activities that are done in the community. Notwithstanding these ideals, "there are many IK practices according to different cultures, making it difficult to choose which IK to use during lessons and which one to leave out" (Angaama et al., 2016, p. 24).

Admittedly, different cultures have different IK and therefore science teachers need to be aware of the IK that is suitable in the cultures where the schools are located. Teachers need to use the IK of learners to suit the curriculum knowledge required to be mastered. Indigenous culture and tradition explore spiritual connections between indigenous people and their environment through ‘languages’, ‘thought’, ‘prayer’, ‘rituals’, ‘art’ and other everyday activities (Botha, 2010). Cultural knowledge is more dominant in learners’ cognition and this makes it difficult to teach learners about WS. Science teachers need to create the smooth movement from WS to IK or from IK to WS to avoid the conflicts in the mind of the learners.

Le Grange (2007) indicated that African learners sometimes find it difficult to put the two worldviews together during the lessons which causes cognitive dissonance. Science teachers should understand that African learners’ learning can be affected by their sociocultural perspectives such as the environment in which they live. Vygotsky’s (1978) SCT associates learning with the culture of the learners. In this regard, Jegede (1999) illustrates that the culture of learners and the environment plays a significant role in how learners assimilate concepts from scientific knowledge into IK. Arguably, that determines how scientific concepts are accepted, learnt and stored in the long-term memory as schemata. By mobilising the culture of the learners in the science classroom, cultural border crossing (Aikenhead & Jegede, 1999) will take place – in this study, this will be in the minds of the teachers during the practical demonstrations by the ECMs for example. The *Oshikwanyama* language was used during the practical demonstrations to allow the ECMs to express themselves comfortably and effectively.

As noted, the ECMs were able to mediate learning of the Chemistry teachers using the language that was common to them and also traditional artefacts. The artefacts helped the Chemistry teachers to get involved during the practical demonstrations that allowed them to learn from each other and the ECMs. A peer-learning community was created when the Chemistry teachers and I engaged in discussions during the practical demonstrations. When teachers were involved in peer-learning with community members, some went through cognitive conflict when what they had learnt as scientific knowledge was challenged by the explanations from the ECMs.

3.2.1.3 Social interactions

Social interaction as a tenet of Vygotsky’s (1978) SCT perspective posits that human cognition is mediated and develops through participation in social activities (Yoon & Kim, 2019). Social interaction allows learning to take place either in formal classes or informal activities that allow the person with less expertise to observe the MKOs when doing activities. The social interaction between the ECMs and the Chemistry teachers allowed the teachers to observe how community members preserve *Mahangu,* make *Mahangu* flour, and make *Oshikundu*. Social interactions situate learning at the heart of SCT. That is, learning is mediated by social interactions between peers of different knowledge levels, and it is the character and quality of such interactions that are crucial to understanding the process of learning (Yoon & Kim, 2019).

Drawing from Vygotsky's (1978) seminal work, social interaction is the cornerstone of the professional development of teachers. Chemistry teachers interacted with the ECMs on preserving *Mahangu,* making *Mahangu* flour, and making *Oshikundu* and the ECMs scaffolded the teachers on the scientific processes involved. "Social interaction is the basis of learning and development, and learning is a process of apprenticeship and internalisation in which skills and knowledge are transformed from the social into the cognitive plane" (Shabani, 2016, p. 2). Learning is the process that can result from social interactions between community members who are knowledgeable about IK practices and the teachers that are less knowledgeable about IK practices.

Social interaction can take place during workshops, colloquiums, seminars, mentoring and/or study when peers meet and discuss. Similarly, in this study, social interactions between the ECMs and the Chemistry teachers took place during the practical demonstrations and participatory observation when they engaged in discussions and practical activities (peer-learning). Knowledge is acquired during the interactions, and this plays a role in how knowledge is manifested in the SCT. Vygotsky's (1978) SCT is grounded in the perspective that does not separate the individual from the social and argues that the individual emerges from social interactions and as such, is always fundamentally a social being (Lantolf et al., 2015). Lantolf et al. (2015, p. 15) highlight the essence of social interaction as follows:

> The social world is the source of all learning in SCT, participation in culturally organized activities is essential for learning to happen. This entails not just the obvious case of interaction with others, but also the artefacts that others have produced.

The social environment plays a role in SCT, as it informs the core of the activities happening in the area around the school. Cultural artefacts differ from culture to culture and using the artefacts that are common in the environment where the learners and teachers come from, might yield positive learning outcomes. Social interactions between Chemistry teachers and ECMs were observed during the practical demonstrations. The ECMs mediated learning by making *Oshikundu* to contextualise the rate of reactions and the Chemistry teachers were active observers and participated during the practical demonstration process.

3.2.1.4 Zone of proximal development

The concept of the ZPD was developed by Vygotsky during the 1920s and elaborated progressively until he died in 1934, in his work *Mind in society* (Shabani et al., 2010). Vygotsky (1978) introduced the ZPD to criticise the psychometric-based testing in Russian schools during those years. The activities that are given to the learners can fall outside their ZPD; some activities learners can do by themselves without the help of an MKO and some need the help of an MKO for them to be able to do them – for example, teaching Grade 3 learners (10-year-old) about balancing an equation on the production of alcohol. This type of knowledge is outside the range of 10-year-old learners, and they might not cope with that knowledge. This has been observed recently (2018–2021) in Namibia when the MEAC transformed the new curriculum. There were some shifts of knowledge from Grade 12 to Grade 9, in almost all the nine subjects, that learners were not able to cope with, especially in Mathematics, Life Science and Physical Science.

Vygotsky's (1978) perspective about the ZPD was intended to keep the learners in their zones as often as possible by giving them interesting culturally meaningful learning and problem-solving that is slightly more difficult than what they can do without the help of the MKO, such that they need to work together either with their peers or with the teachers to finish the task (Shabani et al., 2010). The idea is that after completing the task with the help of another learner or teacher, a learner will be able to do a similar task without any help. In the Chemistry classroom, this might be more practical if the topic to be taught involves indigenous practices that learners are familiar with to help them understand the concepts involved in those indigenous practices. The MKOs in this study were the ECMs that were custodians of IK. The ECMs' practical demonstrations enabled the Chemistry teachers to become the cultural knowledge brokers (Cooper et al., 1999) in this study. The Chemistry teachers subsequently used their cultural knowledge brokerage during science lessons when their learners were engaged in scientific explanations using IK.

Mediation of learning allowed the ECMs to support the Chemistry teachers between the two knowledge levels of ZPD using ZPD agents during practical demonstrations, and then later, when teachers scaffolded learners during their lessons. That is, mediation of learning was two-way traffic where the community members supported the Chemistry teachers with the IK for preserving *Mahangu*, making *Mahangu* flour, and making *Oshikundu* to contextualise the rate of reactions. Using indigenous language, indigenous artefacts and indigenous technologies helped the ECMs to support Chemistry teachers from the level they were at to the new knowledge level. Indigenous technologies in this study refer to the making of *Oshikundu* and other traditional beverages used in this research as examples.

The peer-learning community further helped the Chemistry teachers to scaffold their learners in science lessons when using indigenous pedagogical content knowledge as proposed by Mukwambo (2017) which has a foundation in Shulman's (1986) PCK of teachers. The PCK is the concept that represents teachers' professional knowledge, but in literature, it is widely used as teachers' knowledge (Fernandez, 2014).

3.2.2 Pedagogical content knowledge

Shulman (1986) introduced the concept of PCK as a distinctive body of knowledge for teaching. Pedagogical Content Knowledge (PCK) is an acknowledgement of the importance of the transformation of subject matter knowledge per se into subject matter knowledge for teaching. It refers to teachers' interpretations and transformation of subject matter knowledge in the context of facilitating learners' learning (van Driel et al., 1998). Adding to this, Shulman (2015) further operationalised PCK as "a more dynamic construct that described the processes that teachers employed when confronted with the challenge that described the processes that particular learners in particular setting" (p. 9). Shulman was interested to see how teachers cross transfer the subject matter knowledge they gain to learners in the classroom setting. Shulman's (1986) PCK goes beyond subject matter knowledge to the dimension of subject matter knowledge for teaching (van Driel et al., 1998). Shulman's PCK mostly emphasises how teachers deal with learners' difficulties, in this case, when teachers teach scientific concepts involved in indigenous practices without considering the IK of indigenous people. Building from learners' IK can solve the difficulties teachers face when teaching science.

Shulman (1987, p. 8) outlined the categories of teacher knowledge to promote understanding amongst learners and he introduced seven types of basic knowledge that a teacher must have: content knowledge, general pedagogical knowledge, curricular knowledge, PCK, knowledge of learners and their characteristics, knowledge of educational contexts, knowledge of purposes, educational purposes and educational values and their philosophical and historical bases. Drawing from Shulman's (1987) work, this study addressed general pedagogical knowledge, subject matter knowledge and knowledge of context. The knowledge about the general educational context and the specific educational context is embedded in the knowledge of context.

This research mobilised the IK of community members to help Chemistry teachers integrate the indigenous technology of making *Oshikundu* to contextualise the rate of reactions during science lessons by addressing the three knowledge domains. Pedagogical Content Knowledge (PCK) helped me to analyse how the Chemistry teachers used all three knowledge areas of PCK that were relevant to my research. The use of content knowledge involves curriculum knowledge which is embedded in textbooks, while general pedagogical knowledge involves classroom organisation and management, instructional models and strategies and classroom communication and discourse, and knowledge of context involves the environment, culture and language (Morine-Dershimer & Kent, 1999). Pedagogical Content Knowledge (PCK) helped Chemistry teachers to engage with learners during the lessons after working with the ECMs on the making of *Oshikundu* to contextualise the rate of reactions.

3.2.2.1 Three domains of pedagogical content knowledge

For this research, I looked at three of the five domains of PCK that were more relevant to my research. The knowledge about the specific educational context, curriculum knowledge and knowledge of learners' learning is embedded in those three major domains of PCK. I looked at general pedagogical knowledge, subject matter knowledge and knowledge of context. The combination of the three make up the required domains for this research, however, the other two PCK domains are also important.

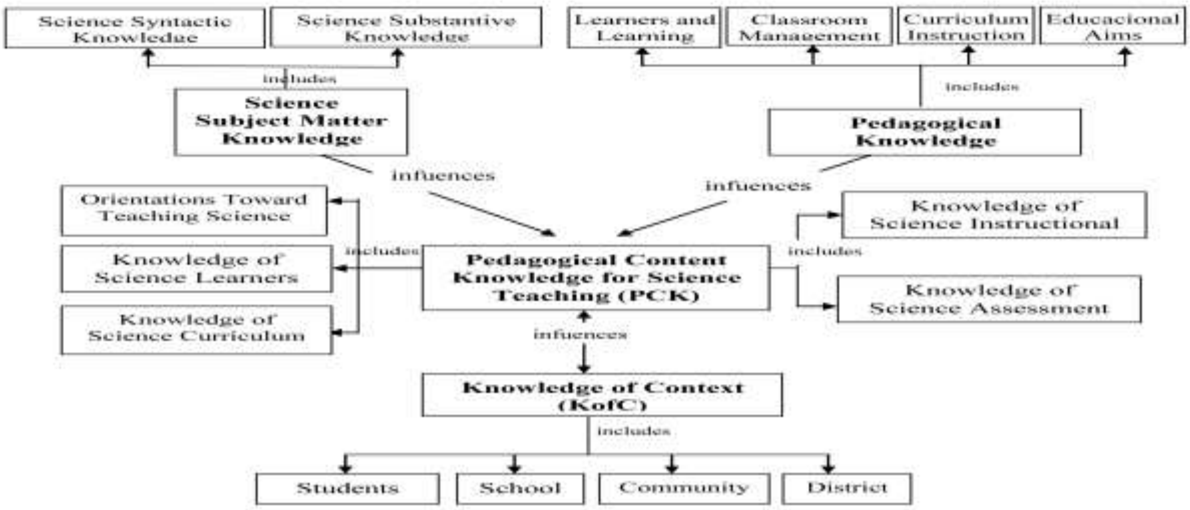


Figure 3.3: A model of science teacher knowledge (adapted from Magnusson et al., 1999, p. 1107)

The PK, content knowledge (CK), and SMK form the PCK that was used in this research as a theory. In support of PCK, three domains of PCK are discussed next that work within PLCs and were relevant to this research.

- **Pedagogical knowledge**

Pedagogical knowledge (PK) is deep knowledge about the process and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values and aims (Mishra & Koehler, 2006). The general knowledge involves issues of learners' learning, classroom management, lesson plan development and its implementation in the science classroom. This type of knowledge is unique only to the teachers that are trained on how to implement an educational curriculum that follows the agreed methodology to be used in the classroom. Their PK allows science teachers to develop strategies that are suitable in the science classroom. It is important to realise that teachers with deep PK understand how learners construct knowledge, acquire skills, develop habits of the mind and have positive dispositions towards learning (Mishra & Koehler, 2006). Furthermore, they identify that PK requires an understanding of cognitive, social, and developmental theories of learning and how they apply to learners in the science classroom.

Our peer-learning community increased the PK of science teachers on how both IK and WS could be interwoven in science lessons. Adding to this, the PCL improved how science teachers cross-fertilised ideas from the IK worldview and the WS worldview. Chemistry teachers used indigenous pedagogical content (Mukwambo, 2017) when the learners traversed from IK to scientific knowledge and vice versa. Such methodology allowed the teachers to use the examples from learners' contexts in understanding science facts in the science classroom. Learners were engaged in out-of-school activities that promoted their understanding of IK. Activities like threshing *Mahangu*, winnowing and other cultural activities were used to explain scientific facts. The Chemistry teachers need to be knowledgeable about which pedagogical methods to use, for them not to cause conflicts in African learners' mind. The PK helps science teachers to deliver the SMK.

- **Subject matter knowledge**

Subject matter knowledge (SMK) or content knowledge is the knowledge about the subject matter to be taught to science learners. The curriculum guides teachers on what is to be taught in the science classroom and how to teach the content. Teachers must know and understand the subject they teach and how to teach it. Thus, PLCs call for teachers to be trained to integrate IK into science lessons. Coupled with this, Mishra and Koehler (2006) proposed that teachers (science teachers in particular) must know and understand the subject they teach, including knowledge of concepts, theories, and procedures within their given fields. The content of Grade 12 Chemistry is vastly different from the content covered in the graduate courses at universities. Science teachers must be able to identify the possibilities of enacting IK in WS to improve the conceptual understanding of science learners in their classrooms. Teachers with a lack of CK promote favouritism and cannot bridge the gap between IK and WS. Advocating for this, Mishra and Koehler (2006) argued that teachers who do not have SMK can misinterpret the content for the learners. Science teachers need to advance their knowledge and understand the theories that could be used in teaching their subjects. An experienced teacher can identify learning strategies, attitudes, motivations and the IK of the concepts to be taught but that requires professional development training. Without the training, science teachers could interpret IK and WS differently and that can cause gaps and contradictions between the two knowledge systems.

Drawing from Rollnick and Mavhunga (2016), exposure of student teachers to skills and microteaching related to their subject has been reported as improving their SMK. The institutions of higher learning are key in developing teacher SMK when they are still student teachers at colleges or universities. The way science teachers are taught or trained will be reflected during their teaching time. Rollnick and Mavhunga (2016) identified the genesis of teachers' SMK in their schooling and argued that the quality of future teachers' schooling experiences is key to their future teaching. They also made a convincing argument that preparation during college years needs to be contextualised.

Kennedy (1998) further illuminated that the nature of the SMK required for teaching embraces both syntactic and substantive aspects. She argued for the conceptual nature of the knowledge required, distinguishing between quantity and quality of knowledge and rejecting what is referred to as recitation knowledge, which is described as the recitation of knowledge and facts.

The SMK varies from a common content base followed by a teacher education phase where SMK is thought of as a pre-requisite for teacher education, to science programmes where concurrent teaching of SMK and methodology takes place (Rollnick & Mavhunga, 2016). There is also diversity in science programmes for primary and secondary schooling learners. Even though the peer-learning community helped teachers develop these different skills and knowledge on how to nexus IK with WS, there is still a need for universities to take the lead in the PD of teachers by decolonising the science curriculum.

- **Knowledge of context**

Broadly, PCK was renamed as pedagogical content knowing (PCKg) by Cochran et al. (1993), where PCKg is an integrated understanding that is synthesised from teacher knowledge of pedagogy, subject matter content, learners' characteristics, and knowledge of the context (environmental context) of learning (Cochran et al., 1991). Knowledge of context associates itself with knowledge of the environment and the indigenous people around the school in which the curriculum is implemented. This part of the domain involves the IK of the learners and how it could be used in the science classroom. Moreover, Knowledge of Content involves knowledge of the environmental context, knowledge of the school climate, parental knowledge, legal issues, and the social context of the community (Cochran et al., 1991). Parental knowledge includes IK of the community that could be used in science lessons.

Science teachers need to be aware of all three knowledge components of PCK when mobilising cultural heritage in their lessons. This will allow them to integrate all five components of TSPCK equally in science classrooms. Teachers are influenced by the national curriculum, subject syllabus, textbooks, and the norms of how they were trained at higher education institutions. Engaging Chemistry teachers in peer-learning communities with community members on the aspects that have scientific explanations in them, could shift the way they view IK in their lessons.

Furthermore, to supplement Shulman's (1986) PCK, Geddis and Wood (1997) introduced teacher transformation of subject matter using five components namely, learners' prior concepts, subject matter representations, instructional strategies, curriculum materials, and curricular saliency. Mavhunga and Rollnick (2013) built on Geddis and Wood (1997) to introduce TSPCK which was used as an analytical framework to analyse the data from co-analysing national curriculum documents and lesson observations in this research.

3.2.3 Topic-specific pedagogical content knowledge

The TSPCK has five knowledge components, namely learners' prior knowledge, curricular saliency, representations, what is difficult to teach, and conceptual teaching strategies (Mavhunga & Rollnick, 2013; Pitjeng-Mosabala & Rollnick, 2018). Mavhunga et al. (2016) outlined the five knowledge components based on the SMK of science teachers. There are concepts in Chemistry teaching that could be explained using indigenous technologies of the community and this could make learners have a better conceptual understanding. The five components of TSPCK were used to analyse the data that emerged from lesson observation. The TSPCK as illustrated by Mavhunga and Rollnick (2013) below was used as an analytical framework under PCK.

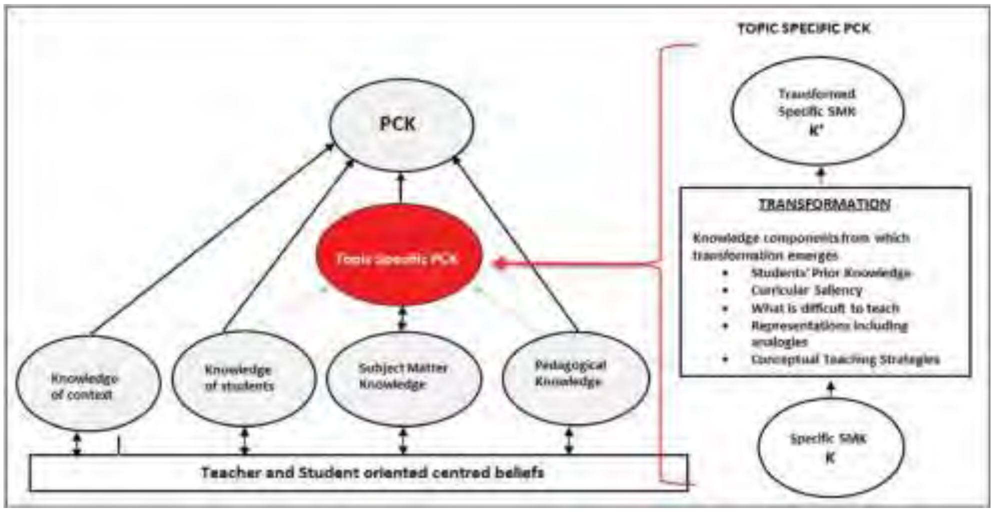


Figure 3.4: A model for TSPCK (Mavhunga & Rollnick, 2013, p. 115)

Learners' prior knowledge includes common learner misconceptions known on the topic. The IK of learners could be embedded in their prior everyday knowledge and this knowledge is gained during the social interactions with community members. Curricular saliency refers to the identification of the most important meaning in the main topic, without which understanding of the topic would be difficult for learners, and also includes the knowledge to logically sequence the learning and the knowledge of pre-concepts needed to teach a topic. The inclusion of IK would help learners and teachers to work together when a topic is presented in the science classroom; this would allow learners to access their IK and use it during science lessons. Ignoring the IK of learners in TSPCK that has IK practices would promote conflict in the minds of learners. The curriculum needs to guide teachers on the use of IK of learners in topics that could be taught with the help of community members.

What is difficult to understand refers to gatekeeping concepts which are difficult to understand often because they cause conflict with previously established understandings. The conflict would occur when science teachers ignore learners' IK in the science classroom. They are concepts that could be explained using IK artefacts of the community and this could help learners have a better conceptual understanding. Interweaving IK and WS would make science topics more interesting to the learners. A CoP would help teachers to work with knowledgeable community members on specific topics. For instance, in this research, I looked at the rate of reactions. Thus, PLCs call for science teachers to be involved in CoPs to help other science teachers make science subjects relevant to learners' prior knowledge. Presentation refers to a combination of the presentation of macro, symbol, and sub-microscopic levels that may be employed to support the explanation. Explaining science concepts based on learners' experiences might help them make the connection between IK and WS and promote the culture of cross-fertilisation of ideas during science lessons.

Lastly, conceptual teaching strategies refer to teaching strategies derived from the considerations made from the other four components and exclude general teaching methodologies. The TSPCK is relevant when exploring the PCK in a given topic that is known to the science teachers that requires IK. The experience of community members can be used to enhance the understanding of teachers on SMK. Science teachers have different TSPCK on different topics when it comes to SMK since they were trained by different institutions and taught by different lecturers. Professional learning communities (PLCs) might help Chemistry teachers to have the same understanding of the integration of IK into science lessons. The TSPCK of science teachers involves topics that are easily taught with the use of IK that is practically done in the community. Some topics could be taught using different indigenous technologies with a similar scientific process.

Since the interception of Shulman's (1986) PCK, further research has been conducted to conceptualise it. In 2016, for instance, a summit was held to further conceptualise PCK and the RCM was introduced (Carlson & Daehler, 2019). The RCM model constituted three realms of PCK, namely, collective PCK (cPCK), personal PCK (pPCK), and enacted PCK (ePCK) (Carlson & Daehler, 2019). The three realms of PCK were used during the research when analysing the knowledge, the Chemistry teachers gained from workshops when we visited the ECMs and the lessons that were observed. Collective PCK (cPCK) is the specialised knowledge base for Chemistry teaching that has been shared by professionals (Coetzee et al., 2020; Corlson & Daehler, 2019; Vollebergt et al., 2021). This was done during co-analysing curriculum documents when teachers shared their expertise on how certain concepts could be taught in Chemistry teaching. The cPCK is the agreed knowledge shared through professional interactions in a social setting. The cPCK was gained during workshops on co-analysing curriculum documents on how the curriculum allows science teachers to integrate IK into Chemistry teaching. Furthermore, the practical demonstrations and participatory observation afforded the Chemistry teachers the opportunity to further interact professionally with the ECMs outside the classroom setting. This allowed the interactions to be more interactive and productive than in the classroom setting.

The intention of the workshops and practical demonstrations was to improve the pPCK, cPCK and ePCK of the Chemistry teachers. In this study, pPCK was shaped during the interaction with other Chemistry teachers and ECMs. Coetzee et al. (2020) indicated that pPCK is the individual knowledge that can be shaped during workshops and professional interactions with other teachers, for the teachers to be able to improve their teaching methods. Vollebergt et al. (2021) reiterated that cPCK belongs to the profession of teaching that informs the development of teachers' pPCK. pPCK informs the ePCK of teachers in the classroom environment. ePCK consists of the knowledge and skills used by the teachers in the classroom (Singh et al., 2021). ePCK was enacted by the teachers when attending workshops and the practical demonstrations with the ECMs on the preservation and pounding of *Mahangu* and making of *Oshikundu* to be used in Chemistry teaching on the topic of the rate of reactions. As illustrated in Figure 3.5, cPCK, pPCK, and ePCK are extensions of Mavhunga and Rollnick's (2013) TSPCK.

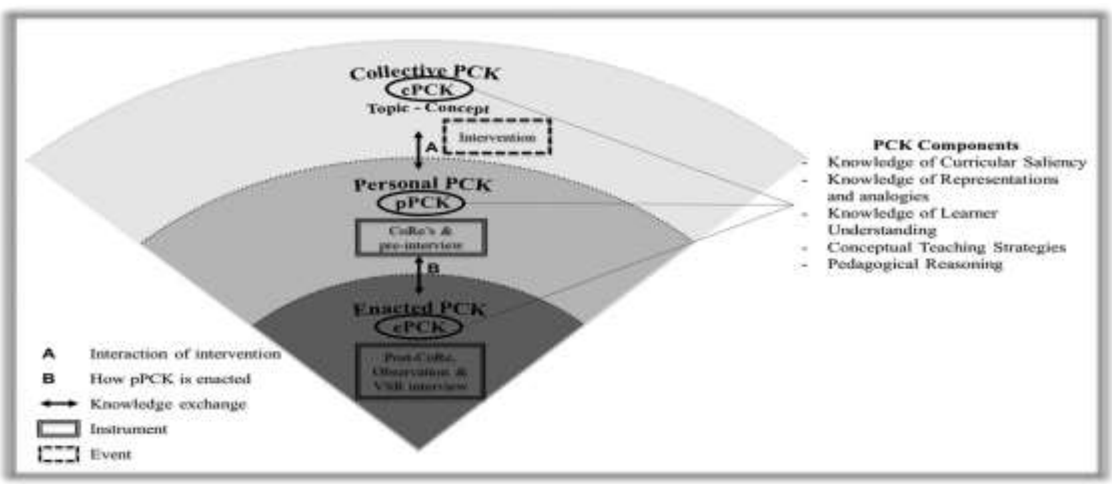


Figure 3.5: Conceptual framework based on the RCM (Carlson & Daehler, 2019, p. 15)

Can (2021) averred that ePCK plays a significant role throughout the pedagogical content knowledge cycle of Chemistry teachers in contextualising the topic of the rate of reactions. Building from Carlson and Daehler (2019), Alonzo et al. (2019) and Can (2021) further conceptualised three forms that exist in ePCK, such as ePCK for planning ($ePCK_P$), ePCK for teaching ($ePCK_T$), and ePCK for reflecting ($ePCK_R$). While $ePCK_P$ and $ePCK_R$ represent the knowledge and skills that teachers use for planning and reflecting respectively, $ePCK_T$ is related to what a teacher does in the classroom (Can, 2021). $ePCK_P$ was achieved when co-developing exemplar lessons with the Chemistry teachers on the topics that integrated IK. Exemplar lesson plans were taught ($ePCK_T$) and observed, showing how Chemistry teachers integrated IK and later, SRIs were done that allowed teachers to reflect on what they did in the classroom environment ($ePCK_R$). This was done to uncover any blind spots that the Chemistry teachers could not detect during the lessons. Next, I discuss the relevance of the two theoretical frameworks used in my study.

3.3 Relevance of the two Theoretical Frameworks in my Study

As discussed earlier in this chapter, I used Vygotsky's (1978) SCT and Shulman's (1986) PCK. The two theories complemented each other in my study (see Figure 3.1). The SCT is a learning theory that underpinned the social interactions that took place during the practical demonstrations, while PCK is the teaching theory. From Vygotsky's SCT, I drew from the mediation of learning, culture and language, social interaction and ZPD. From Shulman's PCK I used PK, SMK, and knowledge of context to analyse the data. I further used TSPCK as the analytical framework for the study. Extending on TSPCK, I used cPCK, pPCK, and ePCK to further understand the Chemistry knowledge of teachers. Both SCT and PCK were important in this research. The nature of the study as PAR made the two theories very important as theoretical lenses to analyse data that were generated from the interactions with the ECMs and the lessons observed. The processes of teaching-learning allowed the theories to complement each other during the study.

3.4 Chapter Summary

This chapter grasped the essence of the study by looking at the theoretical frameworks that were used to analyse the data generated from the seven research phases. The SCT and PCK were outlined in this chapter. In a nutshell, the chapter further addressed the analytical frameworks used to analyse the data. The tenets of SCT and PCK were internalised and shown how they were used to support the theories. As a researcher, I had to design the instruments that would generate the required data for my research. The seven research processes on how the data were generated are discussed in Chapter Four.

CHAPTER FOUR: RESEARCH METHODOLOGY

> Indigenous methodologies can be situated within the qualitative landscape because they encompass characteristics congruent with other relational qualitative approaches (e.g., feminist methodologies, participatory action research) that in the research design value both process and content. This matters, because it provides common ground for indigenous and non-indigenous researchers to understand each other. Significantly, tribal epistemologies are the centre of indigenous methodologies, and it is this epistemological framework that makes them distinct from Western qualitative approaches. (Kovach, 2012, p. 25)

4.1 Introduction

The research methodology is a bridge that connects the theory and methodology used in the research and also brings the researcher's theoretical standpoint (ontology and epistemology) and methods (perspective and tool) together (Creswell et al., 2016, p. 81). The components of the research methodology are the research paradigm and the research design. This research followed the indigenous research paradigm foregrounded by the ECMs as the custodians of IK and the Chemistry teachers who had to be helped by the ECMs so that they could scaffold their learners during Chemistry lessons. Chemistry teachers are challenged on how to use IK concepts in science classrooms. The research methodology used in this study tried to help the Chemistry teachers find ways in which IK could be introduced in science teaching. Furthermore, the methodology allowed teachers to be involved in a peer-learning community and with ECMs during workshops and practical demonstrations.

In this chapter, I thus discuss the research paradigms underpinning this study as well as the research design employed. The research paradigms consist of the transformative research paradigm and indigenous research paradigm and the research design employed was a case study research design. Within the case study research design, I discuss research approaches and the sampling methods I used to select participants for this study. The data generation methods used to generate the needed data to answer the research questions, and the research process are also discussed. The data were generated from semi-structured interviews, co-analysing Chemistry curriculum documents, workshop presentations and discussions, participatory observations, lesson observation, stimulated recall interviews (SRIs) and reflections of participants. I also discuss data analysis (inductive-deductive) and further explain how I achieved trustworthiness, validity, credibility and ethical considerations and conclude with the ethics related to the use of some participants' real names.

4.2 Research Paradigms

A research paradigm is a fundamental belief that affects the way social research is conducted, including the choice of a particular research methodology (Wahyuni, 2012). It influences the researcher on which methodology to use during the research and what participants to involve in the research. Moreover, Wahyuni (2012) asserted that research paradigms address the philosophical dimensions of social science; it is a set of fundamental assumptions and beliefs as to how the world is perceived which then serves as a thinking framework that guides the behaviour of the researcher. The beliefs of participants might influence me as a researcher, on what to do during the research and how to collect the required data from them. It might open up a new understanding of the nature in which the research will be conducted and the assumptions about the theoretical and fundamental beliefs underpinning social research (Wahyuni, 2012). This study used the transformative and indigenous research paradigms that describe the real phenomena surrounding the peer-learning community of the Chemistry teachers when mobilising indigenous practices on the integration of IK in science classrooms or lessons. Similarly to Seehawer (2021), in this research I used two complementary paradigms with the focus on their intersection, viz. the transformative and the indigenous research paradigms (Chilisa, 2012). I now discuss these below.

4.2.1 Transformative research paradigm

Mertens (1999) indicated that ''the transformative research paradigm is characterised as placing central importance on the lives and experiences of marginalised groups, such as women, ethnic/racial minorities, people with disabilities, and those who are poor" (p. 4). The research embraces the culture and knowledge of indigenous elders (Lavallee, 2009). Mertens (1999) avers that "when embracing this paradigm, efforts are made by inquirers to link the results of social inquiry to action, and (to) link the results of the inquiry to wider questions of social inequity and social justice'' (p. 4).

My research involved indigenous elders (ECMs) who are knowledgeable about preservation and pounding of *Mahangu* and the making of *Oshikundu*. The process was used to contextualise the topic of the rate of reactions in Chemistry teaching and learning. The transformative research paradigm works well with indigenous elders and that allows researchers to value their knowledge and culture. This paradigm enabled the Chemistry teachers and ECMs to work together. As a result, the Chemistry teachers were transformed regarding their understanding of the integration of IK. Drawing from Mertens (2010a), Chilisa (2012) illustrates that the transformative research paradigm signifies the family of research influenced by philosophies and theories that emancipate to transform people. For instance, through the research phases that were undertaken during this research, the Chemistry teachers were empowered to become cultural knowledge brokers (Cooper et al., 1999; Meyer, 2010; Wyatt et al., 2017) and cultural beliefs about indigenous elders were transformed, as they started viewing them as the custodians of IK.

Furthermore, Mertens (1999) indicated the transformative paradigm is based on "ontological, axiological, epistemological, and methodological assumptions that are different from those underlying the post-positivist and interpretive/constructivist world views'' (p. 4). Building on the studies by (Denzin & Lincoln, 2005; Guba & Lincoln, 2005), Mertens (2010a) clarified three basic belief systems that constitute the transformative paradigm. Similarly to Mertens (2010), Chilisa (2012) illustrated the nature of reality, knowledge and values that are historically bound to transformative research paradigm similarly to the indigenous research paradigm that also focused on the way of knowing. The way of knowing helped me to understand the nature of knowledge and the way knowledge is transmitted. Seehawer et al. (2015) state that:

> Indigenous knowledge is passed from generation to generation through oral and practical activities. This knowledge is not for everyone but belongs to the certain cultural group of people who share the same knowledge and this is what make the knowledge unique to the specific indigenous people. Indigenous people are proud of their knowledge, because this knowledge belongs to them" (p. 6).

The transformative research paradigm recognises that individuals have diverse backgrounds, and life experiences which contribute to the ongoing construction of reality existing in their broader social context through social interactions. The background and the experiences that the ECMs had on preservation, pounding and making of *Oshikundu* helped them to be confident during practical demonstrations. For instance, ECMs and Chemistry teachers were involved in social interactions that allowed them to learn from each other. A peer-learning community helped the Chemistry teachers to learn from each other and the way they perceived the integration of IK in their teaching and learning was transformed. Literally, the Chemistry teachers' PCK were improved after they were engaged in practical demonstrations by ECMs. That is, the Chemistry teachers were transformed to become cultural knowledge brokers (Aikenhead & Jegede, 1999; Cooper et al., 1999; Meyer, 2010; Wyatt et al., 2017) during practical demonstrations by the ECMs. Transformative research paradigm (Biddle & Schaft, 2015; Chilisa, 2012; Mertens, 2010a; Mertens, 1999) illustrates the four nature of knowing:

Axiology: The recognition of power differences and the ethical implication that derive from those differences in terms of discrimination, oppression, misrepresentation, and being made to feel and be invisible (Mertens, 2010, p. 195). The nature of ethics were well observed during the visit to Mee Mukwaluvala' home. This allowed the process to be done smoothly because the Chemistry teachers were able to respect and adhere to the moral values of indigenous elders. The beliefs and knowledge of ECMs were questioned by the Chemistry teachers for them to be able to understand how things were done and are still done. Chilisa (2012, p. 47) explains that axiology in transformative paradigm views the research as a moral and political activity that allow them to commit themselves to the values of social justice, fostering human rights and respect of cultural values and norms.

Ontology: Building from Neuman (2010), Chilisa (2012) further pointed out that ontology in transformative research paradigm has to do with social reality that is historically and constantly changing depending on social, political, cultural and power of the communities (p. 46). The knowledge of indigenous people seem to be changing based on the wealth of the communities and this was observed that most homes are not threshing and winnowing *Mahangu* the traditional way of using pestles or sticks but they are using machines to do the threshing and they just collect the end product. This nature of reality allowed me to choose the home that was still using the traditional way of threshing and winnowing within the communities. The culture of indigenous people is changing due to the western ways of doing things. This shows that IK is not isolated from other forms of knowledge, but it adjust itself to the new level of understanding.

Epistemology: Mertens (2010a, p. 13) indicated that "the nature of knowledge and the type of relationship between the researcher and participants (Chemistry teachers) need to close in order to achieve and understanding of what is valid knowledge, this knowledge is characterised by a close collaboration between researcher and the participants in the research". The way of knowing allowed us to understand the way of knowing by IK. Cram and Mertens (2016) indicated that epistemology refers to the fact that "knowledge is power" (p. 174). This is similar to Liveve's (2022) study who worked with indigenous people to understand the power of knowledge that indigenous people have on contextualising sound and waves. Working with ECMs on preservation, pounding and making of *Oshikundu* allowed Chemistry teachers and me to understand the power of knowledge that indigenous elders possess that could be used to teach Chemistry. This research was transformative research that described the real phenomena surrounding the peer-learning community of the Chemistry teachers on the integration of IK in their classrooms.

One of the shortcomings of the transformative research paradigm is that it tends to focus on working in groups by learning from each other. Thus, the transformative research paradigm is characterised as a mixed methods practice that cannot be used at qualitative approach only. Biddle and Schafft (2015) and Mertens (2007) explained that transformative paradigm is within mixed methods strategies. To counter argue this, however, Mertens (2007, p. 216) indicated that "a researcher can choose quantitative, qualitative or mixed methods, but there should be an interactive link between the researcher and the participants in the definition of the problem, methods should be adjusted to accommodate cultural complexity, power issues should be explicitly addressed and issues of discrimination and oppression should be recognized". Indigenous people were oppressed and their knowledge were not valued by the oppressed. This research worked with indigenous elders to understand their lived experiences on how they could be used to contextualise teaching of Chemistry. To address this, shortcoming, I thus supplemented it with the indigenous research paradigm (Chilisa, 2012). I tried to weave in indigenous research paradigm to understand how indigenous elders and Chemistry teachers learnt from one other as knowledge was co-constructed. In this research, knowledge was co-created in a peer-learning community by co-analysing curriculum documents, practical demonstrations and participatory observation and lesson observations.

4.2.2 Indigenous research paradigm

Indigenous knowledge (IK) plays an important role in indigenous research methods (Chilisa, 2012). In defining IK, Chilisa (2012) stated that it "is embodied in languages, folktales, stories, and cultural experiences and it is symbolised in cultural artefacts such as sculptures, weaving, and painting, and embodied in music, dance, rituals, and ceremonies such as weddings and worshipping" (p. 96). This research was underpinned by an indigenous research paradigm (Chilisa, 2012). As an indigenous person growing up and being raised by indigenous elders (see Section 1.3), it helped to reflect on how indigenous people are interconnected between themselves and the environment around them. This sparked my interest in the indigenous research paradigm to understand the values of the paradigm in the context of my study. The indigenous research paradigm in the context of this study was thus used to understand the knowledge that indigenous elders have that are applicable in Chemistry. It allowed me to work together with the ECMs and the Chemistry teachers.

Moreover. an indigenous research paradigm allowed us to critique and resist WS and promote the integration of IK. Blended in indigenising research methodologies, the contextualisation of the science curriculum formed the key component of this indigenous research. Contextualisation of the science curriculum calls for African epistemologies to form part of IK teaching (Seehawer & Breidlid, 2021). Indigenous epistemologies involve 'two-eyed seeing' which refers to "learning using one eye to see the strengths of indigenous ways of knowing and the other eye to see the strengths of the westernised way of knowing and using both eyes in this research" (Hatcher et al., 2009, p. 146).

Using 'two eyed seeing' in this research helped me to collaborate with the ECMs and Chemistry teachers in understanding how IK could be integrated. I used the indigenous research paradigm as it "challenges the deficit thinking and pathological descriptions of the formerly colonized and reconstruct a body of knowledge that carries hope and promote transformation and social change among the historically oppressed" (Chilisa, 2012, p. 40). Building on Seehawer (2021), who did her research by working with science teachers integrating IK in science subjects, in my study, I worked *with* ECMs as the custodians of the cultural heritage and these are the people that were oppressed as reiterated by Chilisa (2012). I also refer to indigenous elders as expert community members in this study because they have gained knowledge through observation, storytelling and practical activities on how *Oshikundu* is prepared from their grandmothers and they used that knowledge to help Chemistry teachers understand the roles of IK in Chemistry learning and teaching. So, using the indigenous research paradigm helped me to map out how IK should be integrated into Chemistry learning and teaching. Further, the indigenous research paradigm allowed the Chemistry teachers to be transformed (Seehawer, 2021). Moreover, this assisted me in having a holistic approach to the study, since the indigenous research paradigm helped me to have a research methodology that supported working together with ECMs' and Chemistry teachers' epistemologies and ontologies (Seehawer, 2021).

The indigenous research paradigm was used in this research to understand the knowledge that indigenous elders possess that could be integrated into science lessons to contextualise Chemistry learning and teaching. An indigenous research paradigm is a research paradigm that encompasses ontology, epistemology, methodology and axiology (Wilson, 2001). It is thus grounded in indigenous knowledge, culture, language and indigenous artefacts (Pidgeon, 2019; Wilson, 2003). Research that involves indigenous people should follow the indigenous research paradigm. In this regard, Wilson (2001, p. 175) indicated that the indigenous research paradigm involves ontology – as beliefs in the nature of reality, epistemology, how we think about reality, methodology, and how we are using our way of thinking to gain more knowledge about the reality and axiology – which allows us to have set of morals and ethics. Similarly, indigenous research paradigms connect indigenous people to the environment in which they live (Hart, 2010; Kovach, 2010). Indigenous people have moral values that need to be followed which help them to live within their social settings. For instance, our cultural beliefs helped us to understand and value each other's understanding.

Moreover, Wilson (2001, p. 177) avers that an indigenous research paradigm comes from a belief that knowledge is social. This research was thus conducted in an out-of-school context where the Chemistry teachers had to be accommodated by the indigenous elders within their social settings. Working with the ECMs, for instance, helped me to understand how knowledge can be transmitted and acquired. According to Pidgeon (2019, p. 419),

> Indigenous communities and researchers have come to realize the limitations of non-indigenous paradigm in accomplishing the goals they have set to articulate and implement research within their own indigenous framework. For example, research with indigenous research paradigm emerges from the relationship of an indigenous researcher with the indigenous community.

The indigenous research paradigm influenced how the research processes were undertaken within the context of the environment where the community members lived. For instance, the Chemistry teachers and I visited one ECM's home to learn and engage in indigenous technologies that are done within the community, which could be used to contextualise Chemistry learning and teaching. However, it should be recognised that IK differs from context to context. Hence, using the indigenous research paradigm helped us to understand the commonalities and/or differences that exist between indigenous people from different environments. Pidgeon (2019) argued that commonalities exist between communities, but each community has its own values, beliefs, ethics and protocols. He further claimed that "indigenous research paradigm reclaims research by and for indigenous peoples, and provides a model that non-indigenous scholars could learn from it to inform their research paradigm when working with indigenous communities" (Pidgeon, 2019, p. 421).

Furthermore, this research involved ECMs as the custodians of the cultural heritage. Accordingly, the indigenous research paradigm was deemed relevant as it brought culture, language and IK together. The indigenous research paradigm also influences the choice of methods, how the methods are employed and how the data will be analysed and interpreted (Kovach, 2010). The research design and methods in this study were thus influenced by the paradigms I used that helped me to work within the framework of indigenous research paradigm when collecting data.

In this research, IK and WS were held side-by-side without comparing them, but supplemented each other during the Chemistry teaching of the rate of reactions. Chilisa (2012) articulated that indigenous research paradigms are informed by ontology, epistemology, and axiology, as those three form key components in the Ubuntu perspective.

Mutanho (2021) indicated that an indigenous research paradigm is viewed by many scholars as an emerging approach to research that foregrounds the indigenous people's ontologies, epistemologies, and axiologies (Chilisa, 2012; Le Grange, 2016; Mbembe, 2021; Seehawer, 2021;

Seehawer & Breidlid, 2021). Ontologies, epistemologies, and axiologies are viewed as the core pillars of indigenous identity. Within the indigenous research paradigm, I focused on the *Ubuntu* perspective (Chilisa, 2012; Seehawer, 2018a; Seehawer & Breidlid, 2021) as one of the core pillars within the indigenous research paradigm.

Ubuntu means 'I am a person through other people' and that we are interconnected (Keane et al., 2016; Khupe, 2014; Ogunniyi, 2007a). We depend on other people for whatever we do and we cannot live in isolation. Herein lies the importance of a PLC and collaborating with the ECMs in this study. Certainly, Ubuntu continues to be the epistemological foundation for many Africans and thus cannot be ignored in African knowledge generation (Keane, 2008; Seehawer, 2018a). Adding to this, Ubuntu has connotations for the living and non-living, thus it connects us to the past, present, and future (Chikamori et al., 2019; Seehawer, 2018b).

Indigenous knowledge (IK) research has aligned itself to the Ubuntu perspective that focuses more on explanations than descriptions of the phenomenon. Working with ECMs to explain to the Chemistry teachers how *Mahangu* is preserved, how they make *Mahangu* flour, and the making of *Oshikundu* had all three aspects (past-present-future) (Chikamori et al., 2019). As a research perspective, Ubuntu comprises philosophical values such as the nature of social reality (ontology), ways of knowing (epistemology), and ethics and value systems (axiology) (Seehawer, 2018a). This helped us (Chemistry teachers and I) to be engaged during the practical demonstrations and ask further questions to the ECMs. This research helped us to have an interest in and value the knowledge of the ECMs and we felt culturally revitalised (Cocks et al., 2012; Smith, 1999). Ubuntu refers to an ontology and way of living that has significant differences from those of western paradigms (Keane, 2008). Thus, this paradigm acknowledges the relationship between the researcher and the participants (see Section 1.4).

Drawing from Seehawer (2018b) who counselled that "Ubuntu as a research paradigm, means that research methodology, agenda and ethics are based on Ubuntu epistemology, ontology and axiology" (p. 6). Indigenous way of knowing and the nature of knowledge (epistemology) differ from the western way of knowing (Chilisa, 2012). The nature of knowledge and how the knowledge is acquired influences the paradigm that I used for my research as an indigenous research. Axiology helped us to follow the indigenous ways of doing things. This research followed the ethics that allowed us to work with indigenous elders (Chilisa, 2012; Mertens, 2012). Ontology in this research helped me to nurture the social reality and the way I viewed social reality as an indigenous way of knowing the truth was influenced by the way I was brought up (Chilisa, 2012; Mertens, 2010; Seehawer, 2018b). Indeed, this research used indigenous methods as a hybrid of indigenous practices (Seehawer, 2018b). The interactions and engagement between the researcher and participants made the research part of the Ubuntu perspective. In the Ubuntu perspective, knowledge is not generated and validated by individuals or through conventional scientific processes, but through communal discourse (Seehawer, 2018a, p. 6) as I did in this study. The indigenous research paradigm is the usual framework and the product (Keane et al., 2017), while the Ubuntu perspective is framed as the research process that allows participants to be actively involved during the research and acquired knowledge, thus, this research was framed within the participatory action research (PAR) approach.

Ubuntu is a term used to express 'humanness' or 'being human' (Khupe, 2014). Adding to this, Ubuntu is an African ontological concept that entails respect, [15]humanness, togetherness, dignity, communalism, kindness, generosity, honesty, caring for others, and participation in the common good (Khupe, 2014). This research followed the PAR and the interaction between the researcher and participants allowed us to share the knowledge we gained from different environments (home or community). Ubuntu is based on findings from research participants (Keane, 2008) and is not based on researcher bias.

However, this research required interactions between the Chemistry teachers and ECMs on preserving *Mahangu,* making *Mahangu* flour by using a mortar and pestle, and the process of making *Oshikundu* with a view to workshop the Chemistry teachers on how to contextualise scientific knowledge on the rate of reactions. The research was based on indigenous practices that have a strong Ubuntu ontology because it required us to work as a CoP. The curriculum that builds its objectives on the philosophy that Ubuntu brings in the IK of people in the classrooms. [16] 'We'

---

[15] Humanness suggests both a condition of being and the state of becoming, of openness, or ceaseless unfolding (Seehawer, 2018)

[16] I used 'we' to refer to the participants (teachers) and I as we did the research together.

worked with the ECMs in the spirit of humanness 'I am because we are'. Ubuntu visualises a community that is built upon interdependent relationships (Keane, 2008). This research was grounded in the Ubuntu perspective because we worked together for the benefit of everyone involved in the research. "Ubuntu calls for great researcher responsibility during fieldwork and even during reporting and it demands sensitivity towards the participants regarding their context" (Khupe, 2014. p. 76).

Working 'with' not 'on' participants (Ngcoza & Southwood, 2015) gave them strong ownership of the research and this allowed them to be active during the research process. I observed that giving the participants ownership of the research made them responsible for each step taken in the research. We worked together with the ECMs, and this gave us positive social interactions and the bonds became strong as we went along with the research.

In this study, I used transformative research paradigm and indigenous research paradigms. It is argued that the transformative research paradigm provides the knowledge, ethics, and language of interaction and descriptive tools that enabled me to understand the phenomena under study. Transformative research paradigm also helped me to understand the ontology, epistemology and axiology that helped to understand social phenomena. In this study, I also used an indigenous research paradigm that focused on the knowledge that tells the context part of the research. In the indigenous research paradigm, I focused on the Ubuntu perspective to understand people as people in social settings and not as objects. That is, the relations between people and how people behave were central in this study.

In this research, I thus used two paradigms that helped me to understand the research process and interpret the data. The transformative research paradigm was more visible throughout the research and the indigenous research paradigm was used when we visited the ECMs' home to learn about indigenous practices that are related to the rate of reactions. Even though I used the two paradigms, I might not have interweaved them enough to really see how they helped in the research process that I used to generate data. I was still learning to understand how the two paradigms could be used in the research to support each other.

Within the transformative research paradigm and indigenous research paradigms, I employed a case study research design. To understand this, I employed a CoP and PAR as research approaches. The two research approaches helped me to understand how the Chemistry teachers and ECMs worked in the context of contextualising scientific knowledge. In generating data, the transformative research paradigm was visible in the data generated from semi-structured interviews, co-analysing of curriculum documents, lessons observation and reflections of participants. The transformative research paradigm helped to analyse data using the SCT and its tenets, using PCK and TSPCK, the indigenous research paradigm was used during practical demonstrations and participatory observation that encompassed the *Ubuntu* perspective. For instance, within the indigenous research paradigm, *Ubuntu* was used to understand how the Chemistry teachers interacted with the ECMs during practical demonstrations. Further, during the practical demonstrations and participatory observation, data were analysed using the SCT and the tenets of SCT. Even though the SCT seems to be situated well within the transformative research paradigm, I tried to weave it in to understand the indigenous research paradigm. The two paradigms helped me to choose the research design and research process.

4.3 Research Design

"Research design is a plan of how the researcher will systematically collect and analyse the data that is needed to answer the research question" (Bertram & Christiansen, 2015, p. 40). It is the designed and planned nature of data collection that distinguishes research from other forms of research (Bertram & Christiansen, 2015). Adding to this, Creswell et al. (2016) asserted that research design is a plan or strategy moving from underlying philosophical assumptions to specifying the selection of respondents (participants), the data gathering methods to be used, and data analysis to be done. However, even though research design is an important plan, it is not a fixed plan that proceeds in a very structured or linear way (Bertram & Christiansen, 2015). Henning et al. (2007) accentuated that a researcher should be able to select a research design that will only suit the research questions optimally but will also indicate the researchers' knowledge of how language makes meaning, what role theory plays in interpretation and understanding, and how ideology and politics manifest in the research. In this study, I, therefore, employed a case study research design.

4.3.1 Case study

A case study is a popular approach that allows researchers to generate data and to develop and present an in-depth view of a particular situation, event, and entity (Rule & John, 2011). The case in this study is the integration of IK into science teaching. The practical demonstrations and explanations by the ECMs were used as a catalyst to achieve this. I also adapted Chikamori et al.'s (2019, p. 9) Transformative Model of Education for Sustainable Development (TIMESD) framework, central to which was designing, implementing, and improving IK integrated science lessons. To Chikamori et al. (2019), the transformative model of education for sustainable development (TMESD) framework is composed of three learning sub-processes: "knowing the present", "past-present relationships" (focusing on the dependence of the present on the past), and the "future-present". Indigenous research paradigm (Chilisa, 2012) helped me to understand the past (how knowing was viewed), present (how knowing was transformed from past to present) and the future (how indigenous in integrated in the changing world). The indigenous research paradigm helped me to focus on the case that was under study in this research. Within the case, indigenous elders where involved to transform the knowledge of teachers who were trained in the western epistemology to understand the indigenous epistemologies. The nature of how knowledge is transmitted within indigenous was of knowing and western ways of knowledge differ. This different way of knowing made this research unique as I was interested in the indigenous way of knowing, building from the western way of knowing. The transformative research paradigm helped me to understand how the Chemistry teachers were transformed after engaging in practical activities with the ECMs. The case was to work with indigenous elders on integrating IK into Chemistry learning and teaching.

The PAR allowed me to use TIMESD and Figure 4.1 below illustrates how the PAR and TIMESD are interrelated. Working with Chemistry teachers in the context outside the classroom and working with the ECMs helped me to understand how preservation of *Mahangu*, pounding of *Mahangu* and making of *Oshikundu* used to be done and will be done due to the changing knowledge of the indigenous people. Knowing the past focused on tapping into the ECMs' cultural heritage on the indigenous practices on the preservation of *Mahangu*, making of *Mahangu* flour by using a mortar and pestle, and a practical demonstration on making *Oshikundu*. Knowing the present, entailed co-analysing curriculum documents. Imagining the future focused on the co-development of exemplar lessons that integrated IK. These scholars refer to the process of studying the past-present relationships as retroduction that paves the way for the future, and future-present relationships as retrodiction that builds on the past (see Figure 4.1 below) (Chikamori et al., 2019).

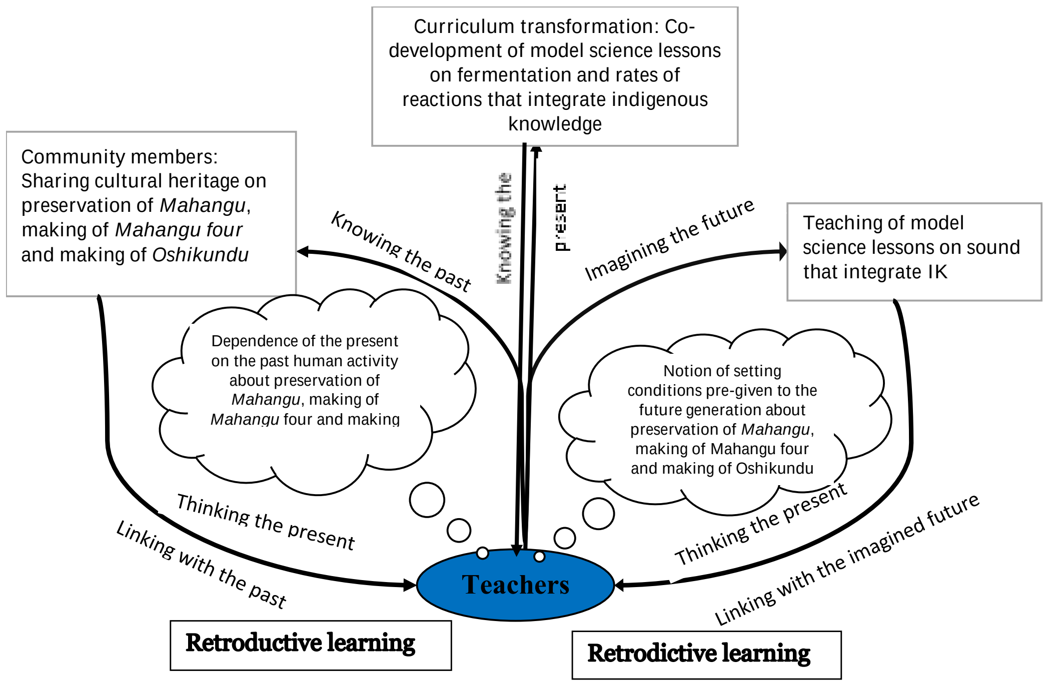


Figure 4.1: Shows the learning process of integrating IK in Chemistry teaching (adapted from Chikamori et al., 2019, p. 9)

The use of Chikamori et al.'s (2019) model which Hashondili (2020) adapted in her study as well allowed me to link the past-present-future on how Chemistry must be taught using community members as resourceful people and custodians of IK around the school to help teach Chemistry. It also helped to analyse the curriculum documents and essentially, take science from schools to the communities and the cultural heritage from the communities was, in turn, taken to the science classrooms.

Cohen et al. (2018, p. 232) defined a case study as "a specific instance that is frequently designed to illustrate more general principles". A case study is a popular approach that allows researchers to develop and present an in-depth view of a particular situation, event and entity (Rule & John, 2011). As indicated in the epigraph, Yazan (2015) stated that the methodologist does not have a full consensus on the design and implementation of the case study. The case studies in this research helped me to work with fewer people to gain an in-depth understanding of the phenomena under study. It was a case of Chemistry teachers learning from ECMs about how *Oshikundu* is made for them to connect it to scientific explanations in Chemistry textbooks.

The study adopted a case study approach to understanding the IK of the indigenous people in the Ohangenwa region, specifically in the Endola Circuit. It involved two ECMs and five Chemistry teachers on indigenous technologies to contextualise the rate of reactions. It helped me foreground the research as context-based looking at specific phenomena. This research hoped to unfold the real phenomenon surrounding the integration of IK into Chemistry teaching after science teachers had gone through PAR with ECMs. Indeed, central to PAR is collaborative participation and this resonates with the indigenous research paradigm. As a result, PAR enabled the cross-fertilisation of ideas between IK and scientific knowledge in order to make science topics more interesting and relevant to the learners. Engaging ECMs in this research yielded positive results needed in this research as community members were engaged in a PLC with science teachers. In the next section, I discuss the research goal and research questions and later I discuss the two research approaches.

4.3.2 Research goal and research questions

In this section, I present the research goal and research questions of my study. This study was guided by how Chemistry teachers could help avoid learners' cognitive dissonance by helping them traverse between the two worldviews and make sense of both knowledge views by border crossing between IK and scientific knowledge in science classrooms. To achieve this, I explored the use of a peer-learning community and the ECMs who worked together.

4.3.2.1 Research goal

The main goal of my study was to explore leveraging a PLC and ECMs on the integration of IK into the learning and teaching of Grade 10 Chemistry on the rate of reactions. This study was guided by the following broad overarching research question:

How do a peer-learning community and expert community members leverage the integration of indigenous knowledge into the learning and teaching of Grade 10 Chemistry on the rate of reactions?

To achieve this goal and broad overarching research question, the following research sub-questions were addressed:

4.3.2.2 Research questions

1. What are Grade 10 Chemistry teachers' experiences, and pedagogical insights on the use of IK in Chemistry learning and teaching before they were engaged in a peer-learning community and with the ECMs?

2. (a) What lessons can Grade 10 Chemistry teachers learn (or not) in their peer-learning community when co-analysing the Chemistry curriculum documents?

   (b) How do Grade 10 Chemistry teachers interact, participate, and learn (or not) during the ECMs' practical demonstrations and explanations on the preservation and pounding of *Mahangu* flour and making of *Oshikundu*?

3. How does a peer-learning community enable and/or constrain Grade 10 Chemistry teachers in using the IK of the ECMs on the preservation and pounding of *Mahangu* and making of *Oshikundu* and other indigenous practices to co-develop exemplar Chemistry lessons?

4. How do the Grade 10 Chemistry teachers selected from the peer-learning community mediate learning of the co-developed exemplar lessons in their Chemistry classrooms?

5. How do discussions and group reflections in the peer-learning community influence (or not) Grade 10 Chemistry teachers' understanding of integrating IK from the ECMs?

4.3.3 Research approaches

This research has two research approaches that were followed during the data collection with the participants. I used a CoP and PAR in this study. I used a CoP to allow the Chemistry teachers and ECMs to share knowledge on indigenous technologies of preservation and pounding of Mahangu as well as making of *Oshikundu* contextualise the rate of reactions and its associated concepts. This research approach allowed me to look into how ECMs and Chemistry teachers interacted during the practical demonstrations and how the Chemistry teachers helped each other after the research was completed. I used the research approach as a catalyst for social interaction. This helped the Chemistry teachers to work as a team of educators (peer-learning community) with the ECMs. To alleviate the shortcoming of CoP, lack of sharing of knowledge and experiences within the community, it was supplemented with PAR. PAR allowed us to join the ECMs during a practical demonstration on preserving *Mahangu*, pounding of *Mahangu* and making of *Oshikundu*.

This is what Vygotsky advocated on social interaction and MKOs. In this case, ECMs were more MKO than Chemistry teachers on indigenous technologies. The interaction helped Chemistry teachers to learn from ECMS and their knowledge shifted. ZPD of Chemistry teachers after practical demonstration done by ECMs, were able to explain the process of making *Oshikundu* from a scientific knowledge by contextualising it. I used PAR for us to work together with ECMs and Chemistry teachers on preservation, pounding of Mahangu and making of Oshikundu to contextualise rate of reactions. PAR and CoP supplemented each other during the research. PAR looked at how Chemistry teachers participated during practical demonstrations and CoP enabled me to understand how Chemistry teachers and ECMs shared knowledge of indigenous technologies to contextualise the rate of reactions.

4.3.3.1 Community of practice

Lave and Wenger (1991) defined the CoP as a group of people who come together to share common interests and goals, share information, develop knowledge, and develop themselves both personally and professionally. Other definitions of CoP are: "groups 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 ongoing basis" (Wenger et al., 2002, p. 4). Within such a community, people share their experiences and tacit knowledge in free flow, improving their abilities and skills, and fostering learning. This allowed the teachers and the community members to build rapport between them and a high level of trust while sharing their knowledge.

Unlike teams and organisational units, CoPs are self-organising systems whose methods of interaction, rules, issues, and lifespan are determined by members, based on the intrinsic value that membership brings (Wenger et al., 2002). Community members develop common sets of codes and language, share norms and values, carry out critical reflection, and engage in dialogue with each other at a professional level, generating an environment characterised by high levels of trust, shared behavioural norms, and mutual respect and reciprocity (Sharratt & Usoro, 2003). This CoP involved five Chemistry teachers and two community members with various levels of knowledge of different indigenous practices. For example, ECMs that were knowledgeable about the preservation of *Mahangu*, pounding of *Mahangu* to make flour, and the making of *Oshikundu*, workshopped the Chemistry teachers on these indigenous technologies and processes that were relevant to the rate of reactions. The Chemistry teachers learnt from the ECMs during the practical demonstrations.

In this case, Chemistry teachers, the researcher, and community members joined the CoP to help each other to understand the scientific knowledge that could be taught using indigenous technologies. Indeed, people join a community to develop knowledge and specific expertise about a particular issue, which could not be obtained elsewhere. Figure 4.2 shows how Chemistry teachers, the researcher, and ECMs interlinked to learn from each other.

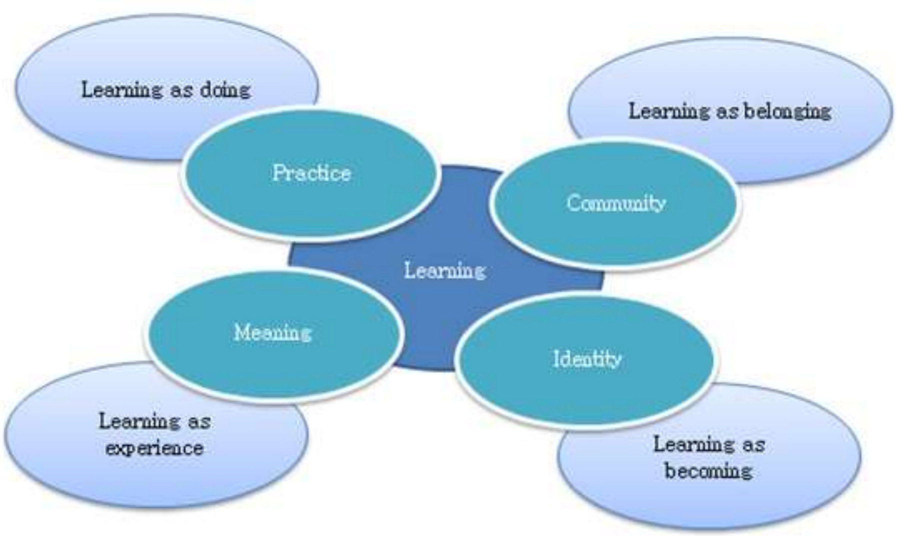


Figure 4.2: Components of a CoP (Wenger, 1998, p. 5)

The central focus of a CoP is mutual learning with the people involved in the group, by using their experiences and their identities to make meaning and the practices that have been done through the centuries by communities. The community becomes a CoP if learning occurs through the collaboration of the members of the group. Wenger (2006) indicated that a CoP is a group of people that share common interests and passion for doing something better and meeting regularly to interact and learn from each other. The Chemistry teachers formed part of the CoP and shared different teaching methodologies and how to integrate IK into science. Lave and Wenger (1991) added that a CoP is a group of people who come together to share common interests and goals aimed at improving their skills by working alongside more experienced members and being involved in increasingly complicated tasks. The Chemistry teachers in this research might not be knowledgeable in some or any indigenous practices. Working in a CoP helped Chemistry teachers to join the ECMs by learning from them. The community is a locus that enables a newcomer to learn by engaging in simple tasks, assisted by comparatively or highly experienced people (the latter being commonly known as old-timers) (Agrifoglio, 2015). Initially, in this research, the newcomers (Chemistry teachers) became acquainted with the tasks, norms, values, and principles of the community and then gradually increased their participation and involvement in indigenous practices that involved scientific knowledge (Agrifoglio, 2015). The CoP has three components, viz., domain, the community, and practices.

According to Mhakure and Otulaja (2017), the domain in this study would be the shared goals that deepened understanding of the integration of IK and scientific knowledge through argumentation. These characteristics were characterised by the members of the CoP when they shared the knowledge and experiences they had on the integration of IK in science lessons. Members of the CoP had their differences and understandings of how certain IK is done in the local community. Chemistry teachers were allowed to ask guided questions, stimulate discussion on the ideas and contribute to the discussion. The ECMs and the Chemistry teachers had ownership of their culture and knowledge during practical demonstrations and shared some common ground and the goals of the project. Furthermore, the domain helped the ECMs to feel they belonged to a community and were accepted by others with whom they shared the practice, therefore developing a sense of community (Agrifoglio, 2015).

Community refers to the social structures that encourage learning through social interactions and relationships among members (Agrifoglio, 2015). Mhakure and Otulaja (2017) cogitated that community in a CoP provided the ECMs and the teachers the context to engage in joint workshops, and further for the teachers to co-analyse curriculum documents, create lessons that integrated IK and then reflect on the integration of IK and WS. Chemistry teachers and community members were the elements of this CoP where knowledge was shared and constructed. Community members who were knowledgeable about IK helped Chemistry teachers to learn from them and engage with the concepts from IK linking them to scientific knowledge. Chemistry teachers did much of the cross-fertilisation of ideas from IK to western science and mastered the knowledge to be taught in the science classrooms. The community-built relationships enabled them to learn from each other; they cared about their standing with each other and interacted and learnt together.

To build a CoP the interaction of members must be regular to enable members to develop a culture of sharing and understanding of the domain and approaches to their practices (Wenger et al., 2002). The community needs to interact more and understand each other views, experiences, and stories on the topic under discussion to enable them to help each other and direct each other on how things must be done. The cultural norms and values need to be understood by the members to avoid arguments as most IK is based on understanding and the connectedness of the people with their environment. For the community to survive, they need to share the same culture, language, and environment. The community members involved in this study could only speak *Oshikwanyama* as their first language and all sessions during the practical demonstration were in the local language where IK is embedded.

Wenger and Wenger-Trayner (2015) indicated that during practice, members share their experiences, stories, tools, problems, and practice. The ECMs shared their experiences with Chemistry teachers on their different IK on the preservation of *Mahangu,* pounding of *Mahangu*, and making of *Oshikundu* that were relevant to the topic of rate of reactions, used as an example in this research. Teachers shared best practices during break times on how to help learners in their subject, the challenges they were facing and how to solve them using the CoP. When teachers shared their experiences during break times, this helped novice teachers to learn how to work in a CoP at their schools. Mhakure and Otulaja (2017) affirmed that practices in a CoP are the shared repertoire of resources such as lesson plans, notes, science kits, theories of learning, and research output by the members of a CoP. The members of the study's CoP helped each other by explaining different experiences they had from the various backgrounds that were acquired from their parents and the communities around them. Practice is not only what people do within a specific context, but it is also the locus of production and reproduction of social relations (Agrifoglio, 2015). This allowed teachers and community members to be involved in PAR.

4.3.3.2 Participatory action research

Participatory action research (PAR) empowers and emancipates participants during the collaborative process and promotes social interaction during the research process (Cohen et al., 2018). This research involved five Chemistry teachers and two ECMs collaborating on the integration of IK in science lessons in Grade 10. This shifted the focus from the individual to collaborative engagement in all phases of the action-reflection cycle of the study.

Participatory action research (PAR) has become widely accepted as effective teaching, learning, and research practice for working with community members and community organisations (Brydon-Miller & Maguire, 2009). This was a formative interventionist study where five Chemistry teachers were involved in a peer-learning community. Participation recognises power imbalances and the need to engage oppressed people (community members) as agents of their change, while action research recognises the value of using research findings to inform intervention decisions (Cohen et al., 2018). Chemistry teachers made their informed decisions based on inquiry-based participation during the visit to the house of an expert community member to observe how *Mahangu* is preserved, the pounding of *Mahangu* flour, and the making of *Oshikundu*. Action research is a systematic study that combines action and reflections to improve or reform the practice (Cohen et al., 2018).

However, PAR does not mean that all participants should be doing the same thing; it recognises the role of the researcher as a facilitator, guider, formulator, and summariser of knowledge and raiser of issues (Cohen et al., 2018). Furthermore, PAR also offers principles and a framework to enable teachers and school-based practitioner inquiry to become more participatory, collaborative, and democratic, in ways that meaningfully engage students, families, and other educators in the full range of the action research cycle (Brydon-Miller & Maguire, 2009). The PAR starts with small cycles of planning, acting, observing, and reflecting which can help to define issues, ideas, and assumptions more clearly so that those involved can define more powerful questions for themselves as their work progresses (Cohen et al., 2018).

The observation was done at one of the ECM's homes for Chemistry teachers to mobilise cultural heritage in science lessons. PAR helped us to participate and to reflect on the processes that were done during the preservation of *Mahangu*, the pounding of *Mahangu* to make flour by using a mortar and pestle, and a practical demonstration of making *Oshikundu*. This allowed Chemistry teachers to take action by reflecting after every excursion was done on the new knowledge and on how to contextualise the IK that was useful in Chemistry on the topic of rate of reactions that was used as an exemplar and other topics. The Chemistry teachers were empowered to become agents of change on integrating IK. For instance, during the practical demonstrations and participatory observation, the Chemistry teachers and I were empowered to become cultural knowledge brokers. That was done through participating on cultural practices of preserving, pounding and making of *Oshikundu* and in a peer-learning community to contextualise rate of reactions. This was central to this research and it allowed us to participate in the cultural activities that are done by indigenous elders.

This was the focus of the research process in particular when we visited the home of Mee Mukwaluvala in order to contextualise rate of reactions. The empowerment was done in an out-of-school context (Braund & Reiss, 2006; Luehmann, 2009; Rennie et al., 2003) which situated the cultural activities and learning within the indigenous research paradigm and was underpinned by the *Ubuntu* perspective. The empowerment could be observed in Sections 7.4–7.8, the practical activities that were done to help Chemistry teachers to contextualise rate of reactions. Chemistry teachers were empowered so that they became cultural knowledge brokers, whose role was to help learners traverse between two worldviews (Wyatt et al., 2017). To achieve this, the PAR approach was used to work with the ECMs. I tried to manage and position the Chemistry teachers as cultural knowledge brokers after empowering them after working with the ECMs.

The action part of PAR is situational and attempts to resolve the problem or achieve the objectives in the CoP (Walter, 2009). This research followed the first five steps of PAR during the practical demonstrations and participatory observation with ECMs.

Step 1: A *problem, issue,* or desire for change is identified by the community of research interest. In this research, we mobilised and contextualised cultural heritage in Chemistry lessons.

Step 2: *collaboration* took place between the ECMs and Chemistry teachers, on the research interest and the researcher and *planning* how to tackle the integration of IK into science teaching. The collaboration between the researcher, Chemistry teachers, and ECMs helped us to work together and have an understanding of the IK perspective.

Step 3: The plan *developed* is then put into action. First, before visiting the community member's house, the workshops were conducted on co-analysing curriculum documents. Three workshops were done with Chemistry teachers in the third phase of the research process.

Step 4: The *action* and its outcomes are then *observed* again by the community of research interest and the researcher. The action from the first step to the last was carried out and at each action Chemistry teachers, the researcher and community members were working together.

Step 5: The final stage in the first cycle was to *reflect* on the action and its outcomes. Each participant was given a journal to reflect on during the research process. Reflection was part of the data-generating techniques, and participants were encouraged to keep reflecting after every workshop session and practical demonstrations at the house of the ECM.

As a research methodology, PAR has been strongly criticised by other social researchers as illustrated in Walter (2009). The criticism has focused on how its participation, democracy, and external ownership aspects can greatly reduce the validity of the research and the rigour of the method used. The other criticism was centred on what is perceived as a moralising tone in PAR methodology. Furthermore, PAR might be seen more as an ideology of how the research should be undertaken, that is, a methodology or a paradigm rather than a practical research method. Even though PAR has been criticised as a methodology it still stands out as one of the methodologies that allow a researcher and participants to work together. This made me supplement PAR with the CoP.

4.3.4 Research site

The research was carried out in the Endola education circuit. The Endola Circuit has 29 schools, 574 teachers, and about 13 734 learners as per the 2020 circuit statistics. The Endola Circuit borders the *Oshana* Region in the South, the *Omusati* Region in the West, and the North borders *Angola* and the *Ohangwena* circuit and *Ongha* circuit in the Eastern part. The research involved five Grade 10 Chemistry teachers from three schools in the Endola Circuit. In the Ohangwena region, Endola is situated at the western part of the region and it is the last circuit in the region (see Figure 1.2). Most people and schools get their services from the Oshakati town, which is the nearest town. The Endola Circuit is 15 km from Oshakati town, in the northern part of the town. The Endola Circuit has many rural schools. The circuit was chosen because all schools that took part in the research are semi-urban schools and learners are from within the region. Most importantly, learners and science teachers had been exposed to many indigenous technologies in the area as they had grown up and lived in this rural region. This research wanted teachers and learners that had been exposed or were being exposed to indigenous technologies. I thus found the Endola Circuit the most suitable circuit to carry out my research.

The research was conducted in the Oshiwambo cultures. The *Aawambo* tribes are found in four regions in Namibia such as the Oshikoto, Oshana, Omusati and Ohangwena regions. The regions are known as the 4O's regions. The four regions also cover the northern part of Namibia that includes the biggest national park in Namibia (Etosha National Park). Aawambo speaking people have many indigenous dialects that are linguistically interconnected. However, the only two languages that were used in this study are *Oshikwanyama* and *Oshidonga*. The *Oshikoto, Oshana* and *Omusati* use *Oshidonga* as their first language in schools, even though people in those regions speak a dialects of *Oshiwambo* languages and can understand each other well. The Ohangwena region uses the *Oshikwanyama* language as the majority of the people in the region speak *Oshikwanyama* as their first language. This research was conducted in the Ohangwena region with one *Oshikwanyama* speaking ECM and the other ECM was an *Oshikwambi* first language speaker and *Oshikwanyama* as their second language. Notably, these two languages (*Oshikwanyama* and *Oshikwambi*) are linguistically interconnected.

4.3.5 Sampling methods

Sampling involves making a decision about which people, settings, events, or behaviours to include in the study (Bertram & Christiansen, 2015). As a qualitative case study research, I used a qualitative sampling of teachers to be participants in this research. Qualitative sampling is the process of selecting participants for a study in such the individuals chosen would be good participants to contribute to the researcher's understanding of a given phenomenon on the integration of IK (Gay et al., 2011). I choose Chemistry teachers based on convenience sampling supplemented by purposive sampling.

According to Cohen et al. (2018), in convenience sampling, the researcher needs to choose the nearest participants (individual) to serve as respondents in the research, while in purposive sampling the researcher chooses the participants based on their experience and the in-depth data. The schools that were chosen to take part in the research were offering Grade 12 in the old curriculum (Grade 11 in the new curriculum). The research was done in Grade 10 (former grade 11) and teachers should be teaching Chemistry in Grade 10. Bertram and Christiansen (2015) differentiated that purposive sampling is when a researcher makes specific choices about which people, groups, or objects to include in the research, and convenience sampling is when the researcher chooses the participants that could be reached by the researcher.

The criteria used to choose the participants were based on the following: teachers should be teaching Chemistry Grade 10, they should be able to reach the ECMs' homes within an hour, and they should be willing to be part of the research process. The participants were selected with the help of the school principals who looked at the teachers that spoke freely and were friendly. Five Grade 10 Chemistry teachers were involved in this research and formed the CoP with two community members that were knowledgeable about indigenous technologies on the preservation of *Mahangu*, the pounding of *Mahangu* to make flour by using a mortar and pestle, and a practical demonstration on the making of *Oshikundu* used as an exemplar in this research. Chemistry teachers attended the practical demonstrations with the ECMs on indigenous technologies that have scientific concepts related to the topic of rate of reactions. Expert community members (ECMs) were chosen after consultation with the community members based on their knowledge of making *Oshikundu*, the methods of ploughing used and the way *Mahangu* is preserved. Expert community members (ECMs) chosen are still preserving *Mahangu* in the traditional way, where IK is embedded. They preserve *Mahangu* in *Okaanda*, the traditional storage.

As proposed by Creswell et al. (2016), purposive sampling members are chosen with a "purpose" to represent a phenomenon, group, incident, location, or type concerning a key criterion. Chemistry teachers chosen in this research were within a 20 km radius of the research venue; they taught at secondary schools that had been offering Grade 11 to 12 (old curriculum) and Grades 10-12 (new curriculum) for the past year; and could reach the training venue within a reasonable time because in most cases, we used the School A as the research centre, unless when going on the excursions to the community members house. They might have been more Chemistry teachers at schools A, B, and C but they were chosen after communicating with the school principals who helped to find participants from their schools.

The Chemistry teachers were selected based on their willingness and eagerness to interact with other teachers and their friendliness, as the study sought to work with the ECMs; the teachers must be teaching Chemistry in Grade 10; they would also be liable to attend all the workshops and practical activities as organised during the research process. At first, I wanted to have three male teachers and three female teachers, however, female teachers were not willing to volunteer as participants in this research. Therefore, there was a gender imbalance in the sampling strategy, four male teachers and one female teacher. The aim at first was not to compare the male and female teachers' data, but for me to have data that were gender-balanced and gender-sensitive. Two teachers from the some school withdrew from the research. However, one teacher voluntarily joined the research participants.

The selection of participants was also influenced by the indigenous research paradigm (Chilisa, 2012; Wilson, 2003). Knowing that the research involved the ECMs and Chemistry teachers, I had to choose teachers that were friendly and embraced other people's cultures. The instruments of generating data were also influenced by the indigenous research paradigm. Working with community members, the practical demonstrations were the best method of generating data. It helped me to generate data because everyone was involved in doing the activities. The ECMs and Chemistry teachers were engaged in the practical demonstrations, which signposted that IK can be transmitted orally, through observation and through engagement in practical activities. This helped us during the practical demonstrations and participatory observation that was carried out at Mee Mukwaluvala's home. The semi-structured interviews, co-analysing curriculum documents, workshops, and practical demonstrations involved all five Chemistry teachers and the practical demonstrations and participatory observation involved five Chemistry teachers, two ECMs, and me as the researcher. Lesson observations and SRIs involved two selected Chemistry teachers who taught co-developed exemplar lesson plans to generate data that answered the research question 4.

4.3.5.1 Teacher participants

This study involved five Chemistry teachers, with four male and one female teacher. I used convenience sampling to select four Chemistry teachers for my research and one joined the research of his own free will. Chemistry teachers opted to use a name they preferred during the research process. For schools, I could not use their real names because I was not authorised either by the Director, Inspector of Education or principals. Thus, A, B and C were used to represent the schools.

Michael from School A

Michael is from the clan of *Omukwamalanga* (their clan is named after an elephant). Michael was the youngest of the cohort of participants. He has one year of teaching experience, and he was the first participant to show his willingness to take part in the research. He holds a Bachelor of Education with Honours, majoring in Biology, Chemistry, and Physics Grades 10-12. He was active throughout the research process, and he volunteered to teach the lessons. I have never seen a more willing person who devoted his time to learning and changing the way he teaches Chemistry to enhance learners' conceptual understanding. He was one of the participants that never wanted to miss the research phases and was always actively asking for the date of the next phase of the research. Michael described himself: "*I am a curious person thus I always want to know the world around me that is why I did not think it twice when he called me to partake in the research*".

Indeed, he was curious, I can attest to that and how involved he was during the practical activities with the ECMs; it was amazing seeing him learning and engaging with ECMs and other Chemistry teachers to unpack the local knowledge embedded in cultural practices. He was not aware of how IK could be integrated into Chemistry lessons; he used to ask about learners' prior everyday knowledge, but he was not that confident to integrate it. After the workshops, practical demonstrations, and participatory observation he developed confidence and he was ready to integrate IK. Even though he was less experienced, the research process helped him to become knowledgeable about many things: "*I feel blessed to be part of this amazing process it is improving my knowledge plus the way of presenting lessons"*. He used the knowledge gained during the research process to further understand how WS and IK could be amalgamated in the lessons.

Sebron from School A

Sebron's family is from the clan of *Mukwanangobe* (their clan is named after a cow). Sebron was a male teacher teaching at the same school as Michael and he was one of the scientists of the group when it came to Biology knowledge as he was teaching Biology and Physical Science at the higher level of the old curriculum (phased out in 2020); for the new curriculum it would be the advanced subsidiary level in Grade 12. He holds an Honours degree in education, majoring in Biology and Chemistry Grades 10-12. He has taught for eight years at the same school, and he showed a great understanding of catalysts when he explained them in terms of enzymes. He wanted to do another BEd Honours with Rhodes University and he was very enthusiastic about studying further. Sebron was driving to and from the ECM's house without complaining about the damage that might be caused to his car. He was excited to be part of the research process as he reflected in his journal: "*I felt very happy as this research process helped me to gain more knowledge and how to integrate IK into the lesson that will enable learners to understand and love the lesson".*

It was observed during the interactions with the community members and other participants that he was always positive during discussions, and he was willing to help where his Biology knowledge was needed to understand certain concepts. He was a highly creative participant who initiated things that were helpful during the research process.

Apart from his willingness to help other teachers, he wanted to grow in the profession and to help other teachers that were willing to grow. He described himself as "*I am keen to learn and understanding and wants to be engaged in professional development as to help in gaining new knowledge and information that will help me to grow".* This was a true portrayal of Sebron as he was responsible for many activities at his school apart from his teaching duties.

Ndeshi from School B

Ndeshi is from the clan of *Mukwanayuma* (their clan is named after a clay pot). Ndeshi was the only female teacher in the research process, and she was teaching at the rural school with Shipefi 16. The school offered Grades 10-11 as of 2021. Ndeshi had 12 years of teaching experience and she was the head of the department (HoD) for Mathematics and science at the school. She holds a BEd Honours majoring in Chemistry and Physics and was currently doing her Master' of Education at Rhodes University. As an indigenous woman, during the practical demonstrations and participatory observation, she used the knowledge she had acquired to work with the ECMs in preparing *Oshikundu*. Her knowledge was noticed throughout the practical demonstrations as she helped the ECM to *Okufifwa*/sieve *Mahangu* flour using *Oshimbale*. She demonstrated her skill in how mixtures could be separated using *Oshimbal*e. This was interesting because none of the male participants could do *Okufifwa* with *Oshimbale (sieve with traditional plate)* and this caught my attention as to why male participants could not do the activities. It was concluded that *Okufifwa* was regarded as a female activity during the pounding of *Mahangu* and sorghum. This concurred with my experiences, when we used to pound maize, sieving was done by the females and males were not allowed to sieve. Ndeshi was skilful in diverse cultural activities and knowledgeable about how things were done in the *Oshiwambo* culture.

Ndeshi was motivated to continue with her PhD after completing her master's in science education that she was currently doing. She narrated in her reflection: "*I had a very great excitement as I learnt a lot through this process. I benefited as much as a Chemistry teacher and as a researcher. It aroused my interest of studying until PhD too"*. This was a true reflection as she continued to reflect whenever we met that the research process helped her in her studies. Without knowing it, the research helped her and encouraged her to do her PhD. Finally, she indicated, "*I would describe myself as a researcher that would always want to find out more, and probe for more information* *from the participants to get what the participants say"*. She was happy being the only female amongst four male participants. Male participants treated her as the queen of the group, and she enjoyed her role as the queen of the family (participants).

Apart from being the queen of the group, she was one of the participants that never delayed moving to the venue whenever the date had been agreed upon. She was always punctual and ready to share the knowledge she had from WS and local science.

Shipefi 16 from School B

Shipefi 16 is from the clan *Mukwamhani* (their clan is named after a ladder). The ladder was used to bring rain. Whenever the rain was needed the clan used to climb the ladder and ask for the rain. He used the name Shipefi as the name of his father which means something new. *Shipe* means new. The name came up when people used to give up *Mahangu* to the church after harvest time, which was done every year. It was on this occasion, which used to be celebrated every year and on the same day that his father was born, and he was given the name. Shipefi 16 was a male participant teaching at the same school as the queen of the group and volunteered himself to present the lesson that was co-planned during the workshop. He completed his studies in Zimbabwe and he holds the Advanced Certificate in Education from North-West University majoring in Physical Science and Biology. At the time of the study, he was teaching Physical Science in the old curriculum to be phased out in 2020 and Chemistry in the new curriculum. He had 12 years of teaching experience that spanned across four schools where he had taught. During the interview, he explained that he loved teaching Chemistry because he was equipped with Chemistry knowledge from the institution of higher learning that he attended:

> *If you have done Chemistry at a higher institution, then yes you can teach Chemistry, but if you just maybe did Physical Science, you will be struggling, but if you have done Chemistry like us in Zim (Zimbabwe) we have done Chemistry and Physics separate subjects. We have done a lot of practicals that helped us to understand the subjects.*

With the knowledge, he gained from the university Shipefi 16 was proud that he did not struggle with the subject content for Grades 10-11 because they did more advanced knowledge than was needed in those Grades. Chemistry and Physics are two separate subjects that allowed him to opt to teach Chemistry as his favourite subject that was influenced by his lecturer who taught him in

Zimbabwe as he narrated: "*He was very good; up to now sometimes I speak like him and learners can laugh at me sometimes when I can speak like him some of the words, but I got them from him*". His love for Chemistry was instilled in him by his lecturer at the university and he could still recall the words and the activities that they used to do in the classroom.

Shipefi 16 was one of the humblest participants and his love of learning was observed throughout the research process. He never came late to the workshops or practical demonstrations because he did not want to miss out on what transpired in his absence. He was eager to study further and improve his PCK as he always inquired about the process of registering at Rhodes University. He always asked questions when he did not understand what was going to be done at any stage during the research process. He reflected: "*I am very flexible and always want to learn new things and gain or enrich my knowledge to the next level*". Flexibility was one of his strong points and during the lesson observation, he portrayed that, and he always listened and then thought about it before answering. The date and time we agreed to do the lesson observation were flexible because of other commitments that came with the post I occupied. We might have planned to meet on a certain day, but other commitments would arise that meant we had to change the date. His flexibility helped me during this research, especially when observing lessons.

Tala from School C

Tala is from the clan of *Omukwanambwa* (their clan is named after a dog). He opted to use the name Tala from his full name Talamondjila, which means looking properly on the road. Tala means to look. The mastermind of the group, Tala join the research process after I informed him about the research that I was doing. As a Rhodes University student doing the BEd Honours degree, he called me and showed his willingness to be one of the research participants, so that he could learn as he would be doing his master's after completing the Honours degree he is currently busy with. Tala holds an Advanced Certificate in Education, and he was studying towards his Honours degree. He was, at the time of this study, teaching Physical Science and Mathematics Grades 8-9 and Natural Science and Health Education Grades 4-7. I called him the '*mastermind'* of the group because he was the one who provoked most of the explanations with further questioning. Throughout the workshops, practical demonstrations and participatory observation, Tala asked more questions of the other teachers to explain further or for the community members to unpack the science behind certain processes. He provoked interactions with questions and his pro-activeness allowed the research to generate more needed data. He always read my mind; whenever I had a question to ask for further explanation, he would ask the question first.

I am so grateful that Tala joined the research process as it made the research more active because the ECMs expected questions from the participants. He created a role for himself that I never expected from the participants. He always questioned for further explanations, and he asked more than 30-50 questions during the practical demonstrations. Even though he found his space in the research process and carried it very well, Tala was eager to learn from other Chemistry teachers and the ECMs. Chapter Six and Seven evidence this as Tala asked question after question. As a student interested in IK, this encouraged him to understand the local practices thoroughly and that could only be achieved by asking the ECMs to explain the cultural identity that they portrayed.

Tala described himself: "*I am a good person who is reliable and ready to help when the need arises*". Indeed, he rose to the occasion when his help was needed, mostly to ask questions and follow-up questions to the ECMs and other Chemistry teachers to clarify further. Apart from this, he was very active during practical activities, as can be seen in most of the pictures in Chapter Seven where he was part of what was happening. Furthermore, he alluded: "*I am convinced that this (presentation) project was the best I was ever involved in"*. Truly from his side, this was noted, as it was observed how he engaged the ECMs and other Chemistry teachers and also by the way he took part in practical activities. In Figure 7.5 he demonstrates his skill in carrying an *Oshimbale* full of *Mahangu* on his head without holding it. This is exceedingly rare for men and more common for women. As Mee Mukwamhani carried her *Oshimbale* without holding it on her head, he decided to copy that.

4.3.5.2 Learners' participation

Learners became secondary participants during lesson presentations by Chemistry teachers, but they were not part of my study per se. Their ages ranged from 16 to 19 years old. Learners were involved in the observations done in the classrooms. For the teachers to enact IK in the science classroom, learners had to form part of the research process. Learners became active participants and their explanations of the integration of IK into Chemistry teaching were outstanding. Due to

COVID-19, however, hostel learners were not allowed to go out of the hostel and all home weekends were cancelled. For this reason, learners could not take consent forms to be signed by their parents. However, the assent for them to be part of the class group was agreed upon in all three schools where the research took place.

4.3.5.3 Expert community members

This research involved two ECMs on the preservation of *Mahangu*, pounding *Mahangu* flour and a practical demonstration on making *Oshikundu*. The ECMs were from two different homes and two tribes (*Kwanyama* and *Kwambi*). The ECMs in this study were regarded as knowledge holders. Thus, through their indigenous practices, they enabled the Chemistry teachers to become cultural knowledge brokers during practical activities. Further, cultural knowledge brokering was fostered through the use of indigenous language and artefacts (Chang, 2020). The two ECMs formed a CoP as they were from different tribes that allowed them to share different knowledge. The aim of choosing two ECMs from the *Oshikwanyama* and *Oshikwambi* tribes was to share how *Oshikundu* was prepared differently in those tribes since IK is context-dependent and context embedded.

Before the practical demonstrations, they met to share the common knowledge that they presented to the teachers during the workshop. They learnt from each other how *Mahangu* is preserved and the way *Oshikundu* is made. They had common knowledge on the preservation of *Mahangu*, pounding of *Mahangu* to make flour by using a mortar and pestle, and a practical demonstration of making *Oshikundu*. This did not stop a family member of one of the involved ECM to form a CoP in helping to enrich the explanations. This family member became an outsider participant, and it was important for her to become part of the research. Indigenous knowledge (IK) can be transmitted orally and by observing practices during the visit to the houses of the ECMs. EMCs did not want to be coded either and they preferred to use their clan names.

Similarly to Mutanho's (2021) study, the ECMs selected for this research were individual people that were known for their cultural heritage of preserving *Mahangu* using indigenous ways of doing it and pounding of *Mahangu* using a pestle as demonstrated in this study, while other indigenous people had moved to the use of machines. This shows that IK is not static but changes with time and technologies. They preserved *Mahangu* in the *Okaanda* (traditionally made storage). They were knowledgeable on making *Oshikundu* and other traditional beverages. This made them well known by other community members. I now look at each EMC involved in my study.

Mee Mukwaluvala

Mee *Mukwaluvala* (their clan is named after a zebra). Mee Mukwaluvala was a 64-year-old female. She has been making *Oshikundu* for the past 60 years and she gained the knowledge when she was young through observing her parents and other community members. The process was instilled in her from an early age. She understood the processes and could explain each step. This resonates very well with the idea that IK could be transmitted orally and through practical engagement in activities and observation, from one person to the other.

Mee Mukwamhani

Mee *Mukwamhani* (their clan is named after a crocodile). The second ECM was 53 years old and had more than 45 years of experience in the preservation of *Mahangu*, making *Mahangu* flour by using a mortar and pestle, and practical demonstrations on making *Oshikundu*. She acted as an assistant to the other ECM. She learnt about making *Oshikundu* through observing what her parents used to do when she was still young.

4.3.5.4 Research assistants A and B

The research involved two research assistants during the visit of the ECMs on the preservation of *Mahangu*, making of *Mahangu* flour by using mortar and pestle and practical demonstration of making *Oshikundu* in the surrounding (communities). Research assistant A was required to help me videotape the practical demonstrations done by the ECMs and other research processes where the video was used to generate data. The use of the research assistant helped me to have better communication with the ECMs as they assisted in videotaping. Research assistant B was used as a translator when transcribing data from practical demonstrations and terminologies in the *Oshikwanyama* language that I could not fully understand, as I am not an *Oshikwanyama* first language speaker. I purposively chose the participant as she had a master's in education (science education). She taught Physical Science (now Chemistry & Physics) Grade 8-12 for the past 10 years.

Language forms a repository of any cultures' knowledge treasures (Vakalahi & Taiapa, 2013) and for *Oshikwanyama* speaking people it is their pride and identity in the Northern part of Namibia. I worked with research assistant B to help me transcribe the data generated from the practical demonstrations. A consent letter was signed by research assistant B where they agreed not to reveal their names and any information related to them. I did not ask if they were willing for their names to be used. During transcribing, the participants' names were used as I was permitted to do so. I used the data from the audio after transcribing was done, to re-watch the video alone and link the data to the participants, which was not done during the process when the research assistant was transcribing. This was done to correct any data that was attached to the wrong participants.

4.3.6 Data generation methods and research phases

This research employed a variety of data gathering methods such as semi-structured interviews, co-analysing Chemistry curriculum documents, workshop presentations and discussions, participatory and lesson observations, SRIs, and reflections of participants.

4.3.6.1 Semi-structured interviews

In the first phase of this study, I interviewed five Chemistry teachers about their perspectives, experiences, and pedagogical insights about the integration of IK in science lessons. Interviewing is a two-way conversation in which the interviewer asks the participant questions to collect data and to learn about the ideas, beliefs, views, opinions, and behaviour of the participant on the particular topic under research (Creswell et al., 2016). I adapted the structure of the interview schedule from Cetin-Dandar and Geban (2017; see Appendix G). This was adapted to illustrate the questions being asked and the purpose of asking such questions as the structure of semi-structured interview questions should be set with purpose. For example, the first question was: *Could you please tell me about your experiences of teaching Chemistry using learners' prior everyday knowledge?* And the purpose was to find out about their experiences of teaching Chemistry starting from learners' prior everyday knowledge.

The semi-structured interview schedule was given to some PhD and master's students to read to ensure that the questions were not ambiguous. After working on any ambiguous questions, I piloted the research by interviewing my classmate doing a PhD and this helped me to see if the questions would generate data that could answer my research question 1. The piloting of this research instrument was done to increase the reliability, validity, and practicability of the instruments before it was used to generate data. The SSIs lasted about 30-60 minutes for each participant. Research questions were in English and Chemistry teachers were allowed to answer the questions in *Oshikwanyama* or English. Most teachers were able to shift between the two languages during the interviews. The semi-structured interviews were conducted at the schools where participants were teaching, and quiet places were arranged for this. Semi-structured interviews allowed me to probe for more information on the responses that were not clear by asking follow-up questions. The data generated from SSIs were analysed using Atallah et al.'s (2010) criteria that focus on the conceptions and dispositions of teachers regarding the integration of IK in science classrooms (see Appendix H).

Semi-structured interviews were conducted in a good atmosphere, as participants refused to be interviewed via the phone but demanded face-to-face interviews. This allowed me to observe and understand the gestures used and other things that I could not observe during phone interviews. During the SSI it was necessary to observe the gestures of the participants to understand if they were sure about what they wanted to say or not. Gestures can give the researcher direction on how teachers/participants felt about the questions when posed to them. Moreover, observing participants' gestures can inform the researcher to rephrase the questions asked. In this study, gestures were observed and used for analysis purposes. For instance, sounds like 'aaaaa, mmhhh' were associated with gestures.

4.3.6.2 Co-analysing curriculum documents and workshop discussions

In the second phase: pre-intervention 1: English was used as the language to generate data, however, the *Oshikwanyama* language was used in some cases when explaining the processes of the rate of reactions using *Oshikundu*. The orientation workshop allowed me as a researcher to introduce myself to the participants and also for the participants to get to know one another. The aim/goal and the objectives of the research were highlighted during this workshop. The research process was explained and made clear to the participants and room for questions and answer were provided. Reflection journals as a data-generating technique were given to participants and it was explained to them the importance of reflecting.

The third phase: pre-intervention 2: Co-analysing documents was useful as the baseline data of my study, particularly if the research design includes other methods such as interviews and observation (Rule & John, 2011). It was hoped that co-analysing curriculum documents would help teachers to have a better understanding of how the NCBE, the Chemistry syllabus, and Chemistry textbooks present the use of the components of topic-specific PCK. This phase allowed Chemistry teachers to learn from each other through peer-learning communities and workshops when analysing the NCBE. They engaged in discussions for further understanding and questions were allowed to be asked for further explanation.

During this workshop, we co-analysed the documents on how TSPCK is addressed. We co-analysed the Chemistry curriculum, Chemistry syllabus, three Chemistry textbooks, and examiners' reports for the past six years (2015-2020). Grade 12 examiners' reports were used to analyse how learners were answering questions. The research was done when the revised curriculum was implemented at the secondary phase. For example, in 2019, the Grade 10 content which was at junior secondary schools was moved to the secondary phase and replaced the Grade 11 content. Moreover, the Grade 11 content replaced Grade 12 in 2020 and Grade 12 became the new grade offering advanced subsidiary (AS) in Namibia in 2021. We needed to analyse Grade 12 examiners' reports and question papers. Grades 11 and 12 in the old curriculum was a two year course, and in the new curriculum,Grade 10 and 11 became a two year course and learners wrote the external examinations at the end of Grade 11. Grade 12 became a one year course. There were three workshops to co-analyse documents.

The first workshop: We co-analysed the NCBE. Analysing national documents made participants aware that it allows them to integrate IK in the science classroom. The curriculum was analysed using Mavhunga and Rollnick's (2013) TSPCK components.

Second workshop: We co-analysed the Grade 10 Chemistry syllabus and three different textbooks used in Grade 10 using TSPCK. This might enable teachers to be aware of the topics that they can integrate with IK.

Third workshop: We co-analysed the Physical Science question papers and examiner's reports for the past six years from 2015 to 2020 on how the questions were asked and the challenges when learners answered those questions; specifically, questions that had IK background in them.

During co-analysing curriculum documents, Chemistry teachers collaboratively shared their understanding and knowledge that helped other participants to become knowledgeable on the integration of IK. Collective PCK (cPCK) (Carlson & Daehler, 2019) was achieved during those three workshops that we had with the Chemistry teachers. The three workshops were conducted in a conducive environment and participants were happy and participated during the workshops. The workshop on co-analysing the curriculum document was one of the best workshops as participants were able to reflect on and use indigenous technologies to explain science concepts. This allowed them to connect scientific knowledge and IK and hold them side-by-side.

4.3.6.3 Practical demonstrations, participatory observation, and discussions

The fourth phase: Intervention phase 1: During this phase, the *Oshikwanyama* language was used to accommodate the ECMs. During this phase ECMs were cultural knowledge brokers (Wyatt et al., 2017) that helped Chemistry teachers to understand IK from a cultural point of view and apply it to scientific knowledge. Practical demonstrations and participatory observation took place at the house of one of the community members on how they preserve *Mahangu*, pound *Mahangu* flour by using a mortar and pestle, and how to make *Oshikundu*. Chemistry teachers were involved in out-of-school context learning with the ECMs on preserving and pounding of Mahangu and making of *Oshikundu* which helped them to learn from the ECMs and from each other. The first visit was to familiarise the participants and the ECMs. This was more of an orientation visit where we agreed on the dates for each step in the preserving of *Mahangu* and the making of *Oshikundu*. The second visit was the first step where the ECMs explained the preservation of *Mahangu*, the pounding of *Mahangu* to make flour using a mortar and pestle, and the preparation of *Oshikundu*. Mee Mukwaluvala and Mee Mukwamhani explained to Chemistry teachers the ingredients used, why such ingredients were used and what apparatus was used in the making of *Oshikundu*. The third visit was to observe the fermentation process and testing of the gas released with lime water and testing for *Oshikundu* as an acid or base. This was more scientific and ECMs were also part of the process. Chemistry teachers were allowed to ask questions so that the community members could explain further.

The interactions that took place between the ECMs and Chemistry teachers helped us understand that the only way to win in the integration of IK is through long-term PD with ECMs. The way the participants were involved from the word go, encouraged Chemistry teachers to be involved. The realms of PCK such as collective PCK (cPCK) and personal PCK (pPCK) (Carlson & Daehler, 2019) were achieved during the practical demonstrations and participatory observation. The ECMs and participants worked collectively, and IK was enacted for the teachers through participatory observation. Chemistry teachers asked questions based on their understanding that helped to direct the ECMs to explain further.

4.3.6.4 Observations and stimulated recall interviews

The fifth phase: Intervention phase 2: In this phase both English and Oshikwanyama were used to generate data. Observation means that the researcher goes to the site of the study, which could be a school, classroom, staffroom, or community meeting, and observe what is happening there and see for themselves (Bertram & Christiansen, 2015). Lending support, Cohen et al. (2018) indicated that observation is a research process that offers the researcher the opportunity to gather "live" data from natural occurring social situations. In this research, two observations were done at separate places.

The first observation was done during the practical demonstration at the house of Mee Mukwaluvala. This was a participatory observation because all five Chemistry teachers and I observed all the processes to gain more knowledge on the preservation of *Mahangu*, the pounding of *Mahangu* to make flour by using a mortar and pestle, and a practical demonstration of making *Oshikundu.* Creswell et al. (2016) explained that observation is the systematic process or recording of behavioural patterns of the participants or objects without questioning them or communicating with them. The first observation was during the workshops and practical demonstrations, and this answered research question 2 and was the result of the CoP when the ECMs scaffold Chemistry teachers. Chemistry teachers were taught by the ECMs on scientific concepts that could be used to contextualise the rate of reactions.

After the workshops with the ECM on the preservation of *Mahangu*, the pounding of *Mahangu* flour by using a mortar and pestle, and the practical demonstration on making *Oshikundu,* I had the workshops with five Chemistry teachers on the integration of IK with WS. The workshops were on how to co-develop exemplar lessons based on the five TSPCK components. This allowed us to reflect on how IK could be useful when integrated into science lessons. The two co-developed exemplar lesson plans included all five components of TSPCK (Mavhunga & Rollnick, 2013). These exemplar lessons were taught later. The workshops were videotaped by the research assistant after permission was sought from the participants.

The sixth phase: Intervention phase 3: The second observation was done in the science classroom when Chemistry teachers taught the lessons using the knowledge gained during the workshops and practical demonstrations. The Chemistry lessons were observed to help me understand the PCK and the five components of TSPCK for science teachers during the science lessons. Cohen et al. (2018) argued that observation data are sensitive to contexts and demonstrate strong ecological validity. We planned two exemplar lesson plans with Chemistry teachers to be able to integrate IK on any topic in Chemistry lessons using TSPCK. I observed two lessons from one teacher at each school and the other teacher served as a critical friend during and after the lessons (see Appendix J). All the lessons were audio and videotaped with the permission of the participating Chemistry teachers. After the lessons, SRIs were conducted with the participants to validate the outcome of the lessons and the interaction during the Chemistry lessons. I probed more by asking questions when watching the videos (lessons) with the teachers. The other teacher became a critical friend during the lessons and the SRIs. Stimulated recall interviews (SRIs) enriched my data; during these interviews, teachers clarified what they meant or wanted to do during the science lessons. The use of SRIs in this research was intended to seek clarity on the lessons that involved different indigenous practices that had scientific concepts in them. The SRI has often been used to explore aspects of cognition that lie behind participants' decisions and actions (Ryan & Gass, 2012). The SRIs helped me to discover unseen knowledge that was not revealed during lesson observations. The SRIs were done within a day or two of teaching the lessons before the participants forgot what they had taught.

Observing Chemistry teachers using IK in westernised classroom settings helped me understand that the two worldviews complement each other in science classrooms. Co-developed exemplar lessons were created to allow Chemistry teachers to have a better understanding of how IK could be integrated. Lesson plans were planned based on the five components of TSPCK. Extending on TSPCK, enacted PCK (ePCK) was used to further understand the role of Chemistry teachers in science classrooms. Three existing forms of ePCK, ePCK for planning ($ePCK_P$), ePCK for teaching ($ePCK_T$), and ePCK for reflecting ($ePCK_R$) (Alonzo et al., 2019; Can, 2021) helped me further understand the PCK of the Chemistry teachers before, during and after the Chemistry lessons.

4.3.6.5 Participants' reflections

The seventh phase: The post-intervention phase: In this phase, reflection is an important step, so that qualitative researchers can address any imperfections in the data analysis (Roller & Lavrakes, 2015). Chemistry teachers were in two groups and came up with mind maps that resulted in a concept map during the reflective workshop. They used their reflection journals to help them with concepts that emerged during the practical demonstrations with the ECMs and other workshops. I allowed Chemistry teachers to use all the concepts that emerged during the practical demonstrations with the ECMS, even the concepts in the local language as this resonated with the SCT (Vygotsky, 1978). Chemistry teachers reflected on how they found the whole research process, what new knowledge was gained, what was insightful about the research or not, what needed to be done differently, what their pedagogical shift was after the workshops, the use of TSPCK to plan exemplar lessons and co-analyse the documents and lastly, their feelings about their involvement in the research process. The reflection journals were collected during the last workshop (see Appendix I). We revisited the ECMs to give feedback on the data that were generated during the practical demonstrations and gave feedback on the findings. However, reflections in this research were guided by questions that directed the participants on what to reflect on. This was done to be able to obtain the data I needed to answer my research questions. Furthermore, the ECMs were given the chance to reflect when we revisited them.

The process was not linear because I had to go back and forth to make meaning from the data generated for the study. I took time to complete all the processes and some processes took more time to carry out successfully. Data generated in this research were analysed using inductive-deductive data analysis.

4.3.7 Data analysis

This research was an interpretive case study that sought to understand the phenomenon surrounding the mobilising of indigenous practices as an example of how to integrate IK to contextualise Chemistry lessons. The data were generated using semi-structured interviews, co-analysing of curriculum documents, practical demonstrations and participatory observation, workshop discussions and presentations, lesson observations, SRIs, and reflection of participants, and were analysed using different analytical frameworks. Data generated were triangulated and coded. Walker and Myrick (2006) defined coding as conceptualising data by constant comparisons of incidents with incidents, and incidents with concepts. Coding is the process of reading carefully through transcribed data, line by line, and dividing it into meaningful analytical units (Creswell et al., 2016). Coding is therefore defined as marking the segments of data with symbols, descriptive words, or unique identifying names (Creswell et al., 2016).

The data generated from participatory observations during the practical demonstrations with the ECMs were coded and analysed using SCT and SCT constructs to be specific, which allowed me to analyse the data generated from lesson observations on the SMK of teachers in the classroom context. I used SCT to analyse the data on how teachers intertwined IK and western science with the focus on culture, language, social interaction, mediation, and ZPD when scaffolding learners using IK to learn science concepts. Teachers' PCK was central to how they dealt with learners' difficulties when learning scientific concepts using IK and learners' life experiences. Therefore, teachers' PCK with the support of the TSPCK translation device was used to analyse data from the co-analysing of curriculum and other related documents.

The data were analysed by taking into account the phase in which it was generated during the process of data-generating techniques and the questions they were answering. The data were analysed using inductive-deductive data analysis. Deductive data analysis looks for the evidence in the existing data determined by the literature, while inductive data analysis allows the themes to emerge from the data itself (Creswell et al., 2016; Creswell & Creswell, 2018). Additionally, Bertram and Christiansen (2020) posited that during the inductive data analysis process data are organised into categories and patterns identified among the categories. In this process, the categories, themes, and patterns emerge from the data. In deductive data analysis, a researcher starts with a set of categories, which are then used to categorise and organise the data. Both data analysis models were employed to add quality to the data analysis process that allowed me to be able to identify new knowledge from the data.

The coding process involved recognising (seeing) important moments and encoding the data before the process of interpretation (Fereday & Muir-Cochrane, 2006). After coding the data into categories, I then grouped them into themes by coding related categories together into themes. Walker and Myrick (2006) asserted that coding in qualitative research is one way of exploring pieces of information in the data and looking for similarities and differences within these pieces to categorise them and label the data. To code means that data are broken down, compared, and then placed in categories that will later form themes. Similar data were placed in related categories, and different data create new categories. To ensure that I carried out the qualitative case study and its data analysis correctly, I needed to abide by the data analysis process as discussed (see Appendix U).

4.3.8 Limitations of the study

This study was based in the Endola Circuit of the Ohangwena Region, and it only involved five Chemistry teachers that could not represent all the Chemistry teachers in the country. The five Chemistry teachers were purposefully selected based on the location of the schools and the rapport between the teachers, me and the help from the principals. As a case study, the findings were specific to the given context and cannot be directly generalised to the larger population of Chemistry teachers. However, the findings could give insights into how WS can be contextualised in science classrooms. This research involved two ECMs and five teachers that represented an exceedingly small percentage of the population in the science discipline. The other limitation could be the use of indigenous research paradigm and transformative research paradigm, I might have not weaved them nicely in my research as a new scholar that has less knowledge on them.

In a case study, a larger sample does not always equate to quality data but depends on the reliability of the research instruments used to generate data. As Shipefi 16 suggested in his journal reflection: "*We need to have more Chemistry teachers*" involved in similar research so that they can learn about the integration of IK into Chemistry lessons. However, even though five participants seemed to be few, the data that were generated using the instruments throughout the research process were enough to answer the research questions fully. The instruments used were reliable and trustworthy. The impact of the COVID-19 pandemic contributed to the limitations on social interactions during workshop presentations and discussions and also during participatory observations. Data were generated keeping in mind the safety precaution as stipulated by the World Health Organization (WHO).

4.3.9 Trustworthiness, validity and credibility of my research

In this section, I discuss the trustworthiness, validity and credibility related to my research. This allowed me to adhere to the ethical considerations. I further look at the ethics related to the use of the real names of participants in this study.

4.3.9.1 Trustworthiness

Gay et al. (2011) averred that qualitative researcher should establish the trustworthiness of their research by addressing the credibility, transferability, dependability, and conformability of their study and findings. The trustworthiness of my research depended on the triangulation of the data collected during the seven research phases. Validity is an important aspect of the research process. Without validity, the outcome of the research could be null or invalid. Gay et al. (2011) asserted that validity is the degree to which qualitative data accurately gauges what the researcher is trying to measure. Validating data in this study was done, especially during the reflective space with the five Chemistry teachers on the research process, as that helped me validate the trustworthiness of the research and the outcomes when interpreting the data gathered during all the research phases undergone in the study.

To this, Yeasmin and Rahman (2012) advocated that triangulation is a process of substantiation that increases validity by incorporating different data and methods. The data generated from all the phases were triangulated for the data to be valid. This allowed me to synthesise the findings of the research. Using multiple data-generating techniques avoids insufficient, ambiguous, and complex data obtained from one method of data-generating technique. Triangulation avoided this and allowed me to have enough data that I could triangulate to improve the validity and trustworthiness of my research. Furthermore, member checking was done to validate the data. Koelsch (2013) indicated that during member checking transcribed scripts are completed to aid researcher reflexivity and assess the catalytic validity of the research study. The trustworthiness of my research depended on the triangulation of the data collected and the feedback I got from the SAARMSTE research school after presenting my findings, which in turn strengthened the research by combining different research methods in this interpretive case study research.

4.3.9.2 Validity

Validity is an important aspect of the research process. Without validity, the outcome of the research could be null or invalid. Validity is often defined as the extent to which an instrument measures what it purports to measure (Kimberlin & Winterstein, 2008). Gay et al. (2011) assert that validity is the degree to which qualitative data accurately gauge what it is trying to measure. Validating data helps the researcher to establish the trustworthiness of the research outcomes when interpreting the data gathered during the process of data narrative and discussion techniques. Validity in this research was ensured by using multiple data-generating techniques and also by testing the instruments to see if they would give the correct data (Cohen et al., 2018).

For further validation, we revisited the ECMs with the Chemistry teachers and were welcomed in the cultural way as discussed in Section 7.3.1. We presented the findings that emerged from the practical demonstrations and participatory observation. Additionally, we engaged the ECMs further on their cultural norms and excitement and happiness were observed during our visit. During the revisit to validate the data, and unlike Liveve's (2022) study where they were seated around the fire to give feedback on their data with the ECMs, we were seated under a big tree in a semi-circle to allow us to have equal distances between ourselves and the ECMs (see Figure 7.18). A sharing circle was used for us to be able to see each other's expressions and gestures, especially the ECMs during the feedback (Afonso-Nhelevilo, 2013; Lavallee, 2009; Smith, 1999). This allowed eveyone's voice to be heard equally and for us to have eye contact. This demonstrated the indigenous research paradigm as discussed in Section 4.2.2. This resembled the *Olupale*, as it was in the form of a three sided rectangle (see Figure 7.1). The ECMs were assured that their knowledge was especially useful in science classrooms and the teachers promised to invite them to their classrooms to present some of the IK relevant to science topics.

For further validation, transcripts were given to the Chemistry teachers to check for accuracy during member checking and they were happy with them. Member checking is often a single event that takes place only with the verification of transcripts. Creswell and Miller (2000) assert that with member checking, the validity procedure shifts from the researcher to the participants in a study and also helps to establish credibility in the research. Furthermore, member checking helps to improve the trustworthiness of the research, when the participants check the correctness of the data, participants (teachers) add credibility to the research by having an opportunity to react to both the data and the final narrative (Creswell & Miller, 2000). Noteworthy is that the member checking in this study was used as a means of verifying the accuracy of a participants' words, but it was also used as a means of equalising power relationships within the research relationship by enlisting participants as members of the research team (Koelsch, 2013). Furthermore, Koelsch (2013) indicated that during member checking, transcribed scripts are completed in order to aid researcher reflexivity and assess the catalytic validity of the research study.

4.3.9.3 Credibility

The credibility of the research depended on the questions that I asked during the research process to generate data to answer the research problem. Shenton (2004) asserts that for credibility to be accurate the following needs to be considered. *Firstly*, the adoption of research methods must be well established in qualitative research. *Secondly*, to develop an early familiarity with the culture of participants or organisations before the first data is collected. A rapport was developed between the participants and me to get to know the culture of the school and the school environment. *Thirdly*, random sampling of the individuals to serve as participants. Participants were chosen based on Bertram and Christiansen's (2015) convenience sampling and, *fourthly*, triangulation by using different data-generating methods. This research used different data-generating techniques such as semi-structured interviews, document analysis, practical demonstration and participatory observation, lesson observation, SRIs and reflection of participants. *Lastly,* tactics to help ensure honesty in participants when collecting data. Creswell et al. (2011) clarify that credibility could also be enhanced through the development of an early familiarity with the participants and the participating organisation, but also through well-defined purposive sampling, detailed data collection methods and triangulation.

4.3.10 Ethical considerations

Before the research was conducted, as a researcher I had to adhere to the ethical considerations outlined by Rhodes University's Faculty of Education and fill in an Ethical Approval Application with the Education Higher Degrees Committee along with the research proposal. The form required me to outline my ethical principles based on the following principles, such as respect and dignity; transparency and honesty; accountability and responsibility; and integrity and academic professionalism. I adhered to these ethical principles during the research process. The process of collecting data and the data analysis needed to be trustworthy, validated and triangulated.

After this, I wrote letters to the Regional Director of the Ohangwena Region, the Inspector of Education and the three principals of the schools in the Endola Circuit who would be involved in this research. The letters requested and informed the Director, Inspector, and the principals of the purpose of the study. This was done from the top to the bottom hierarchy – from the Director of Education down to the teachers. The letter from the Director was attached to the letter that was written to the Inspector, and the two responses were attached to letters that were written to the principals. This process continued until the letters reached five Chemistry teachers and two ECMs. Meetings and telephone calls were held between me and the respective principals to discuss the content of the letter sent to the participants and dates for data collection were agreed upon. In all the letters I made it clear that the teachers who took part in the semi-structured interviews, participatory observations, lesson observations, and SRIs were audio and video recorded.

4.3.11 Ethics related to the use of real names

Ethics related to the use of real names or nicknames were explained to the participants before and during the research process. Chemistry teachers questioned the use of codes if their names could be used and whether they could be happy if the names that they chose were used in the research. With this participants were given the option to choose the name they felt comfortable to be used in the write-up of the thesis. All participants decide to use the name they like to be called with. All participants were assured that their names would be used as agreed. Similarly to Mutanho's (2021) study, participants were not happy with the use of codes but wanted their real names to be used as this made the proud and everyone who would read the thesis would be able to know that they contributed to the knowledge in science. For instance, Ndeshi indicated "*am not a theft for name or identity to be hidden, I want my name to be used and for my grandchildren to be able to know that I contributed to this research. If you cover my face and name how will they know that it was me*". Adding to this, Sebron alluded "*if I could be a criminal, yes I could tell you to hide my names and identity, I will be happy for my name to be used in this research. I am Sebron and I have nothing to hide*". As noted, working with indigenous people always question the covering of faces and not using the names. The ethics were influenced by the indigenous research paradigm. Indigenous people value Ubuntu more than anything and because of this outlook of the Chemistry teachers and ECMs, it allowed me to use their names and photographs in this thesis without covering them.

4.4 Chapter Summary

In this chapter, I presented the research methodology underpinning this study. Within the research methodology, I discussed the research paradigms informing this study, namely the transformative research and indigenous research paradigms. Additionally, I discussed the research design employed in this study, that is, the case study research design as well as the research approaches CoP and PAR. The sampling method was explained and the research process, which included how data were analysed was explained in detail. Lastly, the limitations of the study were addressed and the ethical considerations which included the study's validity and trustworthiness were ensured.

CHAPTER FIVE: SEMI-STRUCTURED INTERVIEWS

> There would have to be a relationship between the interviewer and interviewee that transcended the research that promoted a bond of friendship, a feeling of togetherness and joint pursuit of a common mission rising above personal egos. (Cohen et al., 2018, p. 410)

5.1 Introduction

Central to my interventionist study I carried out was how Chemistry teachers could be supported on how to mobilise indigenous technologies as an example of how to integrate IK on the rate of reactions. However, Snively and Williams (2008) cautioned that before researchers facilitate the integration of IK in science teaching, they should explore their views on the appropriateness of what IK to integrate. These scholars believe that this would enable smooth border crossing (Aikenhead & Jegede, 1999) among the participants. Henceforth, in this chapter, I present the data generated from semi-structured interviews as baseline data for this research and to answer my research question 1: *What are Grade 10 Chemistry teachers' experiences, and pedagogical insights on the use of IK in Chemistry learning and teaching before they were engaged in a peer-learning community and with the ECMs?*

Essentially, I used semi-structured interviews to get in-depth data on Chemistry teachers' experiences, and pedagogical insights regarding the integration of IK in their teaching using rate of reactions as an example. As indicated in the epigraph, the friendship between the interviewer and interviewee created room for freedom for the interviewees. The demographic information of participants is presented in Appendix T, Table 1.

5.2 Findings that Emerged from Semi-structured Interviews

After critically analysing the data generated from the semi-structured interviews, which is phase one in this study, the sub-themes that emerged were combined into five themes. The four themes focused on the experiences, and pedagogical insights of the Chemistry teachers when mediating learning of Chemistry lessons (see Appendix T, Table 2). Data were analysed using inductive-deductive data analysis approaches and SCT and PCK were used as analytical frameworks. The themes that emerged from the data were supported by literature and theory. I now discuss each theme below.

5.2.1 Chemistry teachers' pedagogical insights and experiences on integrating IK in Chemistry teaching

The following questions were asked to the Chemistry teachers: *Could you please tell me about your experiences on teaching Chemistry using learners' prior everyday knowledge? Could you please tell me what your views are on the integration of IK into Chemistry lessons?*

It emerged from the interviews that the five Chemistry teachers who participated in this study that they seemed to be at different levels of their understanding of integration of IK in their classrooms. For instance, Ndeshi, Sebron and Shipefi 16 seemed to be aware of the integration of IK in school science. They showed how scientific knowledge and IK are connected and interconnected indicating that one cannot talk about science without referring to the IK within the community. They also felt that the integration of IK has a potential to help learners to reconnect to their context when examples from the local community are used in the classrooms for further clarification and conceptual understanding. They acknowledged, however, that for the teachers to be able to integrate IK into their lessons, thorough preparation needs to be done before the lessons are taught.

Moreover, teachers have to be able to consider local examples that they can integrate into the lessons. These findings seem to suggest that these three Chemistry teachers might be integrating IK in their classrooms. It should be recognised, however, that it is common for teachers to explain during the interviews what they do in their classes and yet in practice you find that they do something different. Duit et al. (2013) indicated that there still a large gap between what is done in theory and in practice in science classrooms. They further indicated that "large gap between what is known about effective teaching and learning science from theoretical perspectives and the reality of instructional practice" (Duit et al., 2013, p. 1). The gap is created in the pedagogy that teachers use that does not support the integration of IK, for example, the Chemistry teachers indicated that IK could be integrated into their Chemistry lessons during classroom observation.

However, Sebron illustrated by showing his experiences when teaching the topic of fermentation and he elaborated:

> *I equip learners for instance, when am teaching fermentation. I refer them to the way we prepare Ovambo liquor at home, we collect fruits from the trees and put them in water for them to ferment. After fermentation we boil the mixture, the alcohol evaporates first, and water remains because alcohol has a lower boiling point than water.*

Regarding the above excerpt, it shows that Sebron has experience in explaining to the learners how fermentation is happening by taking them back to their context before moving to WS (Chikamori et al., 2019).

In contrast, however, two Chemistry teachers, Michael and Tala seemed to be not knowledgeable about the integration of IK in Chemistry lessons. This suggests that these five teachers were according to Vygotsky (1978) at different ZPDs in terms of IK integration. For example, they had to ask me to explain to them about the integration of IK in science teaching before the semi-structured interviews. It also emerged that they seemed to have different approaches in their teaching. For instance, Michael indicated that, "*In planning, you have to consider what the learners know from home and what you know as a teacher and what you are going to teach*". That is, according to him, the knowledge the learners know should be considered during preparation and what the teacher knows before going to the classrooms. This finding seems to be congruent to Mavhunga and Rollnick's (2013) topic-specific PCK learner prior knowledge component. My criticism of these scholars, however, is that they seem to restrict learner prior to what has been taught in the previous grade or topic at the expense of learners' prior everyday knowledge from home or community as reiterated by Kuhlane (2011). The latter is central to the peer-learning community foregrounded in this study.

In this regard, Shipefi 16 indicated that teachers teaching the same subject need to come together and plan together so that they will be able to use the same examples in their science classrooms. He noted that: *"We have common examination and tests, but planning together what we are going to teach, this part try to integrate this local examples to make learners understand better, we do not do that at our schools"*. This is not visible at his school and it thus be deduced that there a lack of PLCs at the school (Brodie, 2013). Learners' prior everyday knowledge becomes useful in science teaching and learning when science teachers use examples from learners' life experiences in their lessons (Gwekerere, 2016).

On this, three Chemistry teachers had experiences on how to use learners' prior everyday knowledge that they gained when interacting with the elderly or community members (Lavallee, 2009). For instance, three teachers explained that:

> Michael: *I link the knowledge that they learn from home and the one that they are going to learn in the science classroom.*
>
> Sebron: *I explain to them that proteins are made from carbon reacting with Oxygen and Hydrogen and most of the food that we use to eat at home is made from proteins but they do not know that*.
>
> Shipefi 16: *I refer to this example of fractional distillation where we make Ombike, we have that process, and it is a very good example to use when teaching these learners about fractional distillation. The whole process of making Ombike from fermentation is just the same as the one in the textbooks.*

The insights from these statements seem to indicate that Chemistry teachers need to integrate IK by ascertaining what the learners already know from home, the environment, or their communities. Three Chemistry teachers in this research showed that they integrate the IK of learners to help them learn new concepts which is an accepted practice. Aikenhead and Jegede (1999) showed that for 90% of learners' scientific knowledge movement between the micro-culture (IK) of their family and the micro-culture (science knowledge) of school science is not a smooth process and is often limited by disconnection between IK and WS. Le Grange (2007) refers to this as cognitive dissonance. Hence, to address this problem, teachers need to be cultural knowledge brokers (Aikenhead & Jegede, 1999; Wyatt et al., 2017) in order to smoothen the pathway to be able to explain and cross-fertilise ideas between these two worldviews. In this regard, Seehawer and Breidlid (2021) accentuated that there should be a dialogue between IK and WS. Such dialogue might close the gap that is created between IK and WS.

For instance, in her study that Kota (2006) conducted in South Africa, she proposed that teachers should feel free to use all available resources from the learners' community to broaden the curriculum and to provide learners with better conceptual understanding. A constructivist Chemistry teacher would realise the importance of building new knowledge for learners on the existing prior knowledge before elevating to WS (Kuhlane, 2011; Mothwa, 2011). However, Mothwa posited that most science teachers seem to struggle to decolonise the curriculum by integrating IK since they were not trained, or the curriculum does not explicitly explain what is to be included when it comes to IK. Notably, the aim of integrating indigenous knowledge in science teaching is not to compare the two worldviews but rather to see the connectedness of science and IK (Onwu & Ogunniyi, 2006; Seehawer & Breidlid, 2021). Furthermore, Le Grange (2007) suggested that teachers should be aware of the interaction between the learners' culture and WS because it could complicate the learning process in science classrooms. That is, cognitive conflicts could exist in most African learners as long as teachers keep teaching science that is alienated from IK practices (Le Grange, 2007). Such cognitive conflict could be eliminated if teachers understand the importance of IK in science classrooms.

In this study, for instance, two Chemistry teachers seemed to be explicit about how the apparatus for fractional distillation in Chemistry textbooks and the making of [17]*Ombike* are similar to each other by explaining the process. For instance, Tala explained that:

> *When making Ombike, community members use <u>different fruits</u> and put them in the calabash (clay pot) to <u>ferment for two to four days depending on the weather</u>. During winter the process of fermentation is very slow because it is cold than in summer. After fermentation, the mixture then needs to be <u>boiled but before</u> that, the pot needs to be covered with mud soil for the vapour not to escape. The pipe from the calabash passes through the trough that will act as the cooling point and in this trough, there is water that will change vapour to liquid. When the mixture is boiled, <u>fire needs to be regulated</u> for the process not to be fast or slow. In the trough or containers, cold water will be used to cool the vapour and turn it into liquid Ombike.* (My emphasis)

This excerpt shows similarities in apparatus used between the WS of teaching the topic of fractional distillation and the IK on making *Ombike* and how teaching in science classrooms can be localised. Analysing the excerpt, Tala seemed to show knowledge and IK understanding on how learners can be helped to move from IK to WS. Onwu and Ogunniyi (2006) believe that science teachers should use concepts that can be explained using information from home as well

[17] *Ombike* is a traditional alcohol beverage that is made through the process of fractional distillation (Uushona, 2013).

as information from science sources. By doing this, learners will be supported to understand the benefits of IK in science classrooms.

In Shipefi 16’s view, “*it is possible”* that teachers need to put in more effort into their teaching so that they can bring both sides (IK and WS) together as reiterated by Taylor and Cameron (2016) in their integrationist model. That is, he believes that teaching the terminologies that learners know from home might help learners understand the concepts and the processes very well. In this regard, Ndeshi demonstrated the science involved when blowing air when making fire:

> *The other things when we also teaching gases of the air for example. We talk about Oxygen; Oxygen is that gas that actually supports combustion. What do you do when you make fire, this simple thing so if you are making fire, for example, Elilo (traditional plate made from palm leaves) then you have to provide more air (demonstration, by using Elilo to blow air to the fire, the way how to blast furnace works) to the fire, what is happening, you are actually increasing the content of Oxygen there, because you know Oxygen is in the air when you are doing this (demonstrating how to blow air to the fire using Elilo), you are actually increasing the air in the same process you are increasing, you are exposing more Oxygen to the fire.* (Ndeshi)

Analysing the excerpt from Ndeshi, it could be surmised that she was making an effort to use the prior knowledge of learners when teaching Chemistry. Ndeshi elaborated more on how IK could be used to explain how a blast furnace works (Kudumo, 2020) and the topic of combustion. She further elaborated by using the end product from the fire to teach chemical and physical changes:

> *We make fire with firewoods every day. The burning of firewood again on itself, there is another science behind because when we talk about physical and chemical change, you can easily explain to this learners that when you burn the firewood, what will happen, you get ash and charcoal (Ash could be used to teach bases and acidic), will you change those to make firewood again, No how do we call that process is it a physical or Chemical change. These are the things that are happening in our everyday life, and we interact with them in our everyday life and then of course if we try to incorporate them into science and course, Chemistry will be understandable.* (Ndeshi)

This excerpt indicates that Ndeshi seems to understand how IK can be integrated into Chemistry teaching as she explained how physical and chemical changes could be taught by building on learners’ prior everyday knowledge of making fire by using the ash, to teach chemical and physical changes. Similar to Kakambi’s (2020) study, chemical and physical changes could be taught using dying and weaving of African basketry (*Maselo* in Silozi) like *Elilo* (traditional plates) and others.

This knowledge is engraved in the local language as Ndeshi could only demonstrate using gestures but she knew the concepts in the local language.

Michael commented that the translation of local languages to English and then to science language could limit the use of IK in science classrooms since most science concepts are not readily available in local languages and using incorrect concepts might confuse the learners. Adding to this, unfortunately, the transfer of IK from everyday life to science classrooms seems to be not always valued or recognised by science teachers and they regard it as unproven or old-time knowledge that does not exist (Angaama et al., 2016). The dilemmas and contradictions that arise from the integration of WS and IK in science education are complex, not only in terms of curriculum transformation but also in terms of teacher education and pedagogical practices within science lessons (Mhakure & Mushaikwa, 2014). Adding to this, Diwu and Ogunniyi (2012) pointed out that both IK and WS are being underpinned by diverse epistemic authorities. In consequence, this brings disparity between the two worldviews and that can make teachers judge them separately.

5.2.2 Indigenous knowledge enhances pedagogical understanding

Chemistry teachers should build on the knowledge that learners have acquired from their homes or community as they interact with more knowledgeable people. The following questions were asked during the semi-structured interviews: *Could you please tell me how you present the topic/s in Chemistry using IK? Could you please give me examples of any topic/s in Chemistry in which you can integrate IK?*

Three Chemistry teachers revealed that both knowledge views (IK and WS) are needed when teaching Chemistry for the learners to reconnect with their environment. For instance, Ndeshi indicated that "*learners become interested in the topic when IK is integrated into the lessons*". Researchers have found that learners seem to enjoy SMK when it is linked to their own IK (Kambeyo, 2012; Mukwambo, 2017; Shifafure, 2014; Uushona, 2013). In this regard, Mukwambo et al. (2014) reminded us that IK is a legacy of knowledge and skills unique to a particular indigenous people and involves wisdom that has been developed and passed on over generations by the use of 'trial-and-error' approaches. However, when integrating IK in science lessons, teachers need to know how to use it to benefit the learners when they translate local science into western science otherwise it could affect the learning and teaching process. According to Michael, "*Learners would understand the concepts very well if IK is integrated into Chemistry lessons*". Tala indicated that "*I used to include learners' prior everyday knowledge by asking learners the examples that they know from home*". This allows learners to share the knowledge they learnt from home in the science classroom and to move from context to content during the lessons as reiterated by Kuhlane (2011).

From the Chemistry teachers interviewed in this study, it emerged that learners have much knowledge that is connected to scientific knowledge in science or Chemistry (Sebron). For example, Sebron expressed how learners know how to make *Omalondu, Omaongo, Oshikundu* and *Ombike* that have many scientific processes and facts in them. All these traditional beverages involve the process of fermentation and other associated concepts such as the rate of reactions (Nikodemus, 2017). This knowledge can help learners to develop their cognition when they link the WS to their IK and hence curtailing cognitive dissonance (Le Grange, 2007). It could be argued that such interaction between IK and WS is valuable as local people seem to be knowledgeable in many aspects of the science curriculum in their own ways, such as agriculture, pest control and soil types, medicinal plants, and brewing of beers.

In this regard, Shipefi 16 stressed that IK helps learners to understand the concepts much better and that they might even remember the knowledge in the examinations and hence not fail. He added that: "*Most learners are exposed to it and understood the process very well and can explain it in the examinations*". This finding resonates with Mukwambo et al. (2014) who proposed that the Africanisation of the school science curriculum might encourage teachers to embrace cultural knowledge in their science lessons and engage learners in teaching and learning science concepts.

Tala explained that "*indigenous knowledge can help teachers to explain the concepts that are done at home and teachers need to know which indigenous knowledge is good for which topic*". However, in my view, for the teachers to know and be confident in integrating IK into their teaching, they need to be involved in peer-learning communities which was the purpose of this study. This would help them to learn from each other on how IK and WS could be taught simultaneously and Ogunniyi (2007a) refers to this as the equipollent cognitive state. Ogunniyi and Ogawa (2008) further showed that the most effective way to encourage teachers to emphasise science and IK in their classrooms is to engage them in long-term mentoring processes in the form of dialogue, argumentation, role modelling, and explicitly reflective instruction approaches within a conceptual change framework. Chemistry teachers need to understand how the NCBE allows them to integrate IK into science teaching.

In this study, the Chemistry teachers revealed the challenges that they face when integrating IK into Chemistry teaching by using examples from local communities. Tala indicated that, "*I used to be challenged on which IK to integrate in my lessons as most of the knowledge might be confusing to me as a teacher, and learners might ask me a lot of questions that I might not be able to answer*". From this excerpt, it could be hypothesised that IK integration is not easy to do. For instance, Tala seemed to be afraid for his weakness to integrate IK to be exposed. That is, if a teacher is not aware what pedagogical strategies to use in order to make a smooth connection between IK and WS for the learners that might result in cognitive dissonance (Le Grange, 2007). A case in point is that Tala seemed not to be sure if he was ready to build a bridge for the learners to traverse between the two worldviews.

For Chemistry teachers to be able to integrate IK into their teaching, they need to be knowledgeable about the SMK and be mindful of the elicitation of learners' prior everyday knowledge into their teaching and learning. Siseho (2013) found that science teachers seem to come out of higher education institutions without knowledge of IK and how it could be integrated into science lessons. This suggests that there is a need for Chemistry teachers to be involved in professional learning communities on how to integrate IK in the school curriculum in particular.

5.2.3 Factors that influence Chemistry teachers to integrate (or not) IK in their teaching

All five teachers involved in this study seemed to have different factors that influenced them to integrate (or not) IK into science teaching. This was revealed when I asked the following question: *Could you please tell me what challenges you have been experiencing when teaching Chemistry?*

These factors ranged from making learners understand, learners being exposed to the IK, resources being locally available and being cheap to obtain (Michael, Sebron, Ndeshi, Shipefi 16 and Tala). Regarding distillation, for instance, Sebron indicated "*I observed that learners who are exposed* *to cultural knowledge*” and WS parallel to each other (equipollent ideas according to Ogunniyi (2007a)) gain more understanding of scientific processes and explanations. Equipollent ideas are those competing ideas in the minds of the learners that have equal intellectual and emotional forces (Diwu & Ogunniyi, 2012). In this regard, two Chemistry teachers indicated:

> Ndeshi: *The whole process of Ombike and fermentation process can be documented in our Namibian textbooks, then, of course, it could be content in the learners' context*.
>
> Sebron: *Water mixed with salt, if we boil the water, water will evaporate and salts will remain.*

These excerpts indicate that the two Chemistry teachers seemed to be aware of the importance integrating IK into science classrooms. However, Michael in his response seemed to be general and commented that: “*We can bring all this from both sides, learners' prior knowledge and teachers' knowledge side-by-side*”. That is not surprising as he indicated earlier during the interview that he was not aware of how to integrate IK into Chemistry teaching.

Several studies in the field of IK and science education have been carried out in Southern Africa and other parts of the world, especially in Zimbabwe and South Africa, but very few have been done in Namibia (Dziva et al., 2011; Klein, 2011; Mhakure & Mushaikwa, 2014; Shizha, 2007). There is a need for indigenous people's wisdom, values, beliefs, and indigenous practices to be included in science textbooks that could help teachers and learners to bridge the gap between the two worldviews. At the moment there seems to be a knowledge gap between Eurocentric and Afrocentric that is created by the Eurocentric viewpoint that has led Africans to believe that their knowledge is inferior. IK and WS are considered as disparate on the bases of epistemological and ontological grounds (Nakata, 2007). For instance, since the Namibian education system that is controlled by Cambridge University, IK is not explicitly visible in the syllabus and Chemistry textbooks.

To mitigate these aforementioned challenges, Ogunniyi (2007a) has done much of his work on IK using the Contiguity Argumentation Theory (CAT) with in-service teachers in South Africa on the integration of IK in science education (Ogunniyi, 2004, 2007a, 2007b; Hewson & Ogunniyi, 2011; Mushayikwa & Ogunniyi, 2011). His findings showed that CAT helps integrate IK into science lessons. Essentially, his research aimed to bridge the gap that exists between the two worldviews.

If science teachers are not trained to recognise the IK of local people, they will continue to neglect it, deny it, or even denigrate it when it appears as part of student responses in classrooms (Kreisler & Semali, 2001).

The curriculum that allows teachers to integrate their IK with science knowledge is what Aikenhead and Jegede (1999) called cultural border crossing. Cultural border crossing can serve science teachers who are 'pedagogical culture brokers' responsible for making the culture of science accessible to all their learners (Aikenhead & Jegede, 1999). Adding to this, Angaama et al. (2016) argued that the argument for integrating IK in science teaching is based on epistemological and methodological differences between science and IK. Scientific knowledge has dominant epistemological methods to teach it, while with IK, the epistemological methods have only emerged in recent years of research. The two excerpts below illustrate the challenges Chemistry teachers face when teaching Chemistry:

> Ndeshi: *There comes a challenge because when we talk about chemical, the content in the books does not give room for the learners to put content into the context of what they have home and what we are learning in the real content.*
>
> Shipefi 16: *But we lack that time of having all learners at one time or at one room where they can make their experiment*.

From these excerpts, it is evident that even though these Chemistry teachers tried to use western materials, they are very scarce and that seems to be a challenge for them when teaching Chemistry. Such challenges as indicated by Michael could allow him to use local materials to teach Chemistry. They were also faced with other challenges ranging from the time frames given to conduct Chemistry experiments and putting content into the context of the learners. My assumption is that the latter might be influenced by the curriculum that does not explain how the integration of IK should be done in science lessons. That might create biases as was found in Zimbabwe by Shizha's (2007) study.

For instance, Shizha (2007) argued that biases were detected when teachers in Zimbabwe were asked how they integrate IK, culture, traditional beliefs, and customs into their science lessons. Such bias was influenced by the national curriculum that does not promote the integration of IK into the science syllabus and also the use of English as the LoLT (Shizha, 2007) as well as scientific language that is more dominant in science textbooks. English was only linked to WS, not to IK. That is, IK and indigenous languages seemed not to be acceptable in the teaching and learning of science. As a result, indigenous science and language are judged as irrelevant to the understanding of 'modern' scientific concepts and skills that are practised internationally (Shizha, 2007). It also emerged from the interviews that not all IK is valuable or useful in science lessons; some indigenous knowledge creates contradictions between the curriculum and the indigenous knowledge of African people. For instance, Tala indicated that "*IK will bring a lot of problems to the classroom because even the teacher might not be able to explain it*". This finding is congruent to Mukwambo et al.'s (2014) assertion or argument that we need to be aware that IK is not a bag of knowledge waiting to be tapped into and dispensed. Instead, there is a need to critically analyse it before it can be used and to expose any contradictions or misconceptions that might come with it.

Moreover, Mukwambo et al. (2014) discovered that some indigenous terminologies are well advanced, and teachers struggle to make the connection to the correct terminologies in western science. These scholars believe that the Africanisation of the science curriculum may allow more examples of IK to be tapped into in science classrooms. For now, the curriculum does not give the freedom to teachers to include or test/assess the learners' knowledge from home (IK). Instead, the science teachers seem to be influenced by the curriculum, and they do not see the need for IK in school science. To ameliorate this conundrum, teachers need to increase their knowledge about IK for them to be able to integrate it into their teaching.

Shipefi 16 bemoaned and commented that "*IK is not documented*" and that makes it difficult to be considered during science lessons especially by the teachers with little IK knowledge. Tala indicated "*Not examined during examination".* Similar to Shizha (2007) who found that IK could not form part of the examinations in Zimbabwe. Science textbooks seem not to support the integration of IK. It should also be recognised that since not all teachers are teaching in their local environment, it might be difficult for them to integrate the culture or prior everyday knowledge as different cultures have different IK. Science teachers seem to lack models to emulate and appropriate epistemology strategies to effectively teach science and IK integration (Angaama et al., 2016). For authors to include IK in the textbooks, curriculum designers need to include it in the curriculum. Moving forward, Angaama et al. (2016) averred that the policy documents do not explicitly articulate how the integration of IK should be done and they do not consult the teachers who are to implement it. The dilemmas and contradictions that arise from the integration of WS and IK in science education are complex, not only in terms of curriculum transformation but also in terms of teachers' education and pedagogical practices in their science classrooms (Mhakure & Mushaikwa, 2014). Yet, for IK to be integrated into the curriculum, teachers need to have the background knowledge from the local community to be able to teach there, as IK is context-dependent (Kibirige & van Rooyen, 2006).

Fundamentally, findings from three Chemistry teachers showed that they do integrate indigenous knowledge in their teaching, but it was evident that IK was ignored during the planning of the lessons' sequence (Sibanda, 2018). That is, IK used to be brought in as examples during the lessons without considering it when planning the lessons.

5.2.4 Knowledge levels of Chemistry teachers on integrating IK

Even though three Chemistry teachers showed some knowledge on how to integrate IK, what emerged from this study is that some Chemistry teachers could not integrate IK because there was a lack of PLCs in the schools. For instance, when Chemistry teachers were asked about their experiences with the integration of IK into science teaching, they gave the following responses:

> Michael: *I have to consider learners' prior knowledge, so I have to ask them maybe asking them, what they know from home…*
>
> Tala: *I have been teaching for 10 years now, I use to include learners' prior everyday knowledge by asking learners the examples that they know from home. Sometimes I ask them what they learnt from the other grades.*
>
> Sebron: *I used to include learners' prior everyday knowledge by asking learners the examples that they know from home. Sometimes I ask them what they learnt from the other grades. At home, they know about Ombike that they use to prepare with their parents.*

The impression that one gets is that the three Chemistry teachers seemed to integrate IK by just mentioning a few examples of indigenous practices in passing. In this regard, Otera and Nathan (2008) argue that the greatest weakness of many teachers is that they just elicit learners' prior knowledge as part of their introduction to the lesson and never make use of the learners' responses to build new knowledge. Michael indicated that he asks learners about atoms, for instance, what they know about an atom from their homes. However, this knowledge could not be linked to any activities happening at home and this could confuse the learners. This resonates with Meyer (2004) who highlighted that teachers who are not equipped with IK might distract learners from learning in their classroom.

It also emerged that some of them responded to this question by telling me what they ought to do instead of what they were doing. For instance, Michael's response tells us what he should do. He went on to say:

> Michael*: Maybe I will consider when am planning actually, consider their knowledge from home… when they are doing, I mean coming up with something. Let me just be specific, a process in, maybe rate of reaction, maybe I will ask, I will consider for myself, about how I do things considering the temperature maybe cooking porridge also, I know before I put flour in the pot, I will make sure that the temperature must be optimal and if it is too hot I know it will be spoiling my porridge and maybe if too cold it will take time for me to cook the porridge. So considering all this knowledge for learners.... I will consider them when am planning, their prior knowledge for learners.*

From this excerpt, although Michael seemed to show an awareness of a clear scientific example that he could use in his lesson, he was not talking about his experiences but instead what he intended to do. Hence, he drew this example from his own experience and not the learners' experiences. When the Chemistry teachers were asked on which topic/s they integrated IK, their responses indicated that were not integrating IK. For example, they stated: Michael: *I have used the local knowledge, if my memory serves me correct… what did I use?*

> Shipefi 16: *Like on Electricity, I should think there we have too, but then I don't know if this one is local knowledge. Learners need to be exposed to this power station where we use nuclear there radiation nuclear, where it needs to decay when it split and releases the energy that warms or heats the water, to steam that turns the turbine to turn on the generator that produces now the electricity, so Ruacana power station (the biggest hydropower station in Namibia), maybe learners have to go there, I know it is not local knowledge.*

In the first excerpt, Michael seemed to be struggling to remember the topic where he used IK. On the other hand, Shipefi 16 just mentioned the topic because he liked it. Further, Shipefi 16 could not explain electricity using IK and it was interesting when he corrected himself by saying "*I know* *this it is not local knowledge*". If science teachers try to integrate IK that they are not sure, this might cause conflict in the minds of the learners – Le Grange (2007) calls this cognitive dissonance. Science teachers need to be cultural knowledge brokers who allow learners to traverse between the two worldviews without this conflict. The baseline data from interviews revealed that, even though teachers mentioned that they used to integrate IK, it conflicted with some of their responses.

What emerged in this chapter shows that there is a need to support Chemistry teachers on how to integrate IK into science learning and teaching for them to be effective cultural knowledge brokers (Aikenhead & Jegede, 1999; Wyatt et al., 2017). When Chemistry teachers are empowered to be cultural knowledge brokers, it is hoped that they might be able to support their learners to connect what is learnt at home or in the community to the science taught at school (Aikenhead & Jegede, 1999; Gwekwerere, 2016).

5.3 Chapter Summary

When analysing the findings in this chapter one could note that IK has a role in Chemistry teaching. It emerged that three of the five Chemistry teachers involved in this study seemed to use real-life experiences and knowledge at different levels of understanding. They suggested that western science and IK should be taught simultaneously in science lessons without comparing the two knowledge areas. The use of IK could lead to learning and teaching support materials (LTSM) that are locally available in the community. In some cases, teachers seemed to contradict themselves in the answers given when asked which topic they used to integrate IK. That showed that what they were saying might not be what was done in practice. Tala and Michael were not that familiar with the integration of IK at the beginning of the semi-structured interviews. I had to explain to them what the aim of my research was before starting with the interviews. This data formed the baseline for this research in understanding the perspectives and the pedagogical insights of Chemistry teachers on IK integration.

CHAPTER SIX: CO-ANALYSING CURRICULUM DOCUMENTS

> Curriculum analysis fosters the implementation of curriculum reforms, teachers encounter various problems while designing related to conditions set for the design process and lack the knowledge and skills needed to enact collaborative indigenous knowledge. However, little is known about the nature of the support offered to improve teachers' curriculum knowledge. (Huizinga et al., 2014, p. 33)

6.1 Introduction

Central to the integration of IK is the national curriculum documents that are the cornerstone of this. The NCBE (MoE, 2018) advocates for the use of learners' life experiences in teaching science (Gwekwerere, 2016). In a nutshell, the epigraph illustrates the importance of involving teachers in peer-learning communities and how IK can be integrated. Data were generated from three workshops and reflection journals that were given to the participants. The data sets were analysed using Vygotsky's (1978) SCT and PCK and TSPCK translation device (see Appendix K). This was done to answer research question 2 (a): *What lessons can Grade 10 Chemistry teachers learn (or not) in their peer-learning community when co-analysing the Chemistry curriculum documents?*

6.2 COVID-19 Precautions during Workshops

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

- Wash your hands regularly with plenty of soap and running water.
- Keep 70% alcohol-based sanitiser and sanitiser every time.
- Clean and disinfect frequently touched objects.
- Wearing of masks.
- Do not touch your eyes, mouth, and nose with unclean hands.
- Keep a social distance at all times of 1.5 meters.
- Keep temperature records for participants.

Some of the symptoms of COVID-19 are high fever, dry cough, tiredness, severe headache, diarrhoea, body aches, difficulty in breathing, and a tight chest. All the symptoms were made clear to the participants before the workshops. Temperatures were measured in degrees Celsius (^{0}C) as the recommended unit in Southern Africa (see Appendix S, Table 2).

6.3 Data from Orientation Workshop

The orientation workshop was conducted for the participants to be aware of what would be done during the research they were embarking on with me. It is worth noting that I had been working with these teachers during science fairs and so it was easy to introduce myself to them as a co-learner and researcher who would be learning from them during the research and the introduction went smoothly. I explained the consent form to the participants and the journal books that were given on the same day. All participants were given the booklets that contained the following: an informed consent form, participants' reflection journals, and the abstract of my study (see Appendix I). Thereafter, I explained the rationale of the study by focusing on the aim/goal of the study, research questions, and the research process (see Chapter Four, Sections 4.1 and 4.7).

Instead of waiting for phase five, I explained to the participants what the five components of TSPCK are so that they could begin to familiarise themselves with them. The five components were going to be used when analysing documents which was the next workshop (see Appendix Q, Table 1 & 2). It was, henceforth, agreed that we should have our workshop and practical demonstration with the ECMs between 15:00-17:00. Next, I analyse the data generated from co-analysing the NCBE (MoE, 2018).

6.4 Co-analysing the Curriculum Documents

The curriculum that allows teachers to build on the existing knowledge of learners has the potential to be fully implemented from the African perspective (Aikenhead & Jegede, 1999). For example, some teachers believe that certain IK issues should not form part of science and they have perceptions that IK is outdated, time-consuming, degenerated, and demeaning (Angaama et al., 2016). In Zimbabwe and South Africa, bias in implementing the national curriculum was observed because teachers were influenced by the national curriculum that did not integrate IK into the science syllabus and also the use of English as the LoLT (Angaama et al., 2016; Shizha, 2007). To avoid this bias, teachers have to understand the framework of the curriculum. We analysed the NCBE, Chemistry syllabus, and Chemistry textbooks and concluded with previous examination papers and examiners' reports. Chemistry teachers had varying knowledge about the curriculum.

At first when the NCBE was given to the participants to explore the core values that allow them to integrate IK into their teaching, quietness was observed in the room. It could be deduced that the five Chemistry teachers were not sure which core values allow them to integrate IK. After further clarity and explanation, Ndeshi and Sebron became leaders and always explained beyond what was required. This can be attested to in the themes that emerged.

I also observed that Sebron was more knowledgeable about the enzymes involved when making *Oshikundu* to explain and integrate IK into Chemistry teaching and learning. On the other hand, Shipefi 16, Tala and Michael asked questions to understand the integration of IK during the discussions and questions for further clarifications. That allowed us to see how IK integration is viewed in a wide range of NCBE documents. A peer-learning community (Stracke, 2010) helped the Chemistry teachers to learn from each other by asking questions. Moreover, a peer-learning community helped teachers to collaborate, engage and foster each other knowledge during discussions (Stott, 2016; Stracke, 2010). The findings that emerged were categorised into three themes as follows.

6.5 Findings that Emerged from Co-analysing the Curriculum Documents

The data generated from three workshops were critically analysed and two themes emerged from the data. The workshops were pre-intervention workshops to help the teachers understand the concepts used as an exemplar (rate of reactions) when engaging with the NCBE, Chemistry syllabus, and three Chemistry textbooks that are used. Participants were actively engaged throughout the workshops. The aim was for the Chemistry teachers to engage in learning and support each other on how the curriculum addresses the issues of IK integration. The ultimate goal was for the teachers to be able to integrate IK in their classrooms and have a better understanding before visiting the ECMs. Three themes emerged from the three workshops (see Appendix T, Table 2).

6.5.1 Co-analysing curriculum documents enabled the Chemistry teachers to understand IK integration

The findings show that if teachers could engage with the curriculum and understand it, then IK could be fully used in science and other subjects. Teachers should be able to visualise what they know at home and relate it to what is taught in the classroom. Additionally, Erinosho (2013) explained that contextualising is an important pedagogical approach for extending school science outside of the classroom to connect with existing knowledge in the form of prior everyday knowledge of learners in their immediate locality.

In this study, the Chemistry teachers viewed IK as essential when teaching science and this helped them to have a better conceptual understanding. In the peer-learning community, the Chemistry teachers were learning from each other and helped each other on how the curriculum integrates IK (Tosey, 1999). Science teachers need to build on learners' prior everyday knowledge as explained by Erinosho (2013), that prior everyday knowledge serves as a foundation to build on and learn new concepts. Without this foundation, learners might struggle to learn science and might just accept it as a westernised subject. Thus, indigenous scientific knowledge offers a useful tool to contextualise science concepts (Erinosho, 2013). The NCBE (MoE, 2018) encourages teachers to use relevant IK to enhance learners' conceptual understanding. In this regard, two Chemistry teachers indicated that:

> Ndeshi: *I feel the cognitive skills, this is because if you look at the competencies like 'exploring, investigating, enquiring, recognising, contextualising', especially the word contextualising has to do (in my opinion) taking science that we learn 'westernised science' bringing it to our context, using our local examples and practices that we use at home to teach science.*
>
> Tala: *I think that skill (using local cultural practices to teach science) … For example, when you are teaching about the rate of reactions, don't talk about westernised knowledge, and use Oshikundu to enhance learners' conceptual understanding. We have to talk about Omalondu, Oshikundu and others to bring out that knowledge in the context of the learners.*
>
> Michael: *If we only teach about fractional distillation in the book and ignore the one the learners are familiar with, learners will not be able to analogise the two processes or bring them together. Learners will not be able to go home and say this is what we are taught at school. Some of them are even knowledgeable about making Ombike. They can explain from the first step to the last step.*

The excerpts from the three participants showed how Chemistry teachers could integrate IK into Chemistry teaching. Peer learning was initiated during the workshops where teachers helped each other to understand how the curriculum allows them to integrate IK into teaching and learning Chemistry. Hence, Taylor and Cameron (2016) exemplified that a curriculum that respects the dignity, values, and morals of the context of learners will be fully implemented and contextualised by teachers in their classroom. Adding to this, the curriculum that uses the five components of TSPCK is likely to be taught using IK in Chemistry teaching, and IK might form the central part of it.

The Chemistry syllabus does not specify what topics the teachers need to integrate IK into to enhance the conceptual understanding of learners when teaching such topics. Michael explained that teachers have the role of integrating IK in their classrooms as the syllabus does not specify what IK to integrate. For instance, teachers can use available resources to teach the topic of rate of reactions using *Oshikundu*. In support of this Ndeshi and Sebron indicated that:

> Ndeshi: *I think it is upon the teachers to explore the local practices in their specific area because even when we were analysed the textbooks, there is nothing that is directly said about putting this science in the context of indigenous knowledge, nothing was stated like that but it is upon us as teachers to think on which suits the learners that we are teaching"*. (My emphasis)

> Sebron: *You can explain it by linking it to Oshikundu and maybe the factors we can also do exactly like what we are doing in the textbooks. Like, you mention the factor, you give example from the local community like Ehete it increases concentration, particle size you talk about pounding Mahangu, catalyst you talk about Ehete and temperature you talk about why are you warming the water*. (My emphasis)

From these quotes, it emerged that the two participants encouraged each other to use the available resources to teach Chemistry, instead of concentrating on what is documented in the textbooks. Using his lived experiences, Sebron explained how *Oshikundu* could be used to help learners understand science concepts. His explanation indicated that he has experience in teaching Chemistry using learners' life experiences (Gwekwerere, 2016), especially on the topic of rate of reactions. Both Ndeshi's and Sebron's explanations seemed to signify that a peer-learning community was taking place with the Chemistry teachers. That is, the Chemistry teachers were helping each other to understand how IK and scientific knowledge could be assimilated in lessons.

Aikenhead and Jegede (1999) indicated that science teachers feel that school science is like a foreign culture to them; to reduce this, there is a need to develop culturally sensitive curricula and teaching methods that reduce the foreignness felt by teachers and learners in science classrooms (Mhakure & Otulaja, 2017).

Tala raised a question regarding what teachers should do when teaching in multicultural classrooms where the IK of the learners is not the same. In multicultural classrooms instead of using *Oshikundu* as the local example, Shipefi 16 suggested the process of making the fat cake as the most favourable one, as most learners have been exposed to how fat cakes could be made. Interestingly, Sebron explained: "*To accommodate multicultural diversity it can also be a good example because how Oshikundu is prepared is the same because it involves enzymes, it involves starch, it involves temperature, and everything"*. There are many IK practices according to different cultures, making it difficult to choose which IK to use during science lessons and which ones to leave out (Angaama et al., 2016). By asking the question, Tala could now use fat cakes in multicultural classes to help each learner understand rate of reactions, as he was helped to understand by other teachers.

The process of making *Oshikundu* and fat cakes could be used as analogies in Chemistry classrooms as they follow the same process. This could help learners in multicultural classrooms to understand the processes very well. Hewson and Ogunniyi (2010) averred that there are no challenges faced when IK is integrated into the multicultural class, but instead they believe that the integration of IK in science classrooms promotes learners' conceptual understanding. Michael clarified about catalysts in both processes in a multicultural class:

> *When making Oshikundu, it was explained that Ehete was used as a catalyst to speed up the reactions (lower the activation energy) and in making the fat cake we use yeast to speed up the reactions and also we use warm water in both processes and I think we can collect Carbon Dioxide (CO_2) produced and you can test it if you have collected it*.

Thus, *Ehete* and *yeast* are catalysts in these two different processes. Unfortunately, the transfer of IK from everyday life to science classrooms is not always valued or recognised by science teachers and they regard it as 'unproven', 'time-consuming' or 'old-time knowledge' that 'does not exist' (Angaama et al., 2016). Adding to this, Mavuru and Ramnarain (2020) found that in their study on affordances and challenges of teachers incorporating learners' home language, where IK is embedded, they found that when using learners' home language in a science classroom, learners are not accorded the full support and opportunity to access scientific concepts by using IK as gatekeeping concepts to learn science. Teachers need to be made aware of the benefits of integrating IK in science classrooms. Ndeshi warned the other participants that: *"If we cannot bring it down to the context of the learners, let us teach it the way it is in the textbooks"*. This suggests that some topics in Chemistry cannot be contextualised. Contextualising Chemistry teaching might or might not help learners during the examinations.

In the Physical Science 2018 examination paper 2, for instance, learners were asked a question on fractional distillation and had to explain how it works. This question was perceived to be easy for the learners that grew up in the Northern region of Namibia as this process is commonly used to make *Ombike*. The examiners wanted learners to describe how this apparatus (Figure 6.1) could be used to separate the mixture of alcohol and water in apparatus B? Tala wished the traditional apparatus that is locally used could also be put next to scientific pictures. He delineated that: *"If they could bring these two pictures from scientific and indigenous and label them so that learners who do not know western science could use indigenous knowledge to answer the questions"*. The two apparatus could be used side-by-side to allow learners who are familiar with the local artefact to use it when answering the question.

Figure 6.1: Conventional fractional distillation apparatus and traditional fractional distillation apparatus

This could allow learners to view some processes from two different worldviews. The dominant science worldview could be contextualised to the dominant IK worldview when the two pictures are presented together in the examination question papers (Angaama et al., 2016; Ogunniyi, 2007a). Learners who are familiar with the conventional fractional distillation apparatus could explain the process using the knowledge acquired in the lab and learners familiar with the traditional fractional distillation apparatus could explain the process based on the knowledge acquired at home during social interactions with expert indigenous people on making *Ombike*.

Thus, teachers need to understand the philosophical underpinnings that can help them choose teaching strategies that allow them to teach IK and WS side-by-side (Cronje et al., 2015). Ogunniyi introduced dialogical argumentation instructional models (DAIM) as a teaching strategy that could accommodate IK in science teaching (February, 2016; Diwu, 2010, Nuntsu, 2020). DAIM could allow teachers and learners to engage in classroom talk and argumentation. This was evident when the Chemistry teachers were involved in discussions that yielded positive understanding as they could argue and learn from each other in our peer-learning community.

For instance, Sebron indicated that "*I love this workshop; it is making a lot of sense*". Vividly, this shows that the participants were learning new knowledge that they were not familiar with. Learning was influenced by the culture of the teachers that had experiential activity embedded in the culture of the community. The process of making *Ombike* was explained by the participants and how the topic of fractional distillation/distillation could be taught using local examples. Cronje et al. (2015) indicated that IK and western science could be taught side-by-side and also examined side-by-side. Ndeshi explained to the other participants how temperature is distributed in the trough:

> *In Okatemba (trough/condenser), when the water gets warmer you just remove it and add the cold water … If you have an ice cube for example if this water is getting warmer you add, takukala nande pena oshilipi shilimo mokatemba topilula ngaha, to niningi nashoo (sometimes there is a cloth inside the trough, you use it to circulate the water around) to distribute the temperature, if the water has become very hot, there is a hole under that you need to open and the water goes out and you add the other one*.

On the other hand, Tala seemed not to know that cold water could be used in the trough/condenser. Surprisingly, he said: *"I will go teach my granny to start using cold water from the fridge*". Shipefi 16 explained that "*Omeya ngenge matalala nenghono andishe* (if the water is cold is the best) … *it is even much better and the steam that is going through the pipe will condense quickly"*.

Ogunniyi and Ogawa (2008) explained that science teachers should arrange visits for the learners to experience life outside the classroom by meeting with knowledgeable people in the communities that could explain some of the topics in Chemistry that have the potential for IK in them. Lending support and extending on Vygotsky's seminal work, Shabani (2016) proffered that social interaction is the basis of learning and development, and learning is a process of apprenticeship and internalisation, in which skills and knowledge are transformed from the social into the cognitive plane. For African learners, the interaction between the two worldviews (IK and WS) characterises much of their school experiences, complicating the learning process, and potentially resulting in a cognitive conflict called cognitive dissonance/perturbation (Le Grange, 2007).

6.5.2 Chemistry teachers' understanding of Chemistry concepts

Indigenous languages lack key concepts that are used in scientific knowledge as compared to WS. For example, for the teachers to change attitudes towards science and cultural beliefs about the value and potential contribution of IK into science classrooms and define how to integrate this form of knowledge into science lessons, the NCBE, Chemistry syllabus, and Chemistry textbooks need to illustrate the importance of integrating IK in science lessons.

Teachers' inability to integrate IK in their teaching may also result from limited IK and that might be the result of the training they received while still at universities or colleges. The curriculum, textbooks, and syllabus do not guide the teachers, and this leaves teachers with contradicting information on what knowledge to integrate into the classroom. This could also be the result of concepts that are not documented. Science teachers need to use learners' experiences in teaching science and the syllabus only tells the teachers what they must do and not do when teaching science (Owour, 2017) and is silent about the integration of IK. Le Grange (2014) infers that African identity is closely interwoven with African languages. It is time to reconsider the decolonisation of the science curriculum to include African identity and for Africans to start reclaiming their lost knowledge and document it in African textbooks, to be taught to the generations to come.

Decolonising the science curriculum (Le Grange, 2016; Mutanho, 2021; Seehawer, 2018a) science syllabus, and science textbooks could allow science teachers to explore the environment they live in and connect with indigenous people in teaching Chemistry, such as when Mukwambo (2017) illustrated how to teach friction using the IK of making fire (see Figure 2.1). Science teachers are knowledgeable about science topics that could be integrated into science lessons. In this case, teaching friction using the indigenous practice of making fire will enhance learners' understanding that will allow them to connect with the environment around them. This knowledge cannot be argued, and it is proven that friction can produce fire. This is authentic prior knowledge that a teacher can use to contextualise teaching during science (Mukwambo, 2017).

In support of this, Tala stated that when co-analysing the Chemistry textbooks, they mention catalysts and state that a catalyst is a substance that increases the rate of chemical reactions and that this is exactly what was happening when they were preparing *Oshikundu*. He noted that in *Oshikundu*, they also added the catalyst to speed up the rate of reaction or fermentation. He further clarified what would happen if a catalyst is not added to *Oshikundu*:

> Tala: *We add Ongudo, Ongudo is the one that contributes a lot to fermentation of Oshikundu for it to get ready to be consumed. If you do not add Ongudo then obviously Oshikundu will not be ready to be consumed by the next day or you are unable even to prepare it*.

This was interesting to observe from the participants because they could link what was happening in the community to explaining the processes that are documented in Chemistry textbooks. There were misconceptions about *Ongudo* and *Ehete*, on which one was the catalyst as noted from the participants' discussions. In Chapter Seven (see Sections 7.8.2, 7.8.3 and 7.9.1), there is a detailed explanation of the two concepts.

> Ndeshi: *I want to understand something here, we have Ongudo, and we have Ehete. Ehete lokupifa (to make it ready). Which one is giving the activation energy? Giving the starting point now for Enzymes to start working?*

In a constructive argument, she wanted to be sure of the catalyst/*Ehete* that is used when *Oshikundu* is made. The two, *Ongudo* and *Ehete* are added to *Oshikundu* and that brought about the confusion as to which one was the catalyst. Thus, she asked the questions for teachers to engage in a peer-learning community and understand the two ingredients that used to be added to *Oshikundu*. If teachers do not recognise the IK of local people, they will continue to neglect it, deny it, or even denigrate it in their classrooms when it appears as part of learners' responses on the topic they are teaching. The participants, Sebron and Ndeshi, had the same thought that *Ehete* was the catalyst, while Shipefi 16 and Tala were of the sentiment that *Ongudo* was the catalyst; Michael was not sure which one was the catalyst. The episode below illustrates this: Shipefi 16*: "I think is Ongudo, Ehete is when you have Ongudo already used"*. Ndeshi: *"Let me say we have made Oshikundu and mine I put Ehete, and yours you did not put Ehete, which one is going to get ready faster and why?"* Shipefi 16: *"It is yours, supported by Tala: It is yours"*. Ndeshi*: "Why?"*

The question why was asked so that the teachers must engaged in peer-learning and explain why they felt that her *Oshikundu* would be the one that would be ready to be consumed the next day instead of the one with *Ongudo*, but no *Ehete.* To understand this, Sebron clarified this from a scientific point of view:

> *Correct me if am wrong, Ehete now, when Oshikundu is prepared alcohol has to be produced and that alcohol comes from the carbohydrate that is in Ongudo. Alcohol can only be produced if there are microorganisms there. Ehete now has a lot of microorganisms in it that can feed or digest starch into glucose, so that they can feed on glucose and release alcohol; so when alcohol is produced means Oshikundu is ready to be taken. Perhaps I am thinking Ehete has a lot of microorganisms that can fasten the reactions by converting starch into glucose so that they can feed, through respiration Carbon Dioxide and alcohol now Oshikundu will be ready.* (My emphasis)

Sebron understood the role of Ehete and Ongudo from a Biology viewpoint. His understanding helped other Chemistry teachers to learn how microorganisms work during fermentation. Sebron clarified the role of *Ehete* that has active microorganisms and *Ongudo* with dormant microorganisms present in it. In support of this, Caplice and Fitzgerald (1999) explained that most fermented food that is common in the western world is dependent on lactic acid bacteria to mediate the fermentation process. Moreover, even though the western world has its food produced in factories, African identity is still preserved and most food in Africa is fermented without any addition of chemicals as catalysts. Ndeshi was prompted to ask the following after Sebron's explanation: Ndeshi: *"Now my question is, between Ongudo and Ehete which one is acting as a catalyst?"* Sebron*: "Am thinking Ehete is the catalyst because in the end you still have it as it is"*. Ndeshi: *"Am thinking so too"*.

Participants deduced the similarities and the differences between *Ongudo* and *Ehete* from a biological point of view. Without this understanding, participants might have found it difficult to integrate *Oshikundu* into the teaching rate of reactions as they did not have the same understanding. Some participants (Tala, Ndeshi, and Michael) were puzzled about the explanation that was given by Sebron, using his Biology knowledge of enzymes and how they operate, which is not fully explained in Chemistry textbooks. According to Webb (2013), IK should be integrated into science lessons in order for the science curriculum to highlight the link between science and culture. As demonstrated, teachers engaged with indigenous and WS to come up with a better understanding of the cultural practices they used to observe at home. However, effective teaching and learning could depend on teachers' understanding of this interaction and their ability to manage classroom discourses related to this matter (Le Grange, 2007).

It was concluded that *Ehete*, which indigenous people add to *Oshikundu*, is the catalyst mentioned in the textbooks. In support of this, Tala explained: *"For the first time, if you do not have Ehete, and you want Oshikundu to be ready by tomorrow morning, they add Otombo so then Otombo will serve as Ehete … (Onafi/residue/dregs), they will put it there in case you want to drink in the morning"*. This was an indication that without *Ehete, Oshikundu* will take more time to be ready. *Otombo* dregs have enzymes that actively feed on carbohydrates present in *Ongudo*. For IK to be integrated into the curriculum, Chemistry teachers need to have the background knowledge from the local community in order to be able to teach there, as IK is context-dependent (Kibirige & van Rooyen, 2006) and defines community members' identities (Mhakure & Mushaikwa, 2014).

Chemistry teachers were engaged in learning when clearing up the misconceptions between *Ongudo* and *Ehete* as to which one was the catalyst. To other participants, *Ongudo* was the catalyst and to some it was *Ehete*. The differences in understanding led to them arguing and clarifying the concepts for better understanding. This was done when Sebron clarified the two facts of starch and glucose and explained the two concepts using his knowledge of Biology. Sebron explained by using the scientific understanding supported by chemical equations:

$$\text{Starch} + \text{Water} \longrightarrow \text{Glucose}$$

$$(C_6H_{10}O_5)_n + nH_2O \longrightarrow nC_6H_{12}O_6$$

He further explained the next reaction when glucose is digested to produce ethanol *(Oshikundu)* and CO_2.

$$\text{Glucose}_{\text{ catalyst }(Ehete)} \longrightarrow \text{Ethanol } (Oshikundu) + \text{Carbon Dioxide}$$

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$$

After this good explanation from Sebron, all participants understood and could be seen shaking their heads in appreciation of the explanation and examples given. The cPCK and pPCK of Chemistry teachers were enacted which resulted in an improvement in their ePCK (Carlson & Daehler, 2019). After analysing the NCBE, Chemistry syllabus, and three Chemistry textbooks, it was revealed that the NCBE and other documents allow teachers to integrate IK or prior everyday knowledge of learners to teach certain topics in Chemistry. The NCBE allows teachers to teach learners from the known to the unknown. As illustrated by Michael: "*Now I understand the difference between Ongudo and Ehete; at first I thought Ongudo was the catalyst that speeds up the chemical reaction in Oshikundu"*. With the understanding that *Ongudo* is the catalyst (dormant), teachers would teach *Ongudo* as the catalyst to the learners instead of *Ehete* (active). They are both catalysts at different levels. Adding to this, Simasiku and Ngcoza (2019) indicated that IK has many concepts that are not yet developed in science language. There are some shortfalls with indigenous language and some of the concepts might relatively mean the same thing. This call for the concepts to be clarified and documented before indigenous language is called linguicide (Le Grange et al., 2020).

Clarifying the concepts helped to reduce the misconceptions that local language can bring to science classrooms. For example, Sebron further explained that "*Ongudo does not have a lot of starch, it has glucose now it does not take time for microorganism to feed, they just feed they do not digest"*. It was clear that starch and glucose are involved during the making of *Oshikundu* and catalysts such as enzymes are actively involved. In her study, Shinana (2019) found that some teachers when teaching enzymes did not build on what was known to the unknown for the learners to be able to grasp the content. Lending support, Asheela et al. (2021) attributed that, teachers have to teach science using easily available resources that learners are familiar with. The process of making *Oshikundu* has many scientific concepts that are analogical to the rate of reactions topic in Chemistry textbooks.

Thus, the NCBE advocates for teachers to build from learners' experiences in a way that would not limit their thinking and will allow them to reconnect science with the world around them NCBE (MoE, 2018). Teachers will then be able to cross-fertilise the ideas between the two worldview's knowledge to create understanding. Cobern and Loving (2001) argued that IK and WS are antagonists and cannot work in harmony. This pre-dominance of WS over IK exists in textbooks. This study proved that IK and WS could be taught simultaneously and support each other and that teachers could help by using IK as gatekeeping concepts to link to WS. Science knowledge alone is privileged to be documented in textbooks that use English and dominate IK. Snively and Williams (2008) moved that indigenous science is a broad category that includes everything from metaphysics to philosophy to various practical technologies practised by indigenous people. Lastly, Tala concluded that:

> *The documents indeed gave <u>room to integrate IK</u>, but there is one problem which is happening in our schools, number one some of us, some of the teachers are not <u>knowledgeable when it came to IK</u>, they do not know how to integrate it, secondly, we do not have words that can describe some of the … these things in our vernacular language and that plays a very big role … the language itself.* (My emphasis)

This revealed that teachers are influenced by the way they were trained at institutions of higher learning and many science teachers struggle to integrate IK into their lessons because they were not exposed to it during their time at school and institutions of higher learning (Cronje et al., 2015). Vygotsky's (1978) SCT rests on the premise that learning is social, and that it is through social interactions with more knowledgeable peers, that teachers receive assistance as illustrated in the ZPD.

6.5.3 Active engagement of Chemistry teachers helped them learn

Three workshops were done with the Chemistry teachers to analyse curriculum documents such as the NCBE, Chemistry syllabus, Chemistry textbooks, examination papers, and examiners' reports. Chemistry teachers were actively engaged in these workshops to understand how these documents demonstrated the integration of IK in science classrooms. I observed that Chemistry teachers were engaged in further discussions and their explanations became deeper and they could give more clarity on different concepts. Active engagement helped Chemistry teachers to be involved in a peer-learning community. Similar to Tosey and Gregory (1998), peer learning helped Chemistry teachers to improve their personal knowledge, social interaction (Vygotsky, 1978), community interaction and facilitation (p. 76). Sebron manifested his personal knowledge on catalysts (*Ehete* and *Ongudo*) through peer-learning community interactions (Tosey & Gregory, 1998). This helped teachers form CoPs during the research with the aim to help and learn from each other during and after the research.

Research done in Namibia on learners' participation when IK was introduced in the lessons shows positive results as learners were actively engaged (Liveve, 2017; Nikodemus, 2017; Shifafure, 2014). The significant improvement was the result of teachers moving from the westernised teaching methods to indigenous teaching methods by assimilating indigenous practices to enhance the conceptual understanding of learners. It was noted from the discussion when participants were asking questions and helping each other to further understand the link between IK and WS, for example, Ndeshi wanted to know and asked the following question: "*Between Ongudo and Ehete which one was acting as a catalyst*?" This activated the thinking of participants and most of them contributed by explaining what they thought was the catalyst when *Oshikundu* is made at home. This active engagement was interesting and was followed by a discussion about which *Ongudo* was the best to use for sorghum and *Mahangu*. Chemistry teachers had different understandings of why indigenous people use *Ongudo* from *Mahangu* and sorghum. Tala illustrated: *"Let me cut you short a bit, Ongudo we can have for sorghum, and they can make for Mahangu (millets), are we aware of that?"*

In response, Shipefi 16 exemplified*: "But for sorghum is always sweeter than for Mahangu"*. Sorghum has more carbohydrates than *Mahangu* and it is easier for enzymes to feed on them and produce *Oshikundu*. To support this, Sebron illustrated that:

> *It seems sugar is not enough for more alcohol to be produced for Oshikundu to be ready, they add sugar because the more they add sugar it will fasten the process because you increase the concentration of glucose and now you have more glucose in Oshikundu, microorganisms they are now happy they feed and produce alcohol. At the end of the day, my Oshikundu will be ready, and it will make some drunk because a lot of alcohol has been produced*.

Sugar plays a key role in *Oshikundu* being ready within a short time; adding sugar means increasing concentration and this is one of the factors that affect the rate of reactions. Chemistry teachers were engaged in a peer-learning community, and this allowed them to work together in a group and engage collectively (Chauraya & Brodie, 2018; Ngcoza & Southwood, 2019).

As noted, Ndeshi articulated: *"I think the process of coming up with Ongudo it contributed".* Sebron agreed: *"There, yes, it contributed because it doesn't have starch it has glucose, that can be easily digested, that can be directly fed by microorganisms without going the process of digestion ... starch into glucose".* This was acknowledged by Ndeshi but as Tala said: "*You can make Ongudo from Mahangu, but after making Ongudo from Mahangu it will have a different taste from the flour itself. That's why now I want to think that this process of making Ongudo".* As exemplified: Shipefi 16: *"But do you know that they are still looking the same?"* Ndeshi: *"But it also becomes sweeter".* Shipefi 16*: "But not like sorghum".*

> Sebron: *I think that has to do with the amount of starch in that particular fruit (sorghum and Mahangu). If the fruit has a lot of starch obviously when it is turned into* *monosaccharide* *it will be sweeter than the other one with few starches. Sorghum they have a lot of starch in them than Mahangu.* (My emphasis)

Monosaccharide (mono = "one"; sacchar- = "sweet") are simple sugars. In monosaccharides, the number of carbons usually ranges from three to seven. Glucose ($C_6H_{12}O_6$) is a common monosaccharide and an important source of energy. The structure below illustrates the example of a monosaccharide.

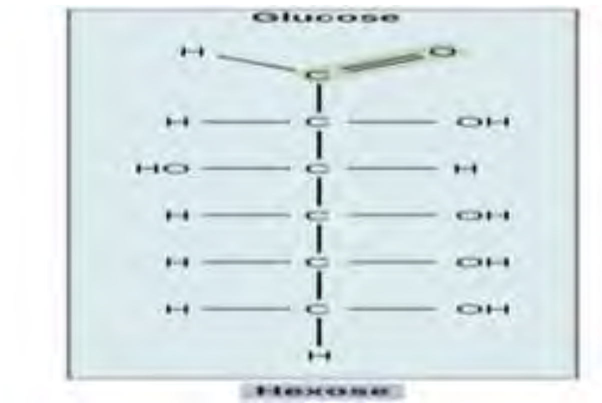


Figure 6.2: Shows the structure of monosaccharide (glucose known as hexose) (http://osp.mans.edu.eg)

The understanding of teachers was based on the observation and testing they used to enjoy when preparing the two ingredients. *Ongudo* from sorghum is sweeter than the one from *Mahangu*, thus indigenous people use *Ongudo* for Sorghum which allows the enzymes to work on them to convert sugar to alcohol for *Oshikundu* to be ready. Ogunniyi and Ogawa (2008) further showed that the best ways to engage science teachers to improve science teaching and integrate IK in their classrooms are to engage them in professional development is to engage them in the form of dialogue, PLCs, argumentation, role modelling, and explicitly reflective instruction approaches within a conceptual change framework.

In this regard, teachers need to have in-depth knowledge of the curriculum for them to be able to incorporate what is not stipulated there into their science lessons in the form of contextual knowledge. Interestingly, Sebron vowed: *"I am going to re-teach this topic tomorrow before I forget what we discussed here"*. Sebron was convinced that the way he taught the lessons to the learners did not support learners' prior everyday knowledge and the use of IK as an exemplar to make learning effective. The $ePCK_T$ for Sebron shifted and improved as he reflected ($ePCK_R$) that how he taught the lessons did not support learners' prior everyday knowledge (Kuhlane, 2011).

Science teachers need to be more knowledgeable about the cultural identity and the IK of the learners before attempting to embrace it in the science lessons as IK has a strong link with the culture, traditional beliefs, understanding, and the environment where people live. Teachers need to embrace both IK and western science in their classrooms without comparing the two worldviews and trying to find out if one is superior to the other. A well-trained teacher could ensure learners learn in harmony without causing cognitive conflict (Le Grange, 2007) between learners' IK and western science knowledge. The participants were engaged in the active discussion to understand certain aspects that were happening in the environment around the school or local communities to be used as scientific examples. This showed that their pPCK and cPCK (Carlson & Daehler, 2019) improved during the workshops on how IK should be integrated.

To enlighten his experience on making *Oshikundu*, Tala elaborated, "*I once asked my Granny one day why warm water; she said that Oshikundu will not be ready if using cold water"*. Scientifically, enzymes will not be active to start working at cold temperatures; they can only work at certain temperatures (optimal temperature). Through social interactions, Tala observed and learnt about the use of warm or hot water in the making of *Oshikundu*. Vygotsky (1978) emphasised the importance of social interactions that allow people to learn from each other. Participants learnt how *Oshikundu* is prepared using warm water and the science behind using warm water. Ndeshi elaborated: *"They want the flour to be cooked"*. In support of this Tala indicated that *"Some of them they warm water and some of them they boil water"*. Sebron clarified this and reflected that:

> *Colleagues, I think this has to do with <u>enzymes</u> because we have alcohol that is produced, let us not forget about that, and then those enzymes work best at a <u>certain temperature</u>. They do not work at <u>cold temperatures</u>, now if the temperature is <u>high, they will be denatured</u>, they will work best at <u>optimal temperature</u>, perhaps they want to <u>activate the enzymes</u> so that they can be able to digest and they can be able to work best because the issue of Oshikundu, some enzymes are involved. Wherever there is alcohol produced, respiration is anaerobic and it includes microorganisms and enzymes should be there.* (My emphasis)

This was in agreement with Tala who said, "*You are right sir"*. Tala was convinced that the explanation given was the science behind why local people use warm water whenever they are preparing *Oshikundu*. Sociocultural theorists view learning as integration into a CoP in which social actions are identified and classroom activities designed (Shabani, 2016).

Likewise, the explanation used acted as an analogy (Mavhunga & Rollnick, 2019) which helped Chemistry teachers visualise the process that is involved when making *Oshikundu* and the concepts that are connected to the topic of rate of reactions detailed in the three Chemistry textbooks.

Sebron's explanation got more attention when referring to why indigenous people warm the water regarding how enzymes work when stating: "*certain temperature", "cold temperature", "activated enzymes", and "optimal temperature"*. Chemistry teachers had a better understanding of how enzymes work and thus, the understanding of indigenous people was scientifically proven. Furthermore, from a biological understanding, Sebron explained anaerobic respiration, *"as any activity that breaks down glucose for energy without using oxygen"* (see Section 2.3.1). This acknowledged that teachers' PCK was transformed from subject matter knowledge per se into subject matter knowledge for teaching (SMK_T). Collectively, the PCK of Chemistry teachers was enhanced and they understood the importance of using TSPCK to teach the learners.

There is a need for indigenous people's wisdom, values, beliefs, and indigenous technologies to be infused into science textbooks that could help teachers and learners to bridge the gap between the two worldviews. There is a knowledge gap between Eurocentric and Afrocentric knowledge. IK and western SK are considered to disparate as to be 'incommensurable' or 'irreconcilable' on epistemological and ontological grounds (Nakata, 2007). Looking at the explanation, I argue that IK and WS can work together to support each other but due to our lack of IK we opt to separate the two worldviews as 'incommensurable' or 'irreconcilable'. There is a need to engage science teachers in similar workshops to familiarise them with the curriculum documents that are not well understood by many. Lack of understanding of IK means that IK is not part of the European authored books as this knowledge is regarded to be Afrocentric and has not been proven.

Furthermore, Sebron wanted to know the difference between *Oshikundu* and *Otombo*. In response, Michael indicated the only difference is the type of sugar to be used and the size of the sorghum. In her response, Ndeshi indicated that they are all made from sorghum. Regarding *Otombo*, Shipefi 16 explained that they even make *Otombo* with warm water. To supplement the understanding of warm water, Tala elaborated: "*If it is too cold the container, they will put it in the sun; the water inside will be warm, and they use that water to make Otombo*". To answer the question he asked, Sebron enlightened: "*The only difference is that brown sugar that has caffeine, caffeine also contributes to the function of the brain, that's why it makes people drunk more than drinking Oshikundu. Just because of caffeine in that sugar"*. This shows that teachers wanted everyone to learn and to be able to understand the reasoning behind some behaviour when people drink

Otombo. Surprisingly, Ndeshi was unaware of where the caffeine that would make people drunk came from and she asked: "*Where does caffeine come from*"? In his response, Sebron stressed that brown sugar contains caffeine, and this works on the functions of the brain; when people take *Otombo*, the brain functions will be affected and they will be seen as drunk.

The findings from the three workshops reveal that the PCK (cPCK, pPCK, and ePCK) of teachers shifted from westernised-based knowledge to indigenous-based knowledge. It was evident that teachers could explain western concepts using local and practical examples that were happening in the local communities. Through social interactions with local people, participants had acquired knowledge that was applicable in Chemistry lessons/topics and workshops of this kind need to be held to activate this knowledge. The engagement of Chemistry teachers during workshops shows that they were eager to learn and wanted to implement the integration of IK in their classrooms. A peer-learning community helped them to engage and support each other on how to teach scientific concepts with relevant concepts from IK. To this, Stott (2016) and Stracke (2010) revealed that peer-learning communities helped Chemistry teachers to collaborate, engage and foster new knowledge with each other. It was clear that participants were influenced by the documents, but they understood the importance of integrating IK into the curriculum by starting from learners' prior everyday knowledge. They knew the curriculum and they portrayed that when analysing the NCBE, Chemistry syllabus, and Chemistry textbooks to find out how IK was located. Moreover, we were able to visualise the way *Oshikundu* is prepared when analysing documents and that helped us to recall and reconnect with the way *Oshikundu* is prepared and how it could be used to teach the rate of reactions and other topics in science subjects. Shipefi 16 explained that:

> *These books discussed particle size when it comes to the reaction between Calcium Carbonate and Hydrochloric Acid and temperature and catalyst. This was portrayed in the use of Ehete to speed up the rate of reaction in Oshikundu and remained unchanged or balanced out at the end of a reaction*.

Tala reflected that:

> *The textbooks explained the rate of reaction and the catalyst for increasing the rate of reaction (fermentation) which are applicable in the making of Oshikundu and shows that the indigenous knowledge and scientific knowledge can be integrated. In conclusion, is that all three textbooks are speaking one thing.*

The two excerpts from Shipefi 16 and Tala show that the Chemistry textbooks do not support the integration of IK in Chemistry teaching. However, Chemistry teachers have the mandate to link the topics in Chemistry to what is happening in the local environment. Mukwambo et al. (2014) indicated that learners are loaded with indigenous SK from home. The three Chemistry textbooks that were analysed do not integrate IK and the content presentation did not support the five components of TSPCK. Chemistry teachers showed knowledge about building on what the learners know as prior everyday knowledge before moving to WS.

The curriculum encourages teachers to build from learners' prior everyday knowledge but the contradictions that appear in the textbooks do not present the content in sequence. Curricular saliency was clearer in the curriculum on how it wanted the teachers to build from learners' life experiences. The understanding of catalysts was one of the concepts that participants could not figure out as being *Ongudo* or *Ehete*. These concepts might pose a challenge to Chemistry teachers who have not done Biology, where enzymes are explained in more detail. Regarding what is difficult to understand (Mavhunga & Rollnick, 2013), Chemistry teachers had misconceptions that *Ongudo* was the catalyst, whereas the active catalyst was *Ehete*. This concept posed a challenge to the participants, and they were made to understand the two concepts from a biological perspective. The use of *Oshikundu* to teach the rate of reactions works very well with what is documented in Chemistry. Visualisation helped participants to connect all the factors affecting the rate of reactions as documented in Chemistry textbooks and link them to the practical demonstration of making *Oshikundu*. Teachers then had a better understanding of how IK could be integrated into Chemistry using learners' prior everyday knowledge. Active engagement of participants allowed them to explore more and have a better conceptual understanding of how the curriculum addresses the integration of IK and the gaps that exist between the curriculum and Chemistry textbooks. Sebron elaborated that:

> *The conclusion that I can make is that the education system allows us to link this knowledge (westernised knowledge) to our everyday life experiences but the problem is teachers that we do not want to integrate the indigenous knowledge into the topic that we are teaching. But it has stipulated in <u>all documents that we scrutinised</u> through, maybe it is up to us to see to it that we link these topics so that we <u>foster the knowledge</u> of our learners and they will also be <u>interested in our topics</u> because we usually say learners come in the class but they are not talking about that class they were than they did not learn anything. We must*

allow learners when they go outside to debate about what they learnt, so the moment we hear learners talking about or debating about it means they have learnt something. Only through linking to our everyday life activities so that and also give them the reason why they are taught that topic so that they will get that interest and we must also give them room to go and debate among themselves. (My emphasis)

In summary, when participants analysed the curriculum documents, they considered three things unknowingly – contextualising-prioritising-refining (Roschelle, 1995) the content that was presented in curriculum documents. The use of the five components of TSPCK and their translation helped teachers to critically understand how the curriculum addresses the integration of IK. Michael enlightened that:

If we only teach about fractional distillation in the book and ignore the one the learners are familiar with, learners will not be able to analogise the two processes or bring them together. Learners will not be able to go home and say this is what we are taught at school. Some of them they are even knowledgeable about making Ombike. They can explain from the first step to the last step.

This explanation by Michael was the result of him being involved in co-analysing curriculum documents with other Chemistry teachers. Chemistry teachers contextualised the Chemistry content and explained how the content could be taught using local examples. During this process, the content was refined, and they came to a better understanding. After analysing all documents, participants were happy that they were involved in this research, and they acquired new knowledge. Tala alluded, *"I wish someone could tell those two colleagues who withdrew from this research, the benefits of being part of this research. I am lucky that I joined this educative research"*. Furthermore, Shipefi 16 commented: *"Leave them they do not want to learn new things"*. The Chemistry teachers were eager to learn from each other and this helped them to form a CoP at these schools that was not there before. Briefly, a PLC does not focus only on individual teachers' learning but on collective professional learning within the context of a cohesive group that works with an ethic of interpersonal care (Brodie, 2013).

6.6 Chapter Summary

This chapter presented the findings from three workshops where we co-analysed the curriculum documents in our peer-learning community. The NCBE, Chemistry syllabus, Chemistry textbooks, previous Physical Science question papers, and examiners' reports were analysed on how they integrate IK. The findings revealed that teachers learnt how the curriculum supported the integration of IK to teach learners by building on their life experiences (Gwekwerere, 2016). It was also evident that teachers at first were not that sure about what knowledge to integrate into science lessons.

The participants in this chapter engaged with their understanding of how IK could be integrated into less-resourced schools in Namibia. Their understanding of tapping into the community to contextualise western science helped them to explain the WS documented in textbooks using local examples and artefacts. The chapter sought to give thick descriptions as I used an indigenous research paradigm where Ubuntu is embedded.

CHAPTER SEVEN: TAPPING INTO THE CULTURAL HERITAGE OF COMMUNITY MEMBERS

> The tools with which societies worked and the manner in which they organised their labour are both important indices of social and technological development. Africa created its indigenous technology using its scientific knowledge. There were traditional skills and techniques that were used in the production of arts and crafts, blacksmithing, iron smelting, carding and weaving, and brewing, among others that summed up indigenous technology in Africa. (Shizha, 2016, p. 47)

7.1 Introduction

Indigenous knowledge (IK) is embedded in the cultural practices of indigenous people that have been passed from one generation to the next, orally and by observing and engaging in practical activities. It is the body of knowledge that belongs to a certain community that has developed and refined to changing technology (Kakambi, 2020; Klein, 2011; Mhakure & Mushaikwa, 2014; Shizha, 2016). The epigraph clarifies that different technologies that indigenous people practised even before Europeans arrived are still being used today. What is evident in the above epigraph is that science and technology are not new to Africa because Africans were using science and technology way before the arrival of the European colonisers. This implies that anyone who wants to tap into IK must consult the ECMs who are the custodians of IK (Lavallee, 2009). That is, indigenous people need to be custodians of IK when integrating it into science teaching as illustrated by Hashondili (2020) and Nikodemus (2017).

In this chapter, I present, analyse, and discuss data generated when tapping into the cultural heritage of indigenous people through practical demonstrations and participatory observation on the preservation of [18]*Mahangu*, pounding of *Mahangu* using a mortar and pestle, the making of *Oshikundu*, and reflections of participants. The data were geared to provide answers for my research question 2(b): *How do Grade 10 Chemistry teachers interact, participate, and learn (or not) during the ECMs' practical demonstrations and explanations on the preservation and pounding of Mahangu flour and making of Oshikundu?*

Using the indigenous research paradigm allowed me to focus on the Ubuntu perspective that permitted us to work with the ECMs using the PAR approach when engaging in practical demonstrations and participatory observation with the ECMs on the preservation of *Mahangu*, pounding of *Mahangu* and making of *Oshikundu* to contextualise Chemistry concepts and in particular the rate of reactions.

7.2 Overview of the Research Process

On the first day, Mee Mukwaluvala and Mee Mukwamhani took us through the cultural practices that are believed to have been acquired from their parents on the preservation of *Mahangu*, the pounding of *Mahangu* flour, and the making of *Oshikundu*. Such knowledge has been acquired and transmitted orally from generation to generation without being documented (Kibirige & van Rooyen, 2006). In this regard, Nyika (2017) defined IK as the knowledge that is unique to a culture or society and is sometimes called folk knowledge or people's knowledge. In light of this, the way *Mahangu* is preserved might differ from culture to culture, but this research focused on how *Mahangu* is preserved in the Northern part of Namibia (*Ovamboland*), specifically the Ohangwena region.

The second visit included more scientific explanations on how the making of *Oshikundu* could be used to teach the rate of reactions in Chemistry classrooms. On that day, teachers had to internalise their observations and what they had learnt from the ECMs. The chapter is supported closely by

[18] *Mahangu* are pearl millets mostly grown in Northern and North Eastern part of Namibia as a major source of food (Hashondili, 2020).

the *Ubuntu* perspective and the *voices* of the participants are clearly illustrated with direct quotes (with minor grammatical changes if necessary; underlined sections of quotes are my emphasis to highlight the main ideas from them) from the conversations which happened during the practical demonstrations and participatory observations. Thus, through being culturally and linguistically situated (Goduka, 2005), it is important to use the language that is understood by ECMs as done during practical demonstrations on preserving *Mahangu*, pounding *Mahangu* flour and finally the making of *Oshikundu*. The ECMs' names were Mee Mukwaluvala and Mee Mukwamhani, and the Chemistry teachers gave me their names to use (Michael, Sebron, Ndeshi, Shipefi 16, and Tala). Before each visit, we observed all COVID-19 protocols.

7.3 Precautions and Protocols of COVID-19

As discussed in Chapter Six, Section 6.2, the precautions were translated into the local language (*Oshikwanyama*) for the EMCs to understand and that constituted mutual benefit to the ECMs. Temperatures were measured in degree Celsius (^{0}C) as recommended unit in Southern Africa (see Appendix S, Table 1). Data from practical demonstrations on preserving *Mahangu*, pounding *Mahangu* flour, and making *Oshikundu* were used to answer the research question 2(b).

7.3.1 Greetings and introductions

On our arrival, we found the ECMs waiting for us to start with what was required for the day. We were warmly welcomed by Mee Mukwaluvala who greeted us whole heartedly and made us feel at home. During the greetings we were seated at the *Olupale* (see Figure 7.1 below). As a tradition, among the Vambo people, every visitor has to sit at the Olupale before being welcomed into the house. In *Aawambo* culture, when you arrive at home, they greet all of you at once first. After you have sat down, the normal greeting will start for each and every individual. Shaking of hands was not done due to COVID-19 protocols. The process may look quite cumbersome to non-indigenous people but it is regarded as the right way to welcome visitors to their homes in their culture. It is part of their Ubuntu to hear the voice of each visitor and how the family is doing. After the greeting, we introduced ourselves just to remind the ECMs about the aim of the research and what was expected from them, even though most of this was done during the first day when familiarising ourselves.

After the greeting, we were welcomed with *Oshikundifa*. As elaborated by Embashu et al. (2015), *Oshikundu* is an *Oshiwambo* word derived from *Oshikundifa*, which literally means "*greeting in Oshikwanyama".* This was literally done to welcome us. We were then given *Oshikundu* which is also intended to give energy to the visitors since they might have walked a long distance without eating or they did not have anything to eat. Moreover, giving *Oshikundu* to the visitors also helps them to feel at home. Culturally, *Oshikundu* is given to a visitor before the conversation starts and it is known as *Oshikundufa* (breaking the ice) (Embashu et al., 2013; 2015).

All the participants involved in this study were able to talk, read and write *Oshikwanyama* except me (the researcher). For me, *Oshikwanyama* is my fourth language and I came to learn it through the interactions with learners, teachers and the community members. During this phase, as alluded to in Chapter One, Section 1.4, I positioned myself as a co-learner because I was not aware how *Oshikundu* was prepared and what ingredients were involved in making it. Also with regard to the language, even though I could speak and understand *Oshikwanyama*, some of the concepts that emerged during the practical demonstrations were new to me. As a result, I had to constantly ask for translations from the Chemistry teachers who were standing next to me. That reaffirmed the fact that each and every person in our peer-learning community had something to contribute. But differently, we were all learners and most importantly, I was doing the research *with* them rather than *on* them as emphasised by Ngcoza and Southwood (2015). I also learnt that *Oshikundu* was similar to the traditional drink made in the Zambezi region (formally known as the Caprivi Region), called [19]*Maheu*.

After the practical demonstrations and participatory observation on the first day, we were given a surprise when we were served *Ombike* made from palm fruits. This is regarded as the best *Ombike* and it is very rare to find it. It is also very rare for *Ombike* to be given for free as most communities make it for commercial purposes. This was really a traditional *Oshiwambo* home, where people are valued more than money. This spiced up the day and after this, we went to a nearby house to have dinner with the ECMs. The dinner was prepared by other community members who were not

[19] Maheu is the traditional drink that is made from the left over porridge, by adding sorghum flour that is made from the germinated sorghum and adding water and left to ferment overnight.

part of the practical demonstrations and participatory observation. The dinner was arranged by me (researcher) as a token of appreciation to supplement what we were given by the ECMs.

7.3.2 Practical demonstration and participatory observation

After the greetings and introduction. We started with the practical demonstrations and participatory observation. Traditionally, before the seeds are taken to the field they need to be prayed for as elaborated in *Oshiwambo* by Mee Mukwaluvala: *"Okwa longekida ombuto ei tula mo moshimbale shoshikunino, a tula mo oilya komaludi aeshe ngaashi hashi ngingwa pomufyuululwakalo wovawambo nge tava pitifa ombuto, ngaashi omahangu, oilyavala, omakunde, eefukwa nomatanga*" (When preparing the seeds, you have to put them in the traditional basket for seedlings, they put different seeds the way things used to happen in our *Oshiwambo* culture if they pass the seeds like *Mahangu* (pearl millets), sorghum (*oilyavala*), beans (*Omakunde*), groundnuts (*Eefukwa*), and melons (*Omatanga*)). The prayer was done as per the tradition, before going to the field. Thereafter, the seeds were taken to the field for a sowing demonstration. The Chemistry teachers reflected on the knowledge they gained when preparing the seeds:

> Michael: *From the community members again, I have gained that Christianity has been there because before we went for sowing they prayed for the seeds and again for the rain and thereafter for the good harvest.*
>
> Tala: *The community experts noted before we embarked upon sowing, that first we prayed for the seeds before sowing and this has been a common practice passed on to us by our forefathers and it is a practice within Namibia particularly Oshiwambo speaking people.*

These excerpts illustrate that they prayed for a good harvest. Christianity was something that they believed in and before going for sowing their seeds they had to request a good harvest. These types of beliefs are not practised nowadays as most indigenous people have disconnected themselves from IK and beliefs.

The Chemistry teachers were surprised to hear that, seeds needed to be prayed for before they left the house. Also, they had to be taken to the *Olupale* (traditional home reception area) first. It is the place where the owner of the house eats dinner and women are not allowed to sit there unless there is a problem to be solved.

Figure 7.1: Shows ECMs and the traditional setup of the *Olupale*

Traditionally, all visitors need to sit at this place before they are received by the house owner and all the greetings are done at this place. The *Olupale* has six sides as explained. 1. *Omunu eya meumbo nombili* (a person who comes into the house with peace); 2. *Ovamati vemeumbo* (boys from the house); 3. *Mwene weumbo* (owner of the house); 4. *Oukadona vomeumbo* (girls from the house); 5. *Omunu ehena ombili* (people who come in the house without peace); and 6. *Ovaeti vomadimo* (people who brought pregnancy news). We had come in peace so we sat on the side of those who had come in peace, while the community members sat with the owner of the house and the two ECMs sat in the place reserved for girls from the house.

After this session at the *Olupale*, Mee Mukwaluvala and Mee Mukwamhani took us to the field to demonstrate how the *Oshiwambo* people used to grow *Mahangu* and sorghum as discussed in section 7.4.

7.3.2 Immersion and understanding of IK

I observed that both ECMs were knowledgeable about the preservation of Mahangu, pounding and making of *Oshikundu*. During our visit, they took us through all the steps from ploughing *Mahangu* until *Oshikundu* was prepared and hence enabling us to cultural knowledge brokers (Aikenhead & Jegede, 1999; Wyatt et al., 2017). It was interesting to see how the Chemistry teachers were immersed during practical demonstration and explaining how *Oshikundu* should be prepared. Notably, the two ECMs worked together without opposing each other. For instance, Mee Mukwaluvala took the leading role as they did the practical demonstrations and participatory observation at her home. On the other hand, Mee Mukwamhani took the role of supporting Mee Mukwaluvala.

The Chemistry teachers had different knowledge levels when it came to the way *Oshikundu* was prepared during the practical demonstration. Worth noting is that culturally, boys and men are not allowed to prepare *Oshikundu* as it is regarded as a traditional practice for women or girls. Understandably, Ndeshi, the only female participant in this study was knowledgeable about making *Oshikundu* as she has been doing that at her own house. However, Shipefi 16, Michael and Tala seemed to be aware of how *Oshikundu* is prepared. As a result, Tala actively asked questions for clarity on different cultural activities such as threshing *Mahangu*, pounding *Mahangu* and making *Oshikundu* that are done at home. This was because there are some activities that boys are not allowed to do. Sebron was the least knowledgeable on making *Oshikundu*. Also, he could not do some of the cultural activities, like pounding and *Okuxwa/*threshing.

7.4 Data from Ploughing of *Mahangu* and Sorghum, Harvesting and Preservation of *Mahangu*

Figure 7.2 is an illustration of Mee Mukwaluvala and Mee Mukwamhani and Chemistry teachers demonstrating how ploughing used to be done, while the other participants observed. After tilling the soil using hoes, *Mahangu,* sorghum, and other seeds had to be sown. Nowadays, however, most households use tractors for ploughing and hoes are only used for weeding. The Chemistry teachers were actively interacting with Mee Mukwaluvala and Mee Mukwamhani when tilling the soil and demonstrating sowing different seeds (see Figure 7.2).

According to Ogunniyi and Ogawa (2008), African indigenous people classify soil using colour, texture, and structures. They also use indicator plants such as sorghum for deciding the suitability of the soil for a given cropping system. They classify plants according to how they grow in different types of soil and their habits when growing (Ogunniyi & Ogawa, 2008). *Mahangu,* for instance, grows well in sandy soil and a mixture of loamy-sand soil as observed in Figure 7.2 below. Indigenous knowledge (IK) is local knowledge derived from interactions between people and their environment; these interactions helped people to be able to learn or observe how to control pests in their fields and how plants grow in different types of soil (Kibiringe & van Rooyen, 2006).

Figure 7.2: a) Research participants sowing *Mahangu*, sorghum and others seeds b) Mee Mukwaluvala and Mee Mukwamhani (ECMs) demonstrating how the soil is tilled

Mee Mukwaluvala emphasised, "*Ina i kala kombada otai lika po keexuxwa nokoudila*" (It must not be on top it will be eaten by chickens and birds) and adding to this Mee Mukwamhani said that "*fufileni nawa oilya opo iha likemo koudila, iyaloo shili oshinenga oshapwa oku kuna ngaha"* (Cover *Mahangu* properly, it must not be eaten by chickens, thanks we are done we have sowed our seed). This explanation illustrated that when people were done with ploughing and sowing, they used to be happy. In other cultures, when the ploughing season was over, people used to make traditional beer to celebrate the planting season.

Seeds can germinate properly if covered by moist soil with favourable temperatures. If the soil is not fertile, Mee Mukwamhani indicated that "*Hatula mepya ushosho we ngombe ile we ingombo*" (We used to put cattle or goat mature). This knowledge is useful in agriculture and indigenous people are architects in that. Scientifically, it has been proven that cow dung increases the soil nutrients level as an organic fertiliser, which ultimately increases the harvest (Wisdom et al., 2012). As a result, agriculturists encourage local community members to add cow dung into their fields to improve productivity. Gana (2009) indicated that cow dung contains the undigested portion of the feed eaten by animals, whereas urine contains only the soluble products and has higher nitrogen and potassium contents than cow dung and since these are in a solution, they are quickly available to plants.

7.4.1 Harvesting of Mahangu and Sorghum

"For *Mahangu*, *we harvest with hands, we harvest using hands*" (Mee Mukwaluvala). Surprisingly, Shipefi 16 asked: *"Oo hamba osho hakutiwa ovanhu otava teya? Ndele itava tete otava teya"*? (Ooh that is why they use to say people they are going to break (to harvest with hands, *teya* means break), perhaps they are not cutting but harvesting with hands). The participants seemed not to know the differences between the two forms of harvesting, O*kuteya* and *Okuteta*. Mee Mukwamhani elaborated more by clarifying the differences between the two concepts and forms of harvesting and explained: "*Heeno otava teya ndele itava tete, shaashi otava teya ashike neenyala, osho oshikulu shetu sho nale, oto teya ove totula moshimbale"* (Yes, we harvest with hands, but we do not cut, because they just harvest with hands that is the old way of harvesting, when they harvest with hands they put it in a traditional basket). *Okuteya* is harvesting with hands, and *Okuteta* is harvesting with knives. *Teya* is translated as break and T*eta* is translated as cut. Mee Mukwamhani made it clearer that *Okuteya* was the old way of harvesting since people did not have enough knives. This type of harvesting is still commonly used today.

Figure 7.3: a) Shows *Mahangu* in the field after *Okuteya* b) Shows Mee Mukwaluvala, Mee Mukwamhani and Tala demonstrating how *Mahangu* used to be carried to its next destination

7.4.2 Preservation of Mahangu by sun drying

After harvesting, *Mahangu* is taken to the *Omutala* for the first step in the process of preservation by sun drying (Hashondili, 2020). *Mahangu* needs to be exposed to the sun for a long period for it to dry completely. Sun drying is one of the methods that indigenous people used to preserve food and seeds. Food crops such as maize, *Mahangu*, sorghum, beans and groundnuts used to be sundried before storage, to increase their shelf-life span to about six months (Agea et al., 2008). This practice was common for most indigenous people and was believed to be the best method of preserving food and seeds. *Mahangu* used to be sundried to increase its life span and this process used to be done when the rains had stopped or towards the end of the rainy season and harvesting time. It could be argued that indigenous people observed and developed their knowledge from the experiences that they had acquired through interacting with the environment. This has helped them to know the time when *Mahangu* should be placed in the *Omutala* for further sun drying. Should it rain while *Mahangu* is already in the *Omutala*, the drying process will be delayed.

Mee Mukwaluvala further explained that the corrugated iron prevents the complete circulation of air as it blocks the air movement from the sides. Most community members do not use corrugated iron to make *Omutala* for those reasons as the *Mahangu* cannot dry quickly. Corrugated iron creates moisture that could make the *Mahangu* germinate which would lead to it being spoiled. Corrugated iron is WS that has been integrated into indigenous knowledge to make an *Omutala*.

Figure 7.4: a) Shows ECMs and Tala taking *Mahangu* to the *Omutala* b) Shows how *Mahangu* used to be preserved by sun drying

In Figure 7.4(b) above, two sections of the *Omutala* are shown – one with the traditional way of doing it and the other one with the westernised method of using corrugated iron. Analysing the two sections gives a clear understanding of why the *Omutala* made from corrugated iron was not filled up like the one made from branches and grasses. Corrugated iron does not allow air circulation, thus the *Omutala* made out of it was not filled. This shows that indigenous practices are not static but instead evolve over time and are dynamic. This vividly concurred with researchers that advocate that IK evolves and this observation was a clear indication that local people are integrating WS to supplement their local way of doing things (Dziva et al., 2011). The bottom part of the *Omutala* is made using shrubs and grasses. Integration of WS in localised ways of doing things is evidence that the two worldviews have the potential to complement one another and be in dialogue as postulated by Seehawer and Breidlid (2021). Mee Mukwaluvala explained the process done at the *Omutala* and she also ostensibly explained the scientific processes involved in preservation (translated version):

> *If Mahangu is being harvested from the field usually people take Mahangu to the Oshipale, if they are brought to the Oshipale they put it on the Omutala, which is made from sticks, and fresh leaves of trees and with glass to close the gaps for Mahangu not to pass through. Mahangu stays on the Omutala for several weeks or some months to sun-dry, even though some Mahangu was dry already. There it's safer at the Omutala than putting it on the ground because it helps the Mahangu not to be destroyed by animals, ants, and children and also by the rain if the harvest is done during the rainy season or if rain falls during the harvesting time and the Mahangu will be not spoiled. If the Mahangu is being put on the ground they can easily get spoiled by the rainfall and it can germinate easily; but if they are on the Omutala, water can pass through and there is not much spoiling compared to the one on the ground, and they can get dry again – some people used to make fire under the Omutala to help the water to dry up by the smoke and fire if there is rainfall.*

This excerpt from Mee Mukwaluvala illustrates that indigenous people have developed IK on how to preserve *Mahangu* to last longer based on their experiences. Sun drying allowed the *Mahangu* to last longer meaning that the *Mahangu* used to be exposed to direct sunlight so that they would lose their moisture, enabling the *Mahangu* to dry completely. To prevent the damage that could be caused by children and other *Mahangu* eaters like ants, the *Mahangu* used to be put on the *Omutala*. It was amazing how they came to know that air could be used to dry the *Mahangu* during the rainy season by using tree branches and grasses to make the *Omutala* – this allowed the water to drop out and air to circulate which dried the moisture around the *Mahangu*. This could take one to two months depending on the rainy season. However, if it was raining, it could have taken longer than expected because the *Mahangu* needed to be completely dry before the next process could take place.

7.4.3 Threshing of Mahangu

After the *Mahangu* is completely dry it was placed in the *Oshipale*. At the *Oshipale*, the *Mahangu* were hit with sticks and some people used mortars and pestles to separate the *Mahangu* grains from the unwanted chaff. This process involved the separation of mixtures as the grains were mixed with the chaff. Mee Mukwamhani explained that *"oilya oyeya poshipale ohatu kufeni nee omishi tuxweni ovanhu tava xu oilya yavo, Ova Tameka Okuxwa tava imbi oyiimbo yavo yoshiwambo, shaashi ovanhu nge tava xu ohava imbula oyiimbo yopamufyuululwakalo*" (*Mahangu* is now at the *Oshipale*, we can take the pestle to thresh it, people thresh their *Mahangu* when they start threshing they start singing songs for *Oshiwambo* culture because when people are threshing they do sing their cultural songs). Singing as part of the communication was used to call the neighbours to come help and it was another way of encouraging each other not to get tired. This revealed a strong *Ubuntu* perspective that connected people living within the same area. They had the culture of helping each other by giving a helping hand and that connected people for a long time. They sang a song for us during the practical demonstration on threshing *Mahangu* using a mortar and pestle. Indigenous people use songs to send messages to each other and during threshing, songs were meant to make the work easier. For example, they sung this song when threshing *Mahangu*:

1. Okamushi kange kawa nokutala
Okamushi kange kawa nokuxwifa,
Okamushi kange kokahenga djove,
Ngeenge oka teka naame onda teka.

2. Ngeenge ndafi tuleinge moshindada
Nduude omundaungilo womunhu taka yela,
Omundaungilo womunhu taka tila ketut

3. Nghee tweya nale ongula,
Noshilambu shetu mela, nondjala yetu medimo
Kudunga nye inamudunga
Kutwa ina mu twa hano.

Translating the song verbatim into a western language might dilute the meaning of the song. Literally, the song means their pestles are good to use when threshing *Mahangu*, if they break they will also break. This shows how proud they are to be threshing Mahangu using pestles. This resonates with the indigenous research paradigm (Chilisa, 2012) in that the ECMs sung the song that sends messages to the neighbouring homes to come help during *Okuxwa*.

Figure 7.5: Expert community members demonstrating threshing (*Okuxwa*), and research participants demonstrating their skills after observing the community members

For example, the use of a mortar and pestle for threshing *Mahangu* as the community members demonstrated. *Okuxwa* is using a mortar and pestle and *okudenga* is using the stick. In his study, Liveve (2022) illustrated how threshing could be used to teach energy conversion. Teachers used threshing as an example to explain energy conversion. He stated:

> Hence, the teacher to use this practice as energy converted from a person as stored chemical energy to kinetic energy, potential energy and sound energy when sticks hit Mahangu grains (Chemical energy → kinetic energy ⟶ gravitational potential energy + kinetic energy + sound energy). (Liveve, 2022, p. 107)

As illustrated, science teachers revealed that they understood the process of threshing and they reconnected that to energy conversion. The understanding of science teachers showed that they could contextualise Chemistry teaching. The pestle is curved in such a way that it serves two purposes. The side which has a large end is used when people are threshing the *Mahangu* and sorghum, and the other smooth end is used to pound the *Mahangu* or sorghum flour (Figures 7.5 & 7.8). The *Oshipale* where this process took place used to be plastered with a mixture of clay soil and water. This made the surface smooth so that the *Mahangu* grain did not get mixed with the sandy soil.

The quantity of the *Mahangu* and sorghum at the *Oshipale* differed; this quantity was used for the practical demonstrations only (see Figure 7.5). This was done for the grains of the *Mahangu* and sorghum to come out from the chaff within a reasonable time. Interestingly, Tala asked: *"Hano novalumenhu ohava xu ngoo nee?"* (Do males also thresh *Mahangu* at *Oshipale?*). In her response, Mee Mukwaluvala explained to the participants: "*Heeno, ovalumenhu havo nee hava ndjeluka poipale opo tava imbi"* (Yes, males also work at the *Oshipale,* and they used to sing). Tala further asked: "*Ame ondishi ashike oilonga yetu okudenga ashike ndee opuwo*?" (I thought that our work is only to hit/beat). Mallet and du Plessis (2001) found that manual threshing and winnowing are typically the work of household women, but men and children often joined the family, working as a team. This resonates with the answer given to Tala's question which was influenced by the cultural responsibilities of girls and boys.

Chemistry teachers were learning, and their knowledge shifted from WS to IK and *vice versa*. Sociocultural views of learning shifted the teachers' focus from individually internalising learning, an acquisition metaphor of learning, to a more participative approach (Allahyar & Nazari, 2012). Learning occurred as a result of social interactions (Lutz & Huitt, 2004) and learning awakened a variety of internal development processes (Lutz & Huitt, 2004).

As I elaborated earlier, there were two ways of separating *Mahangu*, namely, *Okuxwa* and *Okudenga*. *Okuxwa* is associated more with girls' responsibilities, which needed less power and only a small portion of *Mahangu* was done at a time. On the other hand, *Okudenga* was associated with boys' responsibilities and a huge amount of the *Mahangu* could be placed at the *Oshipale* at once. This allowed the male participants (see Figure 7.5) to also demonstrate *Okuxwa* at the *Oshipale* as they believed that it was a female's work. The two male participants precisely copied what the community members were doing, and they were heard singing. Shipefi 16 questioned Tala while busy threshing *Mahangu: "Elalakano lokuxwa todingonoka oshindada ola shike?"* (What is the aim of threshing while circling?). Tala responded: *"Opo u ha tatule oilya shaashi eshi toxu ponhele imwaike, to tolitwikile, to lifola popo oilya otai tatauka, fye inatu hala nee oilya* *yatatuka*" (So that you should not destroy *Mahangu*, if you are threshing at the same place, you keep hitting the some *Mahangu* and they will break, and we want *Mahangu* not to break).

Social interactions helped participants to learn why the community members circled while threshing the *Mahangu*. Furthermore, social interactions allowed learning to take place in an informal setting through informal activities that allowed the people with less expertise to observe the MKOs when doing activities. Participants observed what the ECMs were doing and were actively engaged in the practical demonstrations after observing what was done. For example, when male participants heard that men could also thresh the *Mahangu* at the *Oshipale*, they took the opportunity to demonstrate it and acquired the skills and knowledge that they did not have before (see Figure 7.5).

After *Okuxwa* at the *Oshipale,* the *Mahangu* grains needed to be separated from the chaff using wind as the agent. Ndeshi probed: "*Ngeno Oilya oya dengwa ile yaxuwa nee paife owa hala nee Okuyela oto ningi ngahelipi? Kutya ngeno itatu longifa oshipeleki shaashi oshipeleki opo she ya (oshinima sho shinanena) oto ningi ngahelipi?*" (Now *Mahangu* is beaten or threshed, and you want to sieve (separate *Mahangu* grains from the chaff) what can you do? If you do not want to use corrugated iron because it came recently, what do you do?). Traditionally, as she responded to the question, Mee Mukwamhani stressed, *"Ovakulunhu eshi vetu lombwela ovati omhepo ohai pendulwa hai ifanwa taku ti mhepo penduka uta omhepo ohai pendulwa tai tangumunwa ta ku ti ngaha"* (The elderly what they told us, they say you can wake up the wind, you can call it and say wind wake up, by singing then the wind will wake up). They demonstrated singing the song and to our surprise, the wind started blowing. Singing formed part of the way indigenous people used to transmit information. Similarly, the indigenous research paradidgm encloses indigenous research processes that involve indigenous people, culture, language and their knowledge (Chilisa, 2012; Pidgeon, 2019, Wilson, 2003). Culture includes the way of living, songs, music, dance, rituals, and ceremonies (Chilisa, 2012).

After they sung the song, the wind started blowing. This is regarded as a traditional belief that cannot be proven but it was observed during this research. The *Mahangu* grains cannot be blown away by the wind unless the wind is very strong, as it would just fall perpendicularly to the *Oshimbale* during *Okuyela*, while the chaff has to be blown by the wind to the other side and that allowed the community members to collect the grains without the chaff. Tala wanted to know that, apart from singing a song, were there still other methods used to call the wind. Mee Mukwamhani responded "*Ngeenge owa li oku ifana omhepo ndele inai u ya ovakulunhu ohava fola omwiidi umwe hau ifanwa Oshoke, oyo hai kufwa eshi omunhu te ya koshipale ye tei homeke moilya ei yaxuwa ya taalela kouninginino nomhepo otai penduka"* (If you have been calling the wind and did not come, the elderly they will take the grass called *Oshoke* and it is taken to the *Oshipale* and you place it in the *Mahangu* grain threshed already facing the western side, then the wind will wake up). It was interesting to observe how Mee Mukwaluvala and Mee Mukwamhani always referred to the elderly and what they were told by them. This is the key foundation of IK, that it is passed from generation to generation orally (Mapara, 2009; Nyika, 2017).

During winnowing, they sang the following song that was taught to them by their granny. This song has been taught from generation to generation.

Mhepo mhepo

Mhepo yakalolo yaHamutenya yaya nomano oluvanda

Mhepo ila utu kwafele

Mhepo mhepo

Mhepo yakalolo yaHamutenya yaya nomano oluvanda

Mhepo ila utu kwafele

……… the stanza will keep repeating

In short, the song means that the wind of *Kalolo yaHamutenya*, come and help us. In an African perspective, Ubuntu to be specific, we believe that the dead have a role to play in our lives and that way of knowing contradicts with westernised ways of knowing. Notably, when Mee Mukwaluvala and Mee Mukwamhani were singing, they kept calling different names of their ancestors who died a long time ago. Some of them died before they were born and they were just told who these people were. The wind was named *yakalolo yaHamutenya*. The wind was named after their ancestor who lived and died a long time ago before they were born. The transformative research paradigm (Biddle & Schafft, 2015; Cram & Mertens, 2016; Mertens, 2007) and indigenous research paradigm (Chilisa, 2012) helped us to engage in cultural activities with the

ECMs. Ubuntu helped us to work together and learn how to sing the songs that were used as the method of communicating to neighbours when winnowing. Singing is one of the way indigenous elders transmit knowledge to the young generation (Seehawer et al., 2015). Their epistemology in in music, cultural dance, practical activities they do, spirituality and spirit from ancestors (Seehawer et al., 2015). As it was demonstrated when they crooned the song asking for the wind from the ancestor and the wind started blowing.

Apart from the singing and placing the *Oshoke* grass on the threshed *Mahangu,* Tala asked again: *"Haiti Mee Mukwaluvala, nale okwa li ashike hamu ingida omhepo ile okwa li ngoo pena sha omukalo umwe ou hamu dulu vali okulongifa moku ifana omhepo*?" (*Haiti* Mee Mukwaluvala, long ago, you use to call the wind, or there was another way you could use to call the wind). With a smile, Mee Mukwaluvala responded and explained what used to be done if the singing and *Oshoke* grass did not work. She said: "*Omunhu umwe eshi te ya koshipale ota etelele ashike nande okamute/omutoko ndele ta undu kombada yoilya oko, ile eshi eya poshipale ota kufa etutu olo layelwa nale ndele te li xwameke, onghee ngaho omhepo tai penduka konima ngeenge okamundilo okaxulupo, opo nee omhepo tai ya"* (Other people when they come to the *Oshipale* they bring along the ash, then they put it on top of the threshed *Mahangu* or when they come to the *Oshipale* they take the chaff and set it on fire, then the wind will come).

Surprisingly, Michael shouted out: *"That is convection"*. He further said: "*That's why when the house is burning, within a few seconds the strong wind will start to blow"*. Observing the teachers' reactions showed that they were surprised that he had never connected the IK around the community to what was documented in the textbooks. Convection is the result of when warm air rises and cold air sinks to the bottom and a space is created that needs to be filled and the movement of air starts.

Mee Mukwaluvala could not explain further how the fire could make the wind blow. This knowledge is useful when teaching learners about convection and using it as gatekeeping knowledge might help the learners understand the concept. Figure 7.6 illustrates the process of *Okuyela*.

Figure 7.6: Mee Mukwamhani demonstrating *Okuyela*/separating the chaff from the grains

The process of *Okuyela* requires wind for the chaff and *Mahangu* grains to be separated. Without wind, the separation cannot take place and Mee Mukwaluvala and Mee Mukwamhani demonstrated three ways used to call the wind. When the *Mahangu* was separated from the chaff it had to be stored for future use in the *Okaanda*. The traditional storage called the [20]*Okaanda* (granary/barn) used to be made by weaving sticks together using palm leaves or barks of other trees.

Interestingly, Tala asked: "*Mokaanda oilya itai di mo omu tai piti mokati embululu omu?*" (In the *Okaanda*, why do *Mahangu* grains not pass through the hole between the sticks?). This was a result of the teacher observing the gaps that were visible between the sticks that weaved. In his study conducted in Namibia, Shetunyenga (2019) indicated that the *Okaanda* is traditional storage made from sticks weaved together with barks. Mee Mukwaluvala explained: "*Ohamu filwa om nedu loshivanda, ohatu kolonga mo ashike neenyala*" (We close the gaps with the hill soil, we plaster inside with our hands). The hill soil is a mixture of loam and clay and indigenous people found it to be suitable for plastering inside the granary. Ndeshi further asked: *"Omolwashike ovanhu hava kolonga Okaanda meni va lumbakanifa edu netudi longobe*"? (Why do people plaster inside the *Okaanda* by mixing cattle dung with soil?).

---

[20] *Okaanda* is traditionally made storage from sticks that are weaved and curved in the shape of a sphere; it is plastered inside with hill soil or cattle dung to prevent the *Mahungu* from passing through the sticks.

In response, Tala said, *"Omolwaashi oilya mokaanda ohai kala mo efimbo lile opo mu he uye onuko, shaashi nge mu na omatudi ongobe oupuka itava i mo noupu, ohashi dulu oku ningwa nakeshe osho tashi dulu oku kelela mu haye onuko*" (*Omolwashashi Mahangu* used to stay there for a long time, for the pests not to get in, because if there are cattle dung the insects cannot enter easily, it can be made with *nakeshe/*anything that can help to prevent insects/pests from getting in). Vygotsky's (1989) social interactions allow people to learn from each other and the MKOs where the ECMs in the context of this study. Teachers engaged with each other and tried to understand the local practices that helped them prevent pests from destroying their harvests. Observing how the participants were interacting with Mee Mukwaluvala and Mee Mukwamhani, I came to realise that their pPCK and ePCK and the understanding of Chemistry teachers were shifting between two worldviews (WS and IK). The interactions helped them to ask questions for clarity and further explanations as to why certain things were done in specific ways in indigenous communities. Weaving the *Okaanda* required someone with the acquired skills and knowledge of ethno Mathematics so that they would be able to curve the sticks and weave them into a sphere shape.

7.5 Data from the Storage of the *Mahangu* in the *Okaanda*

The process of winnowing helped indigenous people to separate the *Mahangu* from the chaff and the *Mahangu* was kept in the *Okaanda* for future use. When the *Mahangu* was threshed and separated, Mee Mukwamhani explained that "*oilya ohai twalwa nee meumbo, opo ika tuvikilwe mokaanda*" (*Mahangu* is taken to the house, for it to be stored in the *Okaanda*). Adding to this, Mee Mukwaluvala further explained: "*Oilya ohai di mokaanda opo iye koshini, ngeenge nda hala oku twa*" (*Mahangu* is from *Okaanda* when taken to the machine for pounding/crushing). A complete traditional *Okaanda* has a small opening on top where the *Mahangu* used to go through. The hole was very small, and a human being could not fit in it.

After the *Mahangu* was stored in the *Okaanda* through the opening hole, it used to be plastered with mud soil. Mee Mukwamhani illustrated by demonstrating to the participants how the *Mahangu* used to be kept in the *Okaanda* and the plastering that used to be made. "*Ngaha otwa tuvikila oilya mokaanda, ohatu ka ila mo imwe nge hatu i koshini*" (Like this we stored the *Mahangu* in the *Okaanda*; we only come to get some when we want to pound it). The most active participant Tala, questioned why indigenous people used to close the hole on top of the *Okaanda*: "*Omolwashike hatu tuvikileko*?" With a smile, Mee Mukwaluvala responded: "*Opo mu ha ye onuko, opo natango ilya iha tukwe*" (For the pests not to go inside and for the *Mahangu* not to be destroyed). Instead of using pesticides, indigenous people developed their own traditional methods of controlling pests and stopping them from getting access to their harvests. They prevented pests from destroying their *Mahangu* by sealing the opening. Interestingly and with surprise, Tala asked: "*Omapomolo ohaa pitile peni eshi hai momaanda, nge oha kala katuvikwa*"? (*Omapomolo*/Geckos where do they use to pass to go inside the *Okaanda* if it used to be closed?).

In her response, Mee Mukwaluvala explained: "*Aye katushi shi kutya ohaa pitile peni opo aye mo, shaashi eshi nga to ka tuulako omo ngoo to aha nge*" (Ayee we do not know where they used to pass through for them to go in the *Okaanda*, because when you open it you will find them there). Ndeshi used her experience and explained how the *Omapomolo* used to get into the *Okaanda*: "*Omapomolo ohaa i mo ashike nge kwa tuulwa ndele ino fikila wa tuvika ko, shaashi opena efimbo limwe wa filula ko ndee ino tuvika ko vali diva mboli*" (*Omapomolo*/Geckos used to enter when we open and we did not close it properly, because there are times when you open it but you did not close it properly). *Omapomolo*/Geckos are some of the pests that feed on the dry *Mahangu* that was stored in the *Okaanda* and also fed on other pests that could destroy the *Mahangu.*

The thatched roof that was made as a lid and the plastering prevented the *Okaanda* from being destroyed by rain. Prolonged excessive heat could also destroy the *Mahangu* grains that might prevent the *Mahangu* from germinating during the next rainy season. This knowledge has been useful over the years and *Mahangu* used to be preserved naturally without using any chemicals.

Figure 7.7: Shows plastered *Okaanda* with supporting sticks, *Okaanda* under the thatched roof and the *Oluvala* that used to hold the *Okaanda* in position

The *Okaanda* used to be raised from the ground and placed on sticks that were made in a circular format. The sticks were accurately curved and faced inside to be able to hold the *Okaanda* in position so that it would not be blown away by storms or strong winds. The shape of the *Okaanda* (shape of the sphere) allowed it to be fixedly held by the sticks in a circular form.

Tala asked: "*Omolwashike Okaanda ita ka kala pedu"*? (Why is the *Okaanda* not placed on the ground?). Mee Mukwaluvala explained that "*Ota kalika po keehedi ngeenge oka kala pedu, ko ota ka nyanauka komeva*" (It will be destroyed by ants if you place it on the ground and also the rain water will destroy it). To date, most of the storage grains are not placed on the ground for the reasons mentioned by Mee Mukwaluvala. Adding to Mee Mukwaluvala's explanation, Ndeshi elaborated: "*Etomelo la kula, olo ku amena Okaanda komeva nokeehedi*" (The big reason is to protect the *Okaanda* from ants and water).

7.6 Data from Hands-on Practical Activities of Pounding of *Mahangu* and Sorghum

After the *Mahangu* was stored in the *Okaanda*, it could only be taken out when someone wanted to pound it to make flour for porridge or for preparing *Oshikundu*. When the *Mahangu* was stored in the *Okaanda*, they used to be mixed with other unnecessary ingredients like soil. The soil and the *Mahangu* had to be separated before they were taken to the pounding place. They separate the two mixtures through the practical process called *Okufifa*. *Okufifa* separated the soil and the *Mahangu* using an *Oshimbale*. An *Oshimbale* is a traditional plate made from palm leaves weaved nicely in a circular format. Ndeshi asked: "*Natu tuleko ashike nande ina i fifwa*?" (Can we just put in even though it is not *fifwa/sieved*) and further explained that *"Shaashi oshili omu landu kutya omunhu tete manga ngeno ina tula oilya koshini oku na oku fifa oilya omadu*" (Because it is a law that when the person takes the *Mahangu* before putting it in the mortar, they must *Okufifa Mahangu* to take the soil out). The mortar and pestle were the two pieces of equipment used by local people to pound the *Mahangu* to make flour. The mortar is carved from the big tree, and it is made with an opening on one side while the other side is closed. The mortar is curved smoothly inside and the *Mahangu* grains and flour would not get stuck. In this way, indigenous people solved the problem of particle size when they were preparing *Mahangu* flour.

7.6.1 The use of mortar and pestle to pound *Mahangu* (increases surface area)

The use of a mortar and pestle is one of the examples that indigenous people are interconnected and have similar knowledge. Indigenous people share common knowledge practices in the fields of science, agriculture, ethno Mathematics, indigenous technology, and indigenous engineering. The mortar was engineered in such a way that it would not fall when placed on the ground and when people are pounding *Mahangu*, it must be steady. The mortar and pestle (see Figure 7.8) are different in size depending on the region and indigenous community. Other communities use big mortars and pestles when pounding. The mortars used to be buried in the houses and the places where pounding took place which was plastered so that the *Mahangu* did not mix with the sandy soil. Apart from burying the mortars, other communities dug small holes where the mortars had to be placed for them not to fall.

Furthermore, Chemistry teachers used the experiences gained at home to pound the *Mahangu* and Mee Mukwaluvala and Mee Mukwamhani could not participate in this activity. Michael indicated: "*Ame ondi hole okutwifa omushi u na ondjudo ihapu"* (Me, I like pounding with the very heavy pestle). This, when translated, meant that the heavier the pestle the more it would crush/pound the *Mahangu* and the fine or small particles could be produced within a short time. Adding to this, Tala explained: "*Shima omushi u na ondjudo ihapu ota u tatutla diva oilya ngaho*" (*Shima* pestle that is very heavy it will crush/pound *Mahangu* quickly). The participants had acquired this knowledge through interactions with the ECMs and using their prior everyday knowledge that they had observed when they had pounded *Mahangu*. Pounding is an activity that seems to be easy when observing people doing it, but it requires knowledge and skill in knowing how to hold the pestle and how not to miss the mortar. These skills and knowledge need to be acquired from an early age through practice and guidance from ECMs. The way the person has to stand when pounding also matters because balance is required to execute the activities. As Michael demonstrated, the centre of gravity needs to be lowered by bending the knees.

Figure 7.8: Ndeshi putting *Mahangu* in the mortar to be pounded, male participant showing his pounding skills, and Ndeshi showing her *Okufifwa* skills (separation of mixture)

Participants were actively involved during the pounding process and they were observed showing each other how they used to pound *Mahangu*. Apart from Sebron that indicated that he grew up in a town where pounding was very limited, the other four participants were able to recall how they used to pound *Mahangu*. *Okufifwa* is the process of separating the fine *Mahangu* flour from the big grains using *Oshimbale*. Indigenous people have not used the sieves that were made in recent years because they had their traditional ways of separating the *Mahangu* flour from the large particles. *Okufifwa* is regarded as a women's work. This was observed when male participants tried to hold the *Oshimbale* to demonstrate how sieving *(Okufifwa)* would be done. None of the male participants could do the activity (*Okufifwa*), thus I could conclude that *Okufifwa*, in most cases, used to be done by females as observed in Figure 7.8.

7.6.2 Preparation of *Ongudo*

After pounding the *Mahangu*, it was time to come up with the *Ongudo*. Ndeshi exclaimed, "*Ongudo oi na nee ondjila ile shaashi oya pumbwa okumena tete"* (*Ongudo* it has a long process because it has to germinate/fingerling first). This was supported by Mee Mukwaluvala: "*Ongudo ei ya tuwa nale kutya, ohadi moilyavala, yafindikwa omo nee hamu di Ongudo ei omo*" (This *Ongudo* is pounded already, it is from sorghum that was buried to germinate, that's where this *Ongudo* is coming from). Indeed, the process of making *Ongudo* is lengthy. Ndeshi wanted to find out how many days it took the sorghum that was placed in water to germinate. She asked: "*Oilyavala ei momeva oya ninga mo omafiku angapi*?" (This sorghum in the water took how many days?).

The participants could observe the fingerling in Figure 7.9, and this prompted Ndeshi to ask her question. In her response, Mee Mukwaluvala explained: "*Oya ninga mo omafiku anhe, atano kefiku lonena, ashike ina i pya natango noku twa, opo tai ka tulwa edu*" (It took four days and today is the fifth, but it is not ready yet to be pounded, it needs to be covered with soil). Community members used the soil to cover the *Mahangu* for it to fully germinate and be ready to make *Ongudo*. This was interesting because, during cultivation, *Mahangu* and sorghum used to be covered with soil for them to germinate. Engaging the ECMs in the discussion, Ndeshi asked: "*Omolwashike ina okumena*"? (Why does it have to germinate?). Mee Mukwaluvala explained, "*omino odo hadi eta omulyo mongudo*" (The fingerlings they are the ones that bring *omulyo* (taste) in the *Ongudo*).

In support of Mee Mukwaluvala, Mee Mukwamhani explained: "*Nge oya mene ohai kala iwa, nge oyamene ndele tai tilyana opo hai ningi oufila u kale utilyana nge inai mena oufila itau tilyana filufilu*" (If it is germinated it is fine it germinates it makes the flour to be reddish and if it does not germinate fully, the flour will not be reddish). The germinated sorghum has to do with the level of carbohydrates in it. In Chapter Six, participants indicated that *Ongudo* for Sorghum has high levels of carbohydrates and is sweeter than *Mahangu* flour. Even though the ECMs could not explain that the germination of sorghum increases the level of sugar that is needed by the catalyst, they understood the importance of germinated sorghum in making *Oshikundu*. They referred to the sugar as *omulyo* (taste). Germination of cereals has been used for centuries to soften kernel structures; increase nutrient content and availability; decrease the content of anti-nutritive compounds; and add new flavours without knowing the biochemistry behind these phenomena (Warle et al., 2015). Germinating the seeds increases the nutritional level and thus, indigenous people could germinate sorghum before using it. The sorghum contains maltose, glucose, and fructose but during germination, the level of germination increases because of the conversion of maltose and fructose to glucose, due to activities of α-amylase and β-amylase enzymes, which increase with soaking and subsequent germination (Warle et al., 2015).

Figure 7.9: (a) Shows Mee Mukwaluvala demonstrating covering sorghum with sand which is then watered and (b) sorghum that has fingerlings

Apart from soaking sorghum in water, indigenous people developed ways in which to make sorghum grow fingerlings that were needed for them to have *Ongudo*. The sorghum used to be put in water for it to ferment and germinate quickly and then from there it is taken out for further processing. Mee Mukwamhani stated: "*Opo itute nawa, yo idule okumena diva yo ininge omino ngaha*" For it to be wet so that it can germinate quickly and to make *omino* like this (pointing at fingerlings).

Adding to this, Mee Mukwaluvala elaborated on the different processes used to make sorghum germinate. She explained: *"Oto dulu oku kala ino itula medu toi tula ashike moshiyaha, to tuvike kononailona, to kala nee ho shashako oumeva kombada yonailona, otai ningi ashike omino ndele tai fiki nawa ndele oufila tau kala utilyana muwa"* (You can sometimes not put it under the soil, you just put it in a dish and cover it with sacks, you keep watering on top of the sacks, it will make *omino* nicely and the flour will be reddish nicely). Indigenous elders have different ways of coping with different situations. Even though dishes and sacks are westernised before the arrival of dishes they used to bury the sorghum in a hole for it to germinate. This was done so that they would have a different flavour from *Mahangu* flour. Barley malting is the most widely known controlled germination used in factories (Warle et al., 2015), while indigenous people also used the same process but on a small scale done in their houses.

It has been found that the germination stage increases the level of glucose due to the starch-hydrolysing effect (Nkhata et al., 2018). Participants were eager to make *Oshikundu* and learn more about the scientific processes involved. Interestingly, Sebron then spoke about moving to the next process in making *Oshikundu*. He said: "*Paife otu na oufila womahangu nongudo, paife ohatu kadunga Oshikundu*" (Now we have the flour for *Mahangu* and *Ongudo*, now we are going to make *Oshikundu*). This was the result of the encouraging interactions between the Chemistry teachers and Mee Mukwaluvala and Mee Mukwamhani and harmonic working relationships.

7.7 Data on Making Fire Flames

Mahangu and sorghum flours were prepared, and the next practical demonstration was to make *Oshikundu*. The ECMs boiled the water that was used to make *Oshikundu*. During this process, the fire was not flaming, and Mee Mukwaluvala used *Oshimbale* to pepela (blowing) air onto the fire for it to have flames. This resulted in scientific explanations, as teachers engaged each other to explain why. Ndeshi probed Mee Mukwaluvala: "*Oshike to pepele omundilo ngaho mee*?" (Why are you *pepela*/blowing air in the fire like that Mom?). It emerged that indigenous people used to blow the air onto the fire to make flames based on their understanding that air can make flames. Mee Mukwaluvala explained: "*Pediko ota pai omhepo eshi handi pepele, oyo tai fudile po*" (On the fire, air will go there when I am *pepela*, then it will breathe/blow there). The air that community members blew on the fire consisted of oxygen (21%) that supports combustion.

That prompted more engagement between the Chemistry teachers to explain and help each other to understand why. For example, Sebron explained to other Chemistry teachers: *"Omhepo oyo tai i pediko omhepo ei hatu fudile mo, shaashi ohaku tiwa omhepo ei hatu fudile mo ohai yambidida omutemo*" (The air that we blew to the fire, air that we blew there because it said the air that we blew there it is supporting the flame to come). The participants were struggling to come up with the local word for oxygen, as oxygen is WS, and they did not want to use westernised terminologies. During the interactions to help each other understand, Ndeshi stressed that: "*Heeno elumbakano lomhepo ei hatu fuda nai hatu fudile mo*" (Heeno, it is a combination of air that we breathe and the one we blew to the fire).

This was interesting because the argument and question was that when we blow the air on the fire using our mouths, why does the fire make flames, as the air from our mouths does not have oxygen in it? Ndeshi indicated that before the air from our mouth reaches the fire it will mix with other air and that air contains Oxygen that supports combustion. Even though explanations were made, Tala had a lot of questions as he asked: "*Oshike tashi eta omundilo uteme*?" (What will bring the fire to make flames?). The active engagement between participants showed that they were willing to unpack the SK embedded in our everyday activities. Through my observation, I could see the shift in the understanding of Chemistry teachers and that their knowledge was shifting from WS to IK on how the two worldviews could be integrated into Chemistry classrooms.

Moreover, Chemistry teachers could not convince each other on the reasons why, when we blew on the fire it would make flames. This was explained clearly, but other Chemistry teachers (Shipefi 16 & Tala) wanted more explanation based on the knowledge the indigenous people used and developed, and how they discovered that by blowing air on the fire it would flame. Indigenous people knew that air could make fire flame, thus, they used to blow air onto the fire using *Oshimbale* or their mouths, but they could not explain the scientific process involved. Their understanding of blowing air onto the fire to make flames is scientifically proven (combustion), even though they could not explain how it worked.

7.7.1 Data from making *Oshikundu*

To make *Oshikundu*, warm/boiled water was put in the bucket and *Mahangu* flour was added and stirred for it to mix properly. The participants helped the ECM by stirring the *Mahangu* flour mixed with warm water. Warm water was used to prevent changes that would result in other products, not *Oshikundu* as intended. Tala asked: "*Omeva Oshikundu oshike ha andjene*"? (Water for *Oshikundu*, why do we boil it?). To clarify this, Mee Mukwaluvala explained the reasons behind boiling water to make *Oshikundu*: "*Opo Oshikundu shi ha toke, sho otashi ningi ashike Olumbololo, tashi ningi etepi itashi ikwata*" (For *Oshikundu* not to be white, for it not to make

Olumbololo and not to make *etepi* and it will hold itself). *Mahangu* flour needed to be cooked so that it did not become white or make *Olumbololo,* or *etepi* and hold itself, thus warm or boiled water was favoured over cold water.

7.7.2 Effect of temperature in *Oshikundu* preparation

Water was boiled and it was time to make the *Oshikundu*. Michael explained one scientific process. The use of *Mahangu* flour to see if the water was ready to make *Oshikundu*. It was amazing to observe that teachers had translated IK into SK and could explain this. Michael elaborated: Translated version from the local language.

> *There is another way if the person does not want water to boil, he/she takes flour then puts it on the cooking stick which is on top of the pot without the lid. They wait until the flour changes the colour from the vapour, then from there, it shows that the water in the pot, even before it boils, can be used to make Oshikundu but it will not make etepi.*

Adding to this, Mee Mukwamhani explained that *"Aka haka tulwa koluko ngeenge ino hala omeva a fuluka, andjena. Ashike Oshikundu osho hashi kala shiwa*" (They put it on the cooking stick if you do not want water to boil but to be warm only, that *Oshikundu* used to be nice). This was the other way indigenous people developed to measure the temperature of the water without using their fingers. The flour on the cooking stick become moist due to the steam/vapour evaporating from the water in the pot. This suggests that indigenous people knew that the water in the pot had to evaporate – placing the flour on the cooking stick on top of the pot showed that the water was evaporating – which was similar to the way they make *Ombike*, as explained by learners in Chapter Eight. Thermometers were and are still not readily available in rural communities. They measured temperature by observing the change in colour of the flour and this was developed and adopted as the way to measure the water temperature. Use of a finger is also used in most communities to measure the temperature of water to be used to make *Oshikundu* and other traditionally brewed alcohol. The female participant Ndeshi clarified: "*Ondi wete kutya okaufila oko shama weka tula ko ndele okaninga kafa oshifima ngaho otashi ti omeva oo ota adulu oku longifwa Oshikundu"* (I can see that the flour, if you put it and it is like porridge, then it indicates that the water can be used to make *Oshikundu*).

Participants had different ways of measuring temperature using the vapour as noticed in their explanation. This was influenced by their cultural backgrounds and how the communities used to do it which later was transmitted to them. Furthermore, Shipefi 16 explained that, "*Iho tula mombiya oho teneke ashike oluko kombada yombiya, shima she likwata otashi u like kutya omeva otaa dulu oku dunga Oshikundu itashi ningi etepi*" (You do not put it in the pot, you just place the cooking stick on top of the pot, when the flour holds itself it shows that the water is ready to make *Oshikundu* and it will not make *etepi*). Participants used different terminologies to describe how the flour should look, such as changes in colour, making porridge, and holding itself. This shows the value of how local people discovered a way to measure the vapour of the water to make *Oshikundu*.

7.7.3 Effect of catalyst (*Ongundo* and *Ehete*) in *Oshikundu*

After stirring, the mixture was allowed to cool down before additional water was added and *Ongudo*. Adding to this, Ndeshi explained: "*Ohashi polopo manga kashona, ouwete kutya omolwashike hatu teelele shipolepo kashona, omolwashi, ngeenge Oitungifi oya i moupyu muhapu itai ka longa nawa*" (It is cooling down a little bit, can you see why we wait for it to cool down a little bit because *Oitungifi*/enzymes will not work properly). The scientific reason for allowing it to cool down is to avoid denaturing the *Oitungifi*/enzymes that will make the *Oshikundu* ready. High temperatures denature the enzymes and indigenous people knew, that using lukewarm water will make *Oshikundu* ready. Thus, after the *Mahangu* flour was cooked and water added, the temperature used to be measured by an experienced person using a finger to make sure the temperature was optimal before adding *Ongudo* and *Ehete*. Hot water can denature the active *Oitungifi*/ enzymes that are present in *Ehete*. Denaturing of *Oitungifi* can make *Oshikundu* take longer than expected and to avoid this, Mee Mukwaluvala and Mee Mukwamhani had to reduce the water temperature. The cold water used to be added and the temperature used to be reduced to lukewarm. Indigenous people used to make sure that the *Oitungifi* was not denatured, and the temperature used to be measured using their fingers.

Figure 7.10: Shows the pot on the fire to boil water, research participants mixing *Mahangu* flour with warm water and the paste of *Mahangu* flour

As observed in Figure 7.10 Chemistry teachers were actively engaged and stirred the paste, helping the ECMs during the practical demonstration to make *Oshikundu*. Through this engagement, participants were learning about indigenous science that indigenous people have been doing for years, but had not recognised as scientific. The use of the local language helped the Chemistry teachers and Mee Mukwaluvala and Mee Mukwamhani to share their understanding and explain further to enrich their conceptual understanding from an indigenous perspective. The use of local languages in science classrooms is seen as a hindrance that does not promote critical thinking, yet my observations during the practical demonstration were that teachers were actively engaged in critical thinking during the interactions with the ECMS and after the practical demonstration. Both the ECMs and Chemistry teachers were engaged and learnt from each other how *Oshikundu* is prepared in different communities. This engagement yielded fruitful participation by the participants, and they gained new knowledge applicable in science classrooms.

After adding water, it was time to add *Ongudo* and *Ehete*. Interestingly, Tala asked the ECMs how they could differentiate *etepi* from one that was not. Tala said: "*Nge owatula oumeva omu ndele totula mo oufila otapa kala eyooloko pokati kaashi naashi*" (If you put water here and you put flour in, there will be a difference between this one and that one). *Oshikundu* which is *etepi* is whitish in colour because the flour is not properly cooked. This can be the result of using water that is not at the right temperature to make *Mahangu* flour to be cooked.

Sorghum flour used as a dormant catalyst (*Ongudo*) which is rich in carbohydrates was added to the *Oshikundu*. This was done after the ECMs verified the temperature after diluting the paste, using a finger so as not to denature the active catalyst in *Ehete*. *Ongudo* is rich in carbohydrates that can be digested by the active catalyst in the *Ehete* which releases CO_2 and alcohol *(Oshikundu*) during fermentation. Tala engaged the ECMs on what is present in *Ongudo*. Tala asked: "*Ame Ongudo ohai nye ngenge, mongudo omu na shike*?" (*Me Ongudo*, I fail to understand it, what is in *Ongudo*?). In her reply to Mee Mukwamhani stated that *"Mongudo omu na omulyo muhapu*" (*Ongudo* has a lot of sweet taste). Furthermore, Sebron exclaimed: "*Oooh omulyo oo hau etifa ounyenye moshikundu*?" (Oooh *Omulyo/*taste is it the one that brings nice taste in *Oshikundu?*). The ECM's response was: "*Heeno shaashi ngeenge ongava oya kala inai tenda ile inai pya nawa itashi kala shiwa*" (Yes, because if *ongava* is not yet ready or not well cooked it will not be nice). This showed how knowledgeable the ECMs were on the science around the practical activities that they used to do at home. Mee Mukwamhani explained: *"Oshikundu shimwe ohashi dulu okutulwa ongundu ihapu ngee kuna Ongudo*" (The other *Oshikundu*, we can put in more *Ongudo* if there is enough *Ongudo*). This would make the taste of the other *Oshikundu* different, and the reaction would be faster. The more *Ongudo* that is added to the *Oshikundu*, the more CO_2 and alcohol is produced which will make the *Oshikundu* sour as stated by Tala. Vygotsky's (1978) SCT alludes that the construction of knowledge depends on the interdependence of social and individual processes which occur in a cultural context. The cultural context influences the way we view and understand things around us. That was observed during the practical demonstrations and participatory observation.

Mee Mukwaluvala explained to us the differences between the *Mahangu* flour and the *Ongudo* to be used as a dormant catalyst in our *Oshikundu*. *Ongudo* is made from malted sorghum seeds. We observed that it was not completely sieved and big particles were seen in the *Ongudo*. This was in agreement with Tala who had explained earlier that in the *Ongudo*, big particles used to be left. The big particles would later become the active catalyst, *Ehete*. Michael explained that the big particles in the *Ongudo* were the ones that would become *Ehete* and the dormant enzymes in the *Ongudo* would become active enzymes. *Ongudo* is reddish in colour; this is the result of *oilyavala* (sorghum) which is reddish, and the germination process also increases the reddish colour. Similarly, *Ehete* is added to the *Oshikundu* after the O*ngudo* has been added. *Ehete/dregs* are suspended matter (particles) that tend to settle and form a sediment at the bottom of the *Oshikundu* (Shinana, 2019).

In Chapter Six, Sebron and Ndeshi argued that *Ehete* is the catalyst that speeds up the chemical reaction and itself is not used during the process. Their theory was to be proven in these practical activities. *Ehete* was added after all the process was done and then *Oshikundu* has to be put in a safe place for fermentation to take place. Figure 7.11 shows *Ongudo* and *Ehete.*

Figure 7.11: Mee Mukwamhani shows *Ongudo* before it was added to *Oshikundu,* [21]*Omhindo* with *Ehete/residues/dregs* to be added to *Oshikundu* as an active catalyst

Ehete was used as the catalyst that has active enzymes, even though other researchers have used both *Ehete* and *Ongudo* as a catalyst that has dormant enzymes (Shinana et al., 2021). The use of *Ongudo* or *Ehete* as a catalyst was detailed in Chapter Six, even before the practical demonstration was done and this helped the participants to be more engaged in this practical demonstration.

Mee Mukwaluvala further explained how *Ongudo* could be used when making *Oshikundu* from porridge: *"Omolwaashi Ongudo eshi yatenda ngahenya itai pame vali, nande ngeno oto dungu*

[21] *Omhindo* is a calabash type of a cup that is mostly used when drinking water, *Oshikundu, Omalondu* and *Omaongo* that grow from a pumpkin and cut as cup when dry. It comes in different sizes depending on the type of drink it is being used for.

Oshikundu sho ifima oho dulu oku itula mo ove to nyanyaula oifima, to pilula ashike fiyo tashi ningi embobo, ino tula mo nande omeva" (Because *Ongudo* when it does like that it will not be thick, even when you are preparing *Oshikundu* from *oshifima*/porridge you can put it in the crush/break up porridge, you stir it until when it will come *embobo* before you put in water). There are several types of *Oshikundu*, as illustrated by Mee Mukwaluvala. They all use the same ingredients (*Mahangu* flour, water, *Ongudo, & Ehete*) and undergo similar processes.

7.7.4 Ongudo and Ehete: Which one is the catalyst?

As argued in Chapter Six (see Section 6.4.2) before the practical demonstration, this section trying to find out if Chemistry teachers were correct in their discussions about *Ongudo* and *Ehete*. Before adding the *Ongudo*, we took out two litres of the *Oshikundu* to be the controller of the experiment. After we added the *Ongudo* and took out another two litres, we then added *Ehete* and took out another two litres.

Container A = Water + Mahangu flour = Oshikundu (controller)

Container B = Water + Mahangu flour + Ongudo = Oshikundu

Container C = Water + Mahangu flour + Ongudo + Ehete/dregs = Oshikundu

Sebron asked: "*Fye hatu tale nee kutya, eshi shina Ongudo nehete naashi shihe na ehete ndele oshi na Ongudo, naashi he na sha nande shili pi tashi pi tete*?" (Us we look at, this one with *Ongudo* and *Ehete*, the one with *Ongudo* and without *Ehete*, and the other one without anything, which one will be ready first?). The teachers were reminding each other about what was discussed in the workshops (see Chapter Six) when we co-analysed national curriculum documents and rate of reactions was used as an exemplar during the workshops. That question was not answered by other Chemistry teachers nor the ECMs. Adding to Sebron, Tala explained: "*Hano omu na oinima i li ivali? Ame ondi shi ngeno ohatu kala tu na oinima ili itatu, shimwe ocontrolla, omu inamu yasha Ongudo. Mumwe omwaya Ongudo ndele ina muya ehete, mumwe otamu kala mwaya oinima aishe"* (Do you have two things? Me I know that we must have three things (containers), one is the controller nothing is added, the other one *Ongudo* is added but there is no *Ehete*, and the other one we add *Ongudo* and *Ehete*). The participants were emphasising what had to be done and how the containers should be, by stressing what I had said earlier. On each container, balloons were placed to collect the gas that would be produced during the reactions. This would help us determine the container where the reaction was the fastest by observing the balloons that were inflated the most. Figure 7.12 shows research participants after all the containers were filled and the balloons were placed on them to collect the gas to be produced during the reaction that would determine the rate of reactions in each container.

Figure 7.12: Research participants displaying their containers

For safekeeping, all three containers were placed in a big black container to prevent any children from playing near the experiment and influencing the results. The containers were exposed to the same temperature and condition for us to be able to determine the container where fermentation was taking place the quickest. The black container was opted for, as it would increase the temperature inside as it is a good absorber of heat and that would make the enzymes work best. Shinana (2019) illustrated that enzymes work best at the optimal temperature than at lower temperatures. The enzymes would be dormant and at higher temperatures, they would be denatured. The container was placed in a thatched roof room to maintain the optimal temperature. The container was closed for the heat to be trapped inside and all three containers were exposed to the same temperature.

In his study, Nikodemus (2017) found that learners were able to predict that Oshikundu *outside* would ferment faster than *Oshikundu* inside due to the higher temperature outside. Nikodemus focused on different temperatures and for this study, we focused on the catalyst. In Chapter Six, participants argued that *Ongudo* was not the catalyst, but that *Ehete* was the catalyst. Thus, three containers were given the same conditions but different ingredients, and the catalysts (*Ehete* and

Ongudo) were allowed to ferment. The result will be discussed in the section on day two's visit to Mee Mukwaluvala's house.

7.8 Data from Practical Demonstration Workshop on Scientific Explanations

Day two was one of those days you do not want to forget in the record book of your life stories (Sebron). As usual, we arrived at the agreed time of 15:00 at Mee Mukwaluvala's house for our final practical activity. We were welcomed and greeted like day one with Oshikundu being served to the visitors. After the greeting, we created the laboratory where this practical activity would be carried out under the big tree. The table was arranged with the instruments for the experiments to be done out of the school context. This was interesting because participants brought the required apparatus and chemicals. The beakers, funnel, filter papers, and distilled water were made available by the participants at the request of the researcher. Participants were taking ownership of the research by bringing what was needed for the practical activities. On day two, Mee Mukwaluvala and Mee Mukwamhani were not that engaged since this was intended for the Chemistry teachers so that they could gain further understanding of how to integrate IK and contextualise WS in Chemistry teaching.

After collecting the big black container where the three two-litre bottles were kept, we discovered that the balloon on container C had burst, and teachers were surprised as to what could cause the balloon to burst. The balloon burst because more CO_2 was released during the night and the day. We arrived at Mee Mukwaluvala's house at 15:00, which meant that fermentation that resulted in the release of CO_2 started during the night. Tala explained, "*It was overnight, when you leave it overnight that is a very long time*". The time taken for the experiment was long and Ndeshi indicated that the gas produced was a lot and the balloon could not hold it, so it had to burst. No one expected this, even though Ndeshi warned us on day one that the balloon for container C could burst. Sebron asked: "*How can this one burst*"? Interestingly, Ndeshi who warned us explained: "*Ee Ocarbon dioxide oihapu, ola expanda ashike ndele ihapu*" (CO_2 is a lot, it expanded but it was a lot). The reaction was so great because the container that was used was large, and more CO_2 was produced.

7.8.1 Identifying the catalyst (enzymes/*Oitungifi*) in *Oshikundu*

Three containers were placed on the table for observation, even though container C's balloon had burst, containers A and B's balloons were flat, and no gas was produced over that period. Container A contained only *Oshikundu*, container B contained *Oshikundu* and *Ongudo*, and container C contained *Oshikundu, Ongudo*, and *Ehete*. Bubbles could be observed in container C and the reaction was so amazing that the bubble's sound could be heard from a distance. Container C had *Ongudo* and *Ehete* fermented and produced CO_2 and *Oshikundu*. This finding agreed with what Sebron and Ndeshi advocated, that the catalyst in making *Oshikundu* ferment was *Ehete,* not *Ongudo*. In container B, only one or two bubbles were observed and the *Oshikundu* did not ferment to produce CO_2 and alcohol. Container B needed more time for it to ferment and the temperature for the catalyst (enzymes in *Ongudo*) to be activated. Controller container A was just whitish, and no bubbles were observed. The participants observed the bubbles to see if there was any reaction that was taking place in the containers. Bubbles determined if the reaction was taking place or not and this allowed the participants to conclude that only container C fermented and produced CO_2 and *Oshikundu*. Tala questioned this since container B had one or two small bubbles; he said that the air produced in this container B occupied the space above the *Oshikundu* and if we squeezed it, we would collect that air. To this Ndeshi and Sebron reacted respectively:

> Ndeshi: *I have something to mention, you know when we poured Oshikundu there was a gap left on top that means there was actually some extra air. What is collected in these two bottles … was simply the gas which was there already. If you put another balloon like this that is the gas we collected, this is the gas produced and that one was the gas that was occupying the space above the Oshikundu.*

Adding to this, Sebron explained further:

> *I am saying if you see the content of the air in that one (container B) and that one (container A) and this one which burst, this one inflated on its own, that means the gas was collected. These two, when you squeeze the air on top of the Oshikundu into the balloons, this is not the air produced.*

Chemistry teachers came to the mutual understanding that the air that occupied the space above the *Oshikundu* was the atmospheric air (Sebron) not the air that was produced during the reactions. Shipefi 16 suggested that we collect the gas from container C since the reaction was faster and the bubbles could be heard from a distance. New balloons were placed on all containers and were exposed to direct sunlight to increase the rate of reactions further.

Figure 7.13: Three containers exposed to direct sunlight to increase the rate of reactions

After five minutes, in container C the balloon inflated and expanded at a fast rate. This supported what was discovered and why the balloon on container C burst. The rate of reactions was extremely fast and the *Oshikundu* fermented to produce CO_2. Even after exposing containers A and B to direct sunlight, bubbles were still not visible but in container C, the rate of reactions increased. Ndeshi confirmed that "*Maara omu omuwete kutya okabaroon aka* (Maara you can see that this balloon) *is increasing … Ee bubbles lelalela ashike moving from the bottom"* (you can even see them from the bottom). She concluded that "*the reaction is taking place*". Adding to this Sebron stated: "*Onda hala oku Tala* (I want to see), *oo look at this bubble, tai topa taidi oku ngaha* (they are bursting coming from here). Adding to that Ndeshi said: "*Tai topa taidi koshi*" (They are bursting from the bottom). Observing the reaction that was happening in container C, they marvelled that they could see how the bubbles were produced – that showed that fermentation was taking place and CO_2 was being produced.

In furthering our understanding, I asked them what explanations could be made from the three containers. Tala responded: "*So what we are concluding is that Ehete is causing this one (container C) to produce too much CO_2 and the catalyst caused too much reaction, this is microorganisms we are talking about*". Sebron added: "*Ehete is the catalyst and makes the reaction to be fast*". Furthermore, Shipefi 16 stated: "*Ongudo is the activation energy*". In support of *Ongudo* as the activation energy Ndeshi exclaimed, yes, *Ongudo* gives activation energy, then when you add

Ehete, it becomes a catalyst. *Ehete* contains active microorganisms that feed on carbohydrates that are present in *Ongudo* to produce CO_2 and *Oshikundu*.

In addition, Ndeshi asked other participants about her concern that in those two bottles (A & B), they did not put in anything (referring to *Ehete*) and in the other one they put in *Ongudo* but not *Ehete*, yet the reactions, "*if we compare them, they are almost the same*". The participants could not notice that those two bottles were slightly different in colour. When I asked about the colour differences, Ndeshi who had the concern responded that this meant "*shinya oshapya kashona"* (that one is fermented *kashona* (kashona literally mean small) (container B), *eshi inashipya* (this one is not fermented) (container A) and *eshi oshapya* (this one is fermented) (container C). To further understand, Tala engaged Mee Mukwaluvala and Mee Mukwamhani:

> Tala: *Meekulu otamu dulu okuya mutu kwafele, Omolwashike Oshikundu inashi pya? (Meekulu you can come help us here, why is this Oshikundu not ready?).*
>
> Mee Mukwamhani: *Oshaya <u>Ongudo</u> ile inashi tulwa sha? (Did we add Ongudo, or we did not put it?).*
>
> Tala: *Shimwe osha tulwa Ongudo, shimwe inashi yasha, ashike eshi nge toshi late oshafa shapya, oshili ngoo ngaho… (the other one we put Ongudo, the other one we did not put, but this one if you look at it is like it ready, it just like that…).*
>
> Ndeshi: *Oshafa ngoo ngeno opo tashi tameke nee okupya (It is like it has started to ferment)*
>
> Mee Mukwamhani: *Oshaya <u>Ehete</u> ile inashiya? (Did we put Ehete or did we not?)*
>
> Ndeshi: *Ahawe inashiya (no we did not put).*
>
> Mee Mukwamhani: *Itashipi shashi inashi ya Ehete (It cannot ferment because we did not put Ehete).*
>
> Tala: *Ehete lovene oshike naana moshikundu? Oha li etamo naana shike moshikundu? Efatululo olo unene twa hala (Ehete itself what is it in Oshikundu? It brings what in Oshikundu? An explanation is what we want to hear).*
>
> Mee Mukwamhani: *Ehete olo hali pifa Oshikundu, olo onafi yoshikundu, olo onafi yomalondu (Ehete makes Oshikundu ferment, it's the Onafi/residues/dregs of Oshikundu and it's the Onafi/residues of Omalondu).*

From this excerpt, it could be surmised that Tala engaged Mee Mukwaluvala and Mee Mukwamhani to explain further their IK on the making of *Oshikundu*. The interaction allowed the teachers to gain a better conceptual understanding of the process involved in making *Oshikundu*. When analysing the responses from Mee Mukwamhani, it was noted that before giving a definitive answer she asked about *Ongudo* and *Ehete* as these two play a vital role in making *Oshikundu* ferment. *Oshikundu* cannot be fermented without *Ongudo* and *Ehete*, even though the ECMs could not explain further their role in making *Oshikundu* ferment. That helped teachers understand that *Ongudo* is rich in carbohydrates (activation energy) and *Ehete* has active microorganisms that feed on the *Ongudo* to make the *Oshikundu* ready. *Oshikundu* that has *Ongudo* could take days to be ready as indicated by Mee Mukwamhani: *"Otashi ningi omafiku, ele efiku limwe*" (It will take days or one day).

Adding to this Mee Mukwaluvala explained: "*Nge oshapitifapo efiku limwe, ngeno mongula ovanhu otava nu ngoo*" (If it takes time, one day then tomorrow people can drink). The dormant enzymes or microorganisms in *Ongudo* will be activated and feed on the carbohydrates in *Ongudo* to make *Oshikundu* ferment. *Ongudo* itself contains dormant microorganisms and is rich in carbohydrates. The dormant enzymes or microorganisms need time to be activated and start feeding on the carbohydrates for the reaction to take place. To test for CO_2, lime water was prepared.

7.8.2 Preparation of lime water

The gas was collected from container C. Sebron indicated: "*Is CO_2 produced?*" Ndeshi and Tala replied by stating, "*We are not yet to find out"*. Sebron predicted the outcome before the gas was tested and this is the first step in PEEOE (Shinana et al., 2021). The gas needed to be tested to confirm whether it was CO_2 as predicted by Sebron. Before the balloon was taken out from container C, lime water had to be prepared to test for the gas. Lime water was made from calcium carbonated powder and distilled water.

$$CaCO_3(s) + H_2O(l) \longrightarrow Ca(OH)_2\,(aq)$$

Lime water can also be made from slaking Calcium Oxide (CaO) or quicklime, to give a solution of Calcium Hydroxide, $Ca(OH)_2$.

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$$

The solution was filtered to get clear lime water that was used to test for the gas that was collected from container C. Figure 7.14 elucidates the process that took place when lime water was produced.

Figure 7.14: Shows the process of making lime water and filtration to obtain a clear solution

The solution of Calcium Hydroxide $Ca(OH)_2$ was filtered using filter paper to obtain a clear solution as seen in Figure 7.14. The clear solution was used to test for the gas produced during fermentation. Surprisingly, Ndeshi alluded: "*Eshi nee oshiima teshi ku tilifa okutya oshiima eshi oshitoka maara sha wafiltaring"* (Eshi this thing can frighten you, this one is white maara after filtration) it is clean. Adding to this, Shipefi 16 stated: "*Omeva afa ashike ochalk ndee sha wafiltaring omeva mayela sheke"* (This water is like chalk but when you filter, the water is clear).

The two participants referred to the solution of Calcium Hydroxide ($Ca(OH)_2$) as "*Oshima*" and "*Omeva*". Since $Ca(OH)_2$ is WS, Chemistry teachers struggled to come up with the correct name and they ended up saying "*Oshima or Omeva*". To understand why the solution was clear after filtration, Tala asked "*but why*?" The participant wanted to understand what was making the whitish solution that was like chalk clear when filtered. When comparing the colour in Figure 7.14, the colour was different after the solution was filtered. In responding to Tala's question, Sebron clarified: "*Okaaima aka ofiluta ashike yoovene, orisdue ohai fyaalamo*" (This thing is filter paper, the residue will remain there). After filtering the clear solution, we had lime water. Tala further asked why it was given the name lime water. This was interesting because Chemistry teachers were familiar with the name lime from a WS perspective. Ndeshi and Sebron responded that it was because now the water was combined with Calcium Carbonate ($CaCO_3$). Furthermore, Shipefi 16 explained that "*lime is Calcium Carbonate*". The name lime is derived from $CaCO_3$. In summary, Ndeshi explained: "*You just take distilled water and Calcium Carbonate, stir it, then you filter, the clear one is lime water*". The clear solution that passed through the filter paper was Calcium Hydroxide ($Ca(OH)_2$).

7.8.3 Testing of CO_2 using lime water

The gas that was collected in the balloon was taken out from container C. The balloon was placed on the test tube that contained lime water, and CO_2 was bubbled through the lime water. Sebron explained that when we pass CO_2 through this solution, the two compounds, CO_2 and $Ca(OH)_2$, react to produce Calcium Carbonate ($CaCO_3$) which is an insoluble white solid that precipitates out of the solution. Sebron further explained the process that turns lime water into milky while demonstrating how the solution turned from clear to milky.

Figure 7.15: Participants analysed the result after CO_2 was bubbled through limewater

The result showed that the gas that was produced during fermentation was indeed CO_2 as the test confirmed. Lime water turned milky.

Sebron explained the reason:

> *Saashi the reason why is milky ohai forming insoluble salt, which will now cause that colour to change milky which is Calcium Carbonate, Ocarbonate oyo hai fyaalamo, omu ohamu i ocalcium hydroxide, eshi to tulamo ocarbon dioxide tai forming Calcium Carbonate, shaashi ocalcium carbonate is an insoluble salt*.

(The reason why it is milky is it forms insoluble salt, which will now cause that colour to change to milky which is Calcium Carbonate; Carbonate will remain (referring to the filter paper), here only Calcium Hydroxide, when you add Carbon Dioxide it forms Calcium Carbonate because Calcium Carbonate is an insoluble salt). This was in agreement with the reaction:

$$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s)_{\text{(white precipitate)}} + H_2O$$

The solution will go from being clear to being milky, that is why the resulting solution is known as *milk of lime*. Adding to this, Shipefi 16 indicated that the reaction was a neutralisation reaction. The test result helped the Chemistry teachers to conclude that the gas produced was Carbon Dioxide (CO_2). Briefly, Ndeshi stated: "*This is clear lime water, this lime water has changed to milky (white)"*. CO_2 changed lime water to milky as documented in Chemistry textbooks. The participant was referring to two test tubes as in Figure 7.15. Furthermore, Ndeshi concluded, "*Now we are concluding that the gas that was produced during the fermentation process is Carbon Dioxide*". According to Ramorogo and Ogunniyi (2010), teachers should be given a good grasp of alternative ways of viewing what is worth knowing so that their learners are allowed to consider different ways of knowing and interpreting experiences.

7.8.4 Testing of CO_2 using glowing splinter

The teachers did other tests to confirm if the gas was CO_2; they tested the gas with the glowing splinter. If it extinguishes the glowing splinter, then the gas is CO_2 as it does not support combustion. A different balloon where CO_2 was collected was placed on the test tube. On removing the balloon, the matchstick (*glowing splinter*) was brought to the test tube. The glowing splinter went off and Ndeshi exclaimed: "*It went off"*; Shipefi 16 said: "*Yes it went off*". Tala wanted to understand the process and wanted a further explanation as he asked: "*It is going off,* *why is it going off?"* Shipefi 16 explained: "*It is CO_2 because CO_2 does not support burning"*. Interestingly, Tala challenged the other participants: "*Are we really sure that it is going off because of CO_2*?" This prompted the participants to do two different experiments as indicated below.

Figure 7.16: Testing for CO_2 using glowing splinter; confirmation that the glowing splinter did not go off because of air

The glowing splinter in Figure 7.16 was extinguished when it was brought next to the test tube after removing the balloon, while in the other box the glowing splinter did not go off but kept burning. The glowing splinters were lit simultaneously. The gas produced during the fermentation process was confirmed to be CO_2 as both the test results confirmed it.

7.8.5 Testing *Oshikundu* using blue and red litmus paper (acids or bases)

The last scientific experiment was to test *Oshikundu* as an acid or base. Blue and red litmus papers were used to test for alkalinity and acid. The *Oshikundu* had a sour taste, and this made most people predict that it was acid. Sebron indicated, "*This is blue litmus paper, if it remains blue it is alkaline, if it turns red then it is an acid*". This study found that *Oshikundu* was an acid. Shipefi 16 averred, "*It is turning red, it is an acid*". Michael was surprised to see that *Oshikundu* was acid as he stated: "*Tashi ti Oshikundu oshina oacid*" (It means *Oshikundu* has acid). Shipefi 16 alluded that *Oshikundu* is acid as it has a sour taste and during fermentation, alcohol is produced which is acidic. The experiment was repeated with red litmus paper, and it remained red. Shipefi 16 said: "Put the red litmus paper, if it remains red it is an acid". The red litmus paper remained red and it was concluded that *Oshikundu* was an acid. Tala exclaimed: "*So Oshikundu is an acid*". This finding indicated that Tala was used to teach acids and bases without integrating local examples from the local community. Figure 7.17 below summarises the findings of the experiment.

Figure 7.17: Research participant testing *Oshikundu*; research participants show the results for both red and blue litmus papers

Integrating IK into school science teaching is one way of maximising the sociocultural relevance of science education to enhance learners' performance (Zinyeka et al., 2016). The IK of teachers was maximised during this experiment and teachers were actively engaged and active participation was observed. Kibirige and van Rooyen (2006) confirmed that if we incorporate IK into our science lessons it will encourage learners to participate, the notion being, that to educate is to change the meaning of experiences and that meaning is constructed through shared experiences. This was the case during the workshops where teachers were able to shift their understanding of IK into scientific understanding.

7.8.6 Data from re-visiting the ECMs

The ECMs were excited to see us coming back to them to create a strong bond between us. The revisit was aimed at giving feedback on the findings and for the teachers to engage the ECMs on other topics that were not part of our first visit, for them to be able to understand both worldviews and be effective cultural knowledge brokers. During the revisit to Mee Mukwaluvala's home, masks in Namibia were not compulsory, thus Chemistry teachers were not wearing masks.

The presentation of the findings was correlated with what is documented in science textbooks. The joyful feelings and expressions were observed from both the ECMs and Chemistry teachers. This allowed us to engage in other cultural activities that are happening in communities. The Chemistry teachers learnt from the ECMs and *vice versa*, and this allowed us to share our understanding of different indigenous practices and those that we grew up practising but were never explained to us.

On our arrival to give feedback to the ECMs, a prayer was made before we started with the feedback. The introduction and greeting was done as explained in Section 7.3.1. After the introduction and greeting, before the feedback, *Oshikundu* and Ombike were served to us. The Ubuntu perspective was observed in how indigenous people care about each other's wellbeing. This was the way of welcoming us in their home and it made us feel at home. The figure below illustrates the seating arrangement under the big tree (Wild berry tree) that was used during the practical demonstrations and participatory observation and during the feedback to the EMCs home it was used as shade (see Section 7.8). It was interesting to observe how Sebron and Michael used *Oshikwanyama* to explain to the ECMs about the WS that was linked to the activities that were done during the practical demonstrations and participatory observation.

Culturally, sitting under a tree from the African perspective is associated with sharing of knowledge and storytelling during the day. During the night, however, people sit around the fire. This is the time when the elderly have a chance to share their life experiences and African wisdom. It also portrays the cultural heritage of sharing knowledge about life after long morning hours working in the fields. It is thus regarded as a time to educate children. Surprisingly, males and females used to be separated by sitting under different trees. This means that males used to discuss and share knowledge that concerned them, some which did not need to be heard by their female counterparts. This was also the case with the females. African knowledge is portrayed in songs, storytelling, myths and religious ceremonies (Lilemba, 2009). In this study, from the African perspective, we used the tree to give feedback (sharing of knowledge) and learn from each other. Transformative paradigm believe that epistemology can be shared in groups (Cram & Mertens, 2016; Mertens, 2007) and also this research we adhere to the ethics of the indigenous elders in order for use to work in harmony with them.

Figure 7.18. Chemistry teachers writing the feedback on the flipchart and the sharing circle that was used during feedback at Mee Mukwaluvala's home

The Chemistry teachers were given the chance after writing the feedback on the flipchart to present what was learnt during the practical demonstrations of preserving and pounding Mahangu and making of *Oshikundu* in relation to the topic of rate of reactions. Sebron and Tala were given the chance to present what was learnt from the visit to Mee Mukwaluvala's home. This process was exciting as the Chemistry teachers appreciated the knowledge that they had learnt and which they found to be useful in Chemistry teaching. Sharing circles allowed us to engage with the EMCs (Afonso-Nhelevilo, 2013; Lavallee, 2009). Sharing circles allowed Chemistry teachers to share the knowledge they gained during practical demonstration and participatory observation. Ubuntu allowed us to appreciate the roles of the ECMs after the research process was done and to strengthens the collaboration and empower the ECMs on their roles in Chemistry classrooms.

The ECMs also had an opportunity to correct some of the misunderstandings that we had about IK that happens in our community to better our understanding. For example, when Michael explained the link between IK and WS that was observed during the practical demonstrations. Mee Mukwaluvala had to explain why water had to be warm when making *Oshikundu* because Michael could not explain it in detail. The interaction on the revisit was two-way as the ECMs also asked questions of the Chemistry teachers to explain how IK could be taught in school science and what role they could play in science classrooms. It was interesting to observe the ECMs asking questions on what role they could play in science classrooms, as it showed that they were eager and willing to be involved. One interesting event was when Mee Mukwaluvala and Mee Mukwamhani availed themselves to be part of science teaching and the confidence they showed when interacting with Chemistry teachers.

At the end of the revisit, the ECMs were informed that they would be part of the workshops that would be conducted at the regional level to give feedback to other Chemistry teachers on how IK could be integrated. As the custodians of IK, they would practically demonstrate and present the process of making *Oshikundu* during the practical demonstrations and participatory observation. The revisit to the ECMs yielded the following new knowledge:

1. The seating arrangement was influenced by the way the *Olupale* is set up. This allowed us to maintain eye contact and was done under a big tree. A sharing semi-circle formation allowed us to initiate and engage equally in discussions (Afonso-Nhelevilo, 2013; Lavallee, 2009, Smith, 1999).
2. The ECMs were at the centre with Chemistry teachers on both sides, this was done for two reasons:
   - To be able to hear the *voices* of the ECMS equally, to avoid Chemistry teachers being too far from the ECMs to miss their explanations.
   - For cultural norms, as when sitting around the fire and at the *Olupale* (see Figure 7.1), elders have to be in the middle.
3. The Chemistry teachers initiated the discussions after presenting our findings on what was learnt during the practical demonstrations and participatory observation.
4. The interactions between ECMs and Chemistry teachers were amazing as the *Oshikwanyama* language was used throughout the practical demonstrations and participatory observation. The interactions helped the ECMs to explain further and for the Chemistry teachers and me to present the findings.
5. The Chemistry teachers reflected on how the practical demonstrations of preservation of *Mahangu*, pounding *Mahangu* using pestle and sieving and making of *Oshikundu* helped them to teach the topic of the rate of reactions in Grade 10 and how the learners reacted to the topic.

6. The Chemistry teachers reflected on how their Chemistry lessons went and created room for improvement. They also agreed to continue working in our peer-learning community and with the ECMs.
7. ECMs were able to ask questions for further clarifications from the Chemistry teachers and that created room for further engagement between the ECMs and Chemistry teachers.

In conclusion, Sebron summarised the five factors that affect the rate of reactions by tabulating his findings on a flipchart paper. He presented the findings by linking the factors to IK and practices done by the ECMs.

Figure 7.19: Sebron outlining the link between IK and WS

The presentation from Sebron helped the ECMs to understand how useful IK was in Chemistry teaching. I now discuss the findings that emerged from the practical demonstrations and participatory observation.

7.9 Findings That Emerged from Practical Demonstrations and Participatory Observation

Data from practical demonstrations and participatory observation on preserving and pounding *Mahangu* to make flour using a pestle and mortar and the making of *Oshikundu* were analysed. The data generated on day one and day two were collated together and four themes emerged from them. Westernised knowledge and IK were brought together and how best IK could be integrated into Chemistry teaching. I now discuss each theme that emerged from the data on practical demonstrations and participatory observation (see Appendix T, Table 4).

7.9.1 Explorations of IK in Chemistry teaching

Indigenous people have many cultural practices that are viewed as non-scientific; after critically analysing those cultural practices it was evident that some scientific processes could be used to teach certain Chemistry topics. Liveve (2022) exploited the use of cultural practices of drumming and dance to teach sound and waves. Engaging community members as the custodians of IK would help them to get involved in school activities. Nikodemus (2017) and Shinana (2019) included community members when working with learners and teachers respectively on making *Oshikundu*. The result showed significant improvement in the achievement of the learners in the pre-test and post-test as attested by Nikodemus (2017) and Livive (2017). In this research, Chemistry teachers were engaged in practical demonstrations and participatory observation that yielded positive results. Chemistry teachers were able to gain new knowledge from the explanation of ECMs. The preservation of *Mahangu* by indigenous people has many scientific processes embedded in it. Preservation of *Mahangu* involves the process of sun drying as illustrated in Figure 7.4. Sun drying makes *Mahangu* last longer on the shelves and this was and still is the most common way of preservation that has been adopted by indigenous people. Mukwambo et al. (2014) stated that people used to preserve seeds by hanging them in the rafters in the kitchen. This was to make the seeds completely dry and also to coat them with soot. Adding to this, Mukwambo at el. (2014) explained that creosote from the smoke coats the seeds, and this preserves them from being destroyed by insects and other pests.

In the Northern part of Namibia (*Ovamboland)*, *Mahangu* is kept at the *Omutala*. At the *Omutala*, *Mahangu* seeds are exposed to direct sunlight and there they will dry completely. Sun drying is a natural way of preserving seeds and has many natural advantages to the environment. Seeds are not exposed to pesticides that are used in modern times to preserve them, as these pesticides might kill birds and other organisms that are needed in our environment. In the *Oshiwambo* culture, seeds are preserved using the natural method of sun drying. There is a need to promote the use of IK in science lessons to help learners have a better conceptual understanding. We need to recognise indigenous and local communities as custodians of traditional knowledge and practices, while promoting effective protection of traditional knowledge, as appropriate and consistent with international law (Mapara, 2009).

Teaching separation of mixtures in Chemistry classrooms, Chemistry teachers need to cross-fertilise or examine the examples that occur in the local community that include the concepts of separation before concentrating on WS. Building from what is happening in the local community will help learners have a better understanding of the concepts. The roots of the concepts will be delineated from the local concepts. For example, *Okuxwa, Okuyela*, and *Okufifwa* are local practical activities on separating mixtures of different particle sizes. In a nutshell, *Okuxwa* involves threshing of the *Mahangu* by separating the grains from the chaff. This process is common in the *Oshiwambo* culture and teachers need to build from this prior everyday knowledge of learners before introducing the WS to the learners. *Okuyela* involves the separation of grains and chaff using wind as the agent. Chemistry teachers were able to relate cultural activities happening in the local community to what is taught in the classrooms. The results showed that teachers' PCK shifted, and they were able to relate IK to WS.

The curriculum document guides teachers on what to teach in the science classroom and how the content should be taught. Teachers must know and understand the SMK they teach and how to teach it. Thus, PLCs call for teachers to work together with community members to be able to integrate IK into science lessons. Coupled with this, Mishra and Koehler (2006) proposed that teachers (Chemistry teachers in particular) must know and understand the subject they teach, including knowledge of concepts, theories, and procedures within their given field. The practical demonstrations and participatory observation helped the teachers learn from the ECMs how the making of *Oshikundu* could be integrated into science classrooms. The SMK of Chemistry teachers was challenged by the indigenous way of doing things. The engagement between Mee Mukwaluvala, Mee Mukwamhani and the Chemistry teachers allowed them to seek clarity on the concepts they could not understand.

Advocating for this, Mishra and Koehler (2006) argued that teachers who do not have SMK can misinterpret the content when teaching learners. Chemistry teachers showed their understanding of both worldviews and were able to delineate concepts by supplementing knowledge from both. Teachers need to advance their knowledge and understand the theories that could be used in teaching their subjects. Drawing from the practical engagement observed, Chemistry teachers and ECMs engaged each other on different concepts that teachers might have missed understanding.

Exploration of IK to be used in Chemistry classrooms needs the involvement of the ECMs. This research has found that community members are loaded with indigenous technologies that are scientific. In *Okufifwa* for example, the indigenous people used *Oshimbale* to separate fine *Mahangu* flour from the big particles in modern times, a sieve is used to do. The separation of fine *Mahangu* flour increases the surface area and this speeds up the chemical reactions as attributed in Chemistry textbooks. The peer-learning community in this study advanced the knowledge of the Chemistry teachers on the integration of IK in science lessons and helped them develop skills that could be used in the future to help other teachers. This knowledge situates itself well in the context of a peer-learning community. Thus, a CoP between the ECMs and Chemistry teachers was created to help teachers learn from MKOs, in this case, the community members that had advanced IK could be integrated more cohesively into science lessons.

If you look at the knowledge the local indigenous people possess it is linked to the environment where the school is and the community where learners come from. Indigenous people in the Northern part of Namibia are knowledgeable about *Mahangu* planting because their environment does not support the large-scale farming of maize due to the shortage of rain and clay soil without which maize cannot grow properly. Maize grows well in loamy soil. The concepts of *Okuxwa, Okuyela*, and *Okufifwa* are associated with *Mahangu.* The environment and the activities created the knowledge that indigenous people living in the area associated with. For example, it is very rare to find people using western sieves to sieve *Mahangu* flour in rural areas where this research took place. They prefer the traditional way of separating mixtures by *Okufifwa* (see Figure 7. 8). Local people are preserving their IK so that it does not become extinct, as they want to pass it on to the generations to come.

As indicated in Chapter Six, teaching rate of reactions using the making of *Oshikundu* as the teaching aid helped teachers gain a better understanding, so that they could use it to teach the topic in future. The use of *Ongudo* and *Ehete* as dormant and active enzymes respectively, which speed the rate of reactions, worked as teachers predicted in Chapter Six. The findings from the demonstration revealed that *Oshikundu* with *Ongudo* needs time for it to ferment. Even though

Ongudo is rich in carbohydrates for the enzymes to feed on, the enzymes were dormant and needed time to activate. *Oshikundu* with both *Ongudo* and *Ehete* fermented and produced CO_2 and *Oshikundu* as alcohol. The gas produced could be used to teach the testing of CO_2 using lime water (see Section 7.9.3) as the chemical equation revealed that lime water reacted with CO_2 to produce Calcium Carbonate and water:

$$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s)_{\textit{(white precipitate)}} + H_2O(l)$$

Bubbling CO_2 in the clear solution of Calcium Hydroxide produced a white precipitate of $CaCO_3$ that was insoluble and that turned lime water milky. This yielded positive results for the teachers. The use of easily available resources as advocated by Asheela et al. (2021) made learning easier. Tala alluded, "*guys this is what we need to do and litmus paper, we need just Oshikundu, and you test with your learners*". The use of locally available resources was emphasised by Tala. Even though litmus paper is westernised, using the making of *Oshikundu* with learners will bring their local contexts to the classroom. The MoE (2018) also emphasises that schools, have the responsibility to implement the curriculum guided by subject syllabi and identify relevant local knowledge within the community. This curriculum is intended to allow teachers to use the IK in learners' intermediate environment that is relevant to the topics that are taught in science classrooms. For example, the making of *Oshikundu* in this study can be used to teach the following topics (see Table 7.1).

Table 7.1: Shows the relevance between WS and IK

Westernised topics	**Local examples**
Experimental techniques	*Okuxwa, Okuyela* and *Okufifwa* are practical examples that are used to separate mixtures by indigenous people.
Rate of reactions	The stages involved in preparing *Oshikundu* allow teachers to use those examples when teaching the factors affecting the rate of reactions. For example, temperature, particle size, concentrations, and catalysts could be taught as explained in Chapter Six.
Acids and Bases	*Oshikundu* was tested for its acidity and alkalinity to determine whether it was an acid or base. Using litmus paper (blue and red), the blue litmus paper turned red and the red litmus paper remain red. This result shows that *Oshikundu* is an acid. The sour taste of *Oshikundu* also is a good example of a characteristic of acid.
The mole concept	The flour proportion when making *Oshikundu* is a good example to introduce mole concepts.

The relations between WS and indigenous technologies in Chemistry teaching was evident during practical activities. Chemistry teachers linked the practical activities on factors affecting the rate of reactions to practical activities done during the *Oshikundu* preparation process.

Table 7.2: The relations between WS and IK

Factors that affect the rate of reactions	**Community members' experiences**
Catalyst/Enzymes	They add *Ongudo* and *Ehete* in *Oshikundu* and other brewed alcohol
Temperature	They boil the water for preparing *Oshikundu* and if they want *Oshikundu* to be ready in a short time they put it in sunlight
Concentration	They add more *Ehete* and *Ongudo* into the *Oshikundu*
Pressure	The container where the *Oshikundu* is prepared is not tightly sealed, they let the air escape
Particle size/surface area	They pound *Mahangu* and *sorghum* grains to increase the surface area
Light intensity	They expose Oshikundu to light to increase the rate of reactions and activate enzymes

The table summarises how the factors affecting rate of reactions could be taught using indigenous technologies that are familiar to the learners.

Similarly, the results from the practical demonstrations were summarised showing how *Oshikundu* could be used to teach scientific concepts. The western science that is summarised in the table below was made relevant to the IK.

Table 7.3: The results from the practical demonstrations

Test made	The results
Oshikundu with no Ongudo and Ehete	No reaction took place
Oshikundu with Ongudo (dormant enzymes)	No reaction took place
Oshikundu with Ongudo (dormant enzymes) and Ehete (active enzymes)	The balloon inflated with CO_2 and bubbles could be observed
Carbon Dioxide tested with lime water	Lime water turns milky
Carbon dioxide tested with glowing splinter	Glowing splinter went off
Oshikundu tested for acidic and alkalinity	- Red litmus paper remains red - Blue litmus paper turns red

As tabulated, it was discovered that the *Ehete* is the catalyst that has active enzymes that digest the carbohydrates present in *Ongudo*. *Ongudo* itself has dormant enzymes that need time to activate and digest on carbohydrates in *Ongudo*.

Exploring IK in Chemistry classrooms might help science teachers to use relevant resources that are common in the local environment. The examples above are relevant when making *Oshikundu*. Chemistry teachers showed improved conceptual understanding when ECMs were engaged to explain the scientific processes involved in preparing *Oshikundu*. Taking teachers on the excursions helped them to have a better understanding of both worldviews, with the help of the ECMs.

Drawing from Vygotsky's (1978) SCT that views learning as integration into CoPs in which social interactions play a role in acquiring knowledge, the ECMs used their cultural artefacts to help teachers have a better cultural understanding that would be useful in Chemistry classrooms. The artefacts helped the teachers to mediate the understanding they had from western science to IK science perspectives. The interactions that were observed when teachers engaged Mee Mukwaluvala and Mee Mukwamhani, resulted in this new understanding and teachers were able to connect the two worldviews.

7.9.2 Social engagement with ECMs enhanced understanding

Vygotsky's (1978) social interactions helped to create a learning opportunity during the visit to the ECMs. Drawing from several researchers (Mavhunga et al., 2016; Mavhunga & Kibirige, 2018; Mavhunga & Rollnick, 2013; Seehawer, 2018a), teachers were able to integrate IK into science lessons when they were trained, and they further challenged that lack of training might hinder the integration of IK into science lessons. Mavhunga and Rollnick (2013) did an intervention on improving teachers' PCK on the topic of chemical equilibrium, as one of the challenging topics in science, and the results convincingly indicated that teachers showed improvement in their PCK. Adding to this, Naidoo and Vithal (2014) postulated that science teachers had mixed feelings about the integration of IK into science lessons.

The Chemistry teachers were willing to learn the indigenous science that was embedded in some of the cultural activities done in the local community. For example, the preservation of *Mahangu* yielded SK on why indigenous people sundried their harvests before threshing and later storing them. Sun drying increases the life span of the seeds and that is significant as the seeds can be kept for up to two years. Sun drying also helped the chaff and the grain to separate easily. It is difficult to separate chaff and *Mahangu* grains that are not completely dry. The first observation that I noted was that teachers were not aware of some of the science behind certain cultural activities in the process of making *Oshikundu*. This finding seemed to suggest that social interactions that happened at Mee Mukwaluvala's house allowed Chemistry teachers to engage with the ECMs and learn from them.

During *Okuxwa*, for example, Shipefi 16 engaged Mee Mukwaluvala and Mee Mukwamhani by asking: "*Elalakano lokuxwa todingonoka oshidada ola shike*" (The reason behind threshing while going around is for what) was not to crush/destroy *Mahangu*). This type of question shows that the participants were not sure why indigenous people did that and the reasons behind these cultural practices, including the use of fire when the wind is not blowing to activate the movement of air by the convection process. The Chemistry teachers were able to link the explanation of burning chaff to make the wind blow to the concept of convection. This also shifted the understanding of teachers on how convection could be taught by integrating IK. For example, Michael recalled using his experience after the explanation by Mee Mukwaluvala and Mee Mukwamhani that, whenever a house is burning, a strong wind starts to blow, which he never thought was convection.

In their study, Naidoo and Vithal (2014) allowed the science teachers to select IK that was appropriate to WS. The first result was an incorporation approach that brought only selected IK into science lessons. Science teachers had to select the "best IK that fits into science". Similarly, in this study, Mee Mukwaluvala and Mee Mukwamhani were allowed to present their cultural activities surrounding the preservation of *Mahangu*, pounding of *Mahangu* flour, and making of *Oshikundu*. This engaged Chemistry teachers to see the relevance between IK and SK. Chemistry teachers were allowed to choose the IK they felt was useful in teaching certain topics in Chemistry and other science subjects. Chemistry teachers acquired different knowledge that could be used in science lessons. The second result was the approach of holding IK and SK side-by-side. Chemistry teachers used local resources to prove the scientific knowledge documented in Chemistry textbooks. They engaged each other and learnt from each other about the science that is embedded in the making of *Oshikundu*. During practical demonstrations and participatory observation, Chemistry teachers were able to identify new knowledge that could be used to teach Chemistry.

For example, the gas that was produced during fermentation was proved to be CO_2 by using SK. Using lime water that was made from $CaCO_3$ and distilled water, the solution was filtered for residue and clear lime water was collected. Bubbling CO_2 through lime water turned it milky, exactly as documented in Chemistry textbooks. Indigenous knowledge (IK) can be used to teach WS. Adding to this, Naidoo and Vithal (2014) used a similar approach that held IK side-by-side with WS in the classroom. Liveve (2022), Nikodemus (2017), and Shinana et al. (2021) also used a similar approach when using IK to teach certain topics in Physical Science and Life Science respectively. *Oshikundu* as a locally made drink undergoes all the factors that affect the rate of reactions and thus it was used in this study to workshop teachers on how best IK could be integrated into Chemistry teaching. Naidoo and Vithal (2014) called this an integrationist approach that makes connections between IK and SK. This is evident in Chapter Eight when Chemistry teachers integrated IK into science classrooms. These approaches can be useful to teachers when they are trained to interpret the curriculum the same way. Chemistry teachers reflected on how they acquired knowledge during practical demonstrations:

> Sebron: *My interaction with community members helped me to understand the science behind preparing Oshikundu and it helped me to know that engaging parents' experience in our science education will really help them to understand the concepts better than just using knowledge from the textbook (western knowledge). I also learnt that real science starts from home and that learners are born with the knowledge they just need to be boosted.*
>
> Ndeshi*: Asking questions for further explanation. I also did some of the work like Okutwa (pounding), and Okufifa (sieving) of Mahangu during the preparation of the flour. During this practical, I also took part in the preparation of Mahangu flour that is pounding. I learnt a lot through asking questions as to why a certain aspect is to be done and how. Taking part in this activity enriched me as a Chemistry teacher because I will simply apply this knowledge and integrate it into my lessons.*

The vignette from two Chemistry teachers illustrates the activities they did during the practical demonstrations. Sebron on his part, acquired knowledge and gained new skills as he was less knowledgeable about *Okutwa*, *Okufifa* and other activities. Ndeshi, who was knowledgeable about the preservation of *Mahangu*, pounding of *Mahangu* and making *Oshikundu*, indicated the practical activities she was involved in during the practical demonstration. Her experiences and exposure on the preservation and pounding of Mahangu and making of *Oshikundu* was evident in this research. Moreover, research done in Namibia by Asheela et al. (2021) indicated how science teachers could be trained to use locally available materials to teach science topics. Engaging Chemistry teachers in a peer-learning community with Mee Mukwaluvala and Mee Mukwamhani closed the gap that existed between WS and IK in science classrooms. This was evident when Chemistry teachers were engaged in the practical demonstrations with the ECMs and learning become more relevant when using local artefacts in practical activities. The gap that existed between PK, SMK, and knowledge of context as the three components of PCK (Grossman, 1990) was interconnected and narrowed. Science teachers could link the local practices to western activities. Science teachers could lack SMK that could be gained during peer-learning communities and teachers' workshops and also the integration of IK into science lessons as subject content knowledge. A peer-learning community helped Chemistry teachers to learn from each other during the practical demonstrations. Thus, this research found that engaging with the ECMs improved the Chemistry teachers' understanding of the rate of reactions.

In their study conducted in South Africa, Ngcoza and Southwood (2015) found that transformative CPD of science teachers is based on "participative approaches and mutual collegial support are indispensable and that teachers' sociocultural contexts and experiences should be taken into consideration during this process" (p. iv). They further found that science teachers should be regarded as central in the process, and mutual respect and dialogical relationships are pivotal (Ngcoza & Southwood, 2015). Chemistry teachers involved in practical demonstrations were actively engaged by asking questions for further explanation. There is a need for Chemistry teachers to be professionally trained on how to integrate IK into science lessons to help learners have conceptual understandings of scientific terms when building from IK practices. Chemistry teachers involved in the research showed confidence in explaining the science behind indigenous practices after engaging with the ECMs. For example, teachers' social engagement helped them to learn and understand the science present in different practical activities that were done when preparing and making *Oshikundu*.

Briefly, practical demonstrations and participatory observation increased Chemistry teachers' knowledge as they discovered new knowledge that was useful in Chemistry classrooms. Teachers tested the *Oshikundu* to see whether it was an acid or base. This was new knowledge to some participants as they had not thought about using *Oshikundu* to test for acids and bases. Participants engaged each other and learnt that *Oshikundu* was an acid after testing it with litmus paper, both blue and red. As noted from their deliberations in this vignette:

> Sebron: *This is a blue litmus paper if it remains blue is alkaline, if it turns red then it is acid.*
>
> Shipefi 16*: Turning red, is an acid.*
>
> Tala: *Tashi ti Oshikundu oshina oacid.*
>
> Shipefi 16: *Yes, it is an acid.*
>
> Me: *Take the other one and repeat the test*
>
> Ndeshi: *Repeat the experiment.*

Tala: *To prove it.*

Shipefi 16: *Put the red one again, do not remove it, it will remain red, it will remain red*

Tala: *So Oshikundu is an acid.*

Interestingly from this vignette, Tala was not aware that *Oshikundu* became acidic when left to ferment over an extended period, but this was discovered during the practical demonstrations. Active engagement of participants helped the Chemistry teachers to learn from each other and learn the science that is embedded in cultural practices. Jacobs' (2015) study illustrated that "the science teachers who attended the workshop and were trained to integrate indigenous knowledge in the science curriculum were more confident than those teachers who were not trained to integrate IK in the science curriculum" (p. vi). Furthermore, this increased confidence resulted from the practical demonstration which enhanced the teachers' IK content knowledge and made them less dependent on the learners for examples of IK (Jacob, 2015). This illustrated that the CPD of teachers is key for the correct implementation of the curriculum that allows teachers to integrate IK. Science teachers need to be engaged in practical demonstrations with community members to learn more about the scientific processes involved.

Contextualising WS might enable science teachers and learners to work using close social interactions, as learners will use their prior everyday knowledge that they gained from home. Education programmes of science teachers need to explore strategies to enhance the understanding of the integration of IKs. The PCK of teachers were enhanced and the results could be observed when teachers were explaining their understanding of the integration of IK. The IK that was available in the local community enhanced the conceptual understanding of teachers. The making of *Oshikundu* as an example has many scientific processes that emerged during practical demonstrations. The ECMs and Chemistry teachers were positively engaged as teachers were willing to explore more on the indigenous science embedded in the process of making *Oshikundu*. Thus, teachers were learning from the ECMs how to build from their prior everyday knowledge to be able to integrate IK in their classrooms.

The findings signalled the improved integration of IK on the topic rate of reactions. The pedagogical reasoning (Mavhunga & Rollnick, 2013) of Chemistry teachers allowed them to engage Mee Mukwaluvala and Mee Mukwamhani in discussions that yielded positive results.

Teachers were observed during participatory observation interacting with each other to explain the concepts that emerged during practical demonstrations using westernised understanding. Practical demonstrations allowed teachers to work in harmony with Mee Mukwaluvala and Mee Mukwamhani. Cross-fertilisation of ideas allowed Chemistry teachers to be engaged in practical demonstrations and contextualise WS to understand the concepts that emerged from IK using dependent collateral learning (Jegede, 1995). A peer-learning community helped teachers learn from ECMs and other participants/teachers during practical demonstrations.

The threads of the peer-learning community were observed during the practical demonstrations, which included connectivity, collaboration, dialogue, negotiation, and appreciation (Ngcoza & Southwood, 2019) and these were noted throughout the research process. Teachers were involved in dialogue during practical demonstrations, and they acquired new knowledge on how the curriculum allows them to integrate IK into science classrooms. They created a network that included teachers and the community that allowed them to have good connections among the teachers themselves and also with the ECMs. The connectivity that happened during practical demonstrations allowed teachers to engage in discussions and that helped them to contextualise Chemistry. Chemistry teachers were engaged in a transformation network with knowledgeable community members during the visits. The practical demonstration on the making of *Oshikundu* helped teachers and community members to share interests and concerns that motivated them to come together and engage in a peer-learning community with the view of learning (Ngcoza & Southwood, 2019). Through a peer-learning community, teachers collaborated on the topics they wanted to teach and on how the topics could be taught.

Through collaboration, participants were able to share how fractional distillation could be taught, as both teachers from schools A and B used learners as the custodians of local knowledge (see Chapter Eight). The knowledge gained from the practical demonstrations was used to teach the rate of reactions. For teachers to understand the integration of IK in science classrooms, participants had to negotiate the understanding and the link between the two worldviews. Cross-fertilisation of ideas allows both IK and WS to be taught in indigenised classrooms. The relevant knowledge between two worldviews has to be taught simultaneously in the classrooms to avoid cognitive dissonance (Le Grange, 2007). It was evident that the peer-learning community was appreciated by the teachers as they acknowledged that the knowledge gained was helpful in science classrooms.

7.9.3 Hands-on practical activities influence learning

Shinana et al. (2021) introduced PEEOE in practical activities in science classrooms. Additionally, Shinana et al. (2021) in their research used the "principles of classroom inquiry together with the model of inquiry-based science instruction PEEOE were used to scaffold teachers towards the PCK for inquiry-based teaching" (p. 1). It was found that teachers had inadequate information on using PEEOE in inquiry-based learning (Shanana et al., 2021). In Chapter Six, the Chemistry teachers predicted what could be the outcome of the experiment before they engaged with the ECMs. Chemistry teachers predicted that *Oshikundu* with *Ongudo* and *Ehete* was going to ferment, and they indicated that *Ehete* was the catalyst that has active enzymes.

During the practical demonstrations and participatory observation, teachers could not predict as per the first step in PEEOE introduced by Shinana et al. (2021). Practical demonstrations allowed Chemistry teachers to work with the ECMs on the preservation of *Mahangu*, pounding of *Mahangu* to make flour, and preparing of *Oshikundu*. The cultural activities engaged teachers to learn and accommodate the knowledge that they gained during the activities. Most science teachers think that practical work/demonstrations are associated with the laboratory. In this research, practical demonstrations were done outdoors and, in the community, far from the school. As observed, out-of-school activities enhanced teachers' conceptual understanding and their pedagogical strategies improved. The use of *Oshikundu* to collect CO_2 to be tested with limewater, helped teachers not only base their understanding on textbooks but to explore the environment around them to help teach science concepts.

The study allowed Chemistry teachers to challenge the misconceptions and confront the reality of IK. For example, calling the wind by using the traditional way of singing, using the pumpkins, and using the *Oshoke* grass placed at the chaff facing the western side. This IK challenged the teachers' understanding because when the community members started singing the wind started blowing, yet this indigenous knowledge could not be proven or linked to any scientific explanation. Chemistry teachers engaged with each other but could not find the science behind the singing and the blowing of the wind. Practical activities/demonstrations encouraged the Chemistry teachers to be analytical and to be critical thinkers as they were challenged by diverse cultural activities and had to explain certain aspects that were relevant to WS. Hence, this enhanced their motivation and stimulated excitement to think differently from their usual way (Akbar, 2012).

Adding to this, Mudau and Tabane (2014) found that teachers do practical activities to improve group work in their classes. To this note, practical work has become the most effective teaching method/strategy compared to other teaching strategies in science (Abrahams & Millar, 2008). I observed that practical demonstrations yielded four things:

1. The working relationship between the Chemistry teachers, Mee Mukwaluvala and Mee Mukwamhani yielded positive results as teachers were willing to learn from the expert community members and did not undermine them.
2. The relationship between Chemistry teachers that never existed before improved as they started working in a CoP during practical demonstrations and at schools.
3. Chemistry teachers were engaged in critical thinking that helped them unpack the science that is embedded in cultural activities.
4. Chemistry teachers started sharing resources and teaching strategies on the topics that integrate IK as observed in Chapter Eight. Indigenous knowledge (IK) is more useful when it is used in practical activities as teachers can explore, observe, and explain (EOE) (Shinana et al., 2021).

It was also encouraging to note that teachers were able to explore IK after observing and engaging in practical demonstrations. This finding was consistent with Abrahams and Millar (2008) that increasing practical work would amount to improved science education and science teachers would benefit. The practical demonstrations were based on building from IK gained during practical demonstrations and participatory observation to the WS. In this study, the misconceptions of IK not relevant to SK were clear and teachers could explain scientific concepts using indigenous knowledge. Thus, IK and western science can complement each other during science lessons, especially in less-resourced schools. For example, IK can be used to carry out scientific experiments such as the making of *Oshikundu* in this study, which was used to produce CO_2 and then tested with a glowing splinter and limewater.

The making of *Oshikundu* allowed Chemistry teachers to visualise the processes that are involved during the rate of reactions and contextualise westernised concepts that emerged during the practical activities. They did this by connecting the processes that were followed when preparing *Oshikundu* to the processes involved in factories. They visualised the pictures in the textbooks as the processes that were happening during practical demonstrations. Arcavi (2003) explained that using images or symbols allows people to visualise. I observed that when Mee Mukwaluvala and Mee Mukwamhani were demonstrating certain processes, teachers were engaged in trying to re-connect the demonstrations to science knowledge documented in Chemistry and other science textbooks. Advocating for the role visualisation plays in science classrooms (Tall, 1994) indicated that using diagrams, symbols, and processes helps teachers to visualise. In this research, the indigenous artefacts used allowed teachers to connect the indigenous technologies to WS.

Cultural heritage is where IK is embedded and it involves knowledge, language, values, dressing code, the way of living, and food the community eats. Culture plays a role in how knowledge is acquired, and this has allowed indigenous people to transmit their cultural norms to their children. The making of *Oshikundu* is one of the cultural practices that is done in the community where this research was conducted. Many cultural practices are useful for teaching the Chemistry and Physics curriculum. For example, in Physics, research was done on using indigenous artefacts (drums) to teach sound and waves (Liveve, 2022); in Chemistry, the use of *Oshikundu* to teach the rate of reactions (Nikodemus, 2017); and in Life Science, the teaching of enzymes by using *Oshikundu* (Shinana, 2019). All research yielded that cultural practices made learning easier for learners through practical demonstrations. Learning can happen when using the cultural practices that are relevant to the learners' prior everyday knowledge that they have observed and perhaps participated in. The cultural values, norms, knowledge, beliefs, practices, experiences, and language that are the foundation of indigenous culture were explored during the demonstrations. Ideally, practical demonstrations were for the teachers to learn, observe, and participate in different cultural knowledge. Chemistry teachers acquired different skills during practical demonstrations as they were actively engaged when they were done. Cultural heritage allowed community members to use the knowledge they gained through social interactions with elderly people when they were young and transmit it to the teachers through our CoP. Making *Oshikundu* has groundwork instructions for the processes that the community members have been following for years. For example:

- Fine *Mahangu* flour that is properly sieved has to be used.
- Sorghum seeds need to undergo germination to increase their nutritional level.
- Warm water has to be used to make *Mahangu* flour to be cooked and thereafter, cold water has to be added before *Ongudo* and *Ehete* are added to avoid denaturing the enzymes.
- *Ongudo* is added first before *Ehete,* not vice versa.
- *Ongudo* has big particles that will later turn into *Ehete.*
- *Oshikundu* container is not tightly closed, to allow the gas (CO_2) released during fermentation to escape from the containers.

In their study, Asheela et al. (2021) used easily accessible resources to conduct hands-on practical activities in science classrooms to unearth the SK embedded in the local processes. Easily accessible resources helped Chemistry teachers to learn and re-contextualise the knowledge they gained during practical activities. Hence, in this research, Mee Mukwaluvala and Mee Mukwamhani used easily available resources to conduct practical demonstrations for Chemistry teachers to observe and participate in how a traditionally made drink called *Oshikundu* was prepared.

The IK gained during the visits with Mee Mukwaluvala and Mee Mukwamhani, was used by Chemistry teachers to interpret the curriculum on the rate of reactions. The SMK of Chemistry teachers on the rate of reactions, acids and bases, and other topics covered during practical demonstrations improved. A peer-learning community helped teachers to improve their SMK that is needed when teaching learners. Rollnick et al. (2008) indicated that the SMK of teachers improve when they are involved in PLCs. Teachers were able to articulate a high understanding of SMK using IK to explain the scientific concepts that emerged during practical work/demonstrations and participatory observation. This allowed Chemistry teachers to integrate IK into their teaching and learning by building from learners' prior knowledge. The Namibian curriculum (MoE, 2018) allows teachers to use learners' life experiences in their lessons.

Chemistry is part of the curriculum; thus teachers are allowed to integrate the life experiences of learners as prior everyday knowledge which is part of IK.

IK is more experiential than it is theoretical, and thus it should not be viewed simply as a commodity that can be possessed or controlled by educational institutions, but as a living process to be absorbed, understood, and lived. This is evident by research studies conducted in Namibia by Hashondili (2020), Liveve (2017), Nikodemus (2017), Shinana (2019) and Simasiku (2016) that IK is not static but is evolving and can be incorporated into science lessons to help learners have a better conceptual understanding. IK developed through rational empirical means and has been tested and accommodated in nature over many generations (Khupe, 2014). Khupe (2014) further illustrated that IK is not limited to that which is perceivable by the senses, but includes what is beyond the senses (Ogunniyi, 2004). Indigenous knowledge (IK) gives the reality and context in which it was acquired and generated, with its roots in the community living in the area.

In contrast, practical work/demonstrations are seen as ill-conceived, confusing, unproductive, and time-consuming in science classrooms (Abrahams & Millar, 2008). This has been influenced by laboratory work as most schools are not equipped with the required apparatus and chemicals to carry out the experiments as articulated in the textbooks. If the practical work does not yield the required results as in the textbooks, learners are forced to visualise the colour that is not there and can become confused. To avoid this confusion, Mudau and Tabane (2014) argued that "practical investigation and experiments should assess all learning outcomes with the focus on the practical work aspects and the process skills required for scientific inquiry and problem-solving" (p. 446). Science teachers should not only focus on the outcomes but the scientific process/steps involved. Thus, the practical demonstration of the preservation of *Mahangu*, pounding of *Mahangu* flour, and the making of *Oshikundu* did not focus on the outcomes but the whole process was required to be observed and internalised by teachers. *Oshikundu* is prepared using four common ingredients such as *Mahangu* flour, sorghum flour (*Ongudo*), *Ehete*, and water (warm and cold). The preparation of those ingredients formed part of the understanding of teachers during practical demonstrations. Without following all the steps on how ingredients were made, there could be a lot of questions.

The procedure of making *Oshikundu* is similar to the processes that happen in the factory when brewing beer and other drinks. Thus, it helped teachers have a better understanding of the rate of reactions and their SMK improved which resulted in a shifting in their PCK. The processes at the factory resonate very well with the practical demonstrations that were done by Mee Mukwaluvala and Mee Mukwamhani that allowed for EOE (Shinana et al., 2021). Chemistry teachers were allowed to explore the practical aspects of making *Oshikundu* that were relevant to science concepts. They observed how *Oshikundu* was prepared following the procedure and later they were involved in scientific explanations to enhance their conceptual understanding. Language played a key role during practical activities with the ECMs.

7.9.4 Language used as a cultural tool in the mediation of learning

Learning was nurtured by Vygotsky's (1978) social interaction between Chemistry teachers and the ECMs. The language played a significant role during social interactions and the language used was *Oshiwambo* (local language). New terminologies emerged during practical demonstrations that teachers were not aware of. Mee Mukwaluvala, Mee Mukwamhani, and Chemistry teachers were actively interacting with each other as language was not a barrier to them. This allowed teachers to cross-fertilise the knowledge that emerged from the local language into WS. Language played a role when ECMs mediated the practical demonstrations that were carried out. Indigenous knowledge (IK) is embedded in the language and the culture of the people. Using local language allowed the ECMs to express themselves easily without being intimidated by the language used. This allowed community members to be more vocal and not to feel undermined by the teachers if English was used during practical demonstrations.

Ngcoza and Southwood (2015) argued that for science teachers to be able to integrate IK into their Chemistry teaching, they need to be knowledgeable about the TSPCK (Mavhunga & Rollnick, 2013) and be mindful of the elicitation of learners' prior everyday knowledge (Roschelle, 1995) into their teaching and learning. The misconceptions that come with IK can distract the learning process if neglected by the teachers. There is a need to promote the indigenous language to be used in science lessons when integrating IK. As observed, during practical demonstrations that allowed the teachers to acquire knowledge and skills that were brought forth by Mee Mukwaluvala and

Mee Mukwamhani. Local language enhanced the PCK of teachers when ECMs explained the process involved in making *Oshikundu*.

Drawing from Ma (2008), most learners indicated that they learn when involved in discussions rather than reading and writing. Chemistry teachers were involved in critical discussions that yielded improvement in their PCK and they learnt from each other. The language helped them to engage in active discussions with Mee Mukwaluvala and Mee Mukwamhani and from the first day of the practical demonstrations and participatory observation, the local language (*Oshikwanyama*) was used. Some terminologies emerged during the practical demonstration that Chemistry teachers did not translate into the LoLT, fearing that ECMs might not understand the concepts/terminologies. For example, the terminologies that emerged for the first time were *Oitungifi/enzymes.* This was new terminology that emerged from the active engagement between the ECMs and Chemistry teachers. Central to this, language helped Mee Mukwaluvala and Mee Mukwamhani to mediate learning. These types of discussions need to take place in the classroom situation, but in most cases, English used as the medium of instruction hinders the active engagement between the teacher and learners. Sedlacek and Sedova (2017) indicated that there is a need for all learners to participate in classroom discourse.

Dialogic teaching is essential to encourage learners to participate productively in the classroom. But the question remains - will learners be able to engage in dialogue when science classrooms are set in the western model of teaching and when IK and local language are neglected? This research proved that taking learners on outdoor activities around the community might enhance their conceptual understanding as was observed during this research with teachers. In contrast, teachers often view learners' capabilities as fixed and believe that they cannot participate in classroom dialogue (Sedlacek & Sedova, 2017). This belief can be challenged by learners when they are taken out of western setup classrooms and the languages used to accommodate everyone. I believe that after observing teachers vigorously engaging with ECMs during practical demonstrations, this could be translated to learners when taken out of western classroom setups to the community to be engaged in learning. Adding to this, Dziva et al. (2011) found that teachers had limited conceptions of IK and did not perceive IK as useful content in science classrooms. The Eurocentric textbooks used in our education system limit the exploration of IK and the engagement of indigenous people in science classrooms.

It was evident that teachers paid more attention during practical demonstrations and participatory observation, so they were able to grasp new science concepts/contents from the activities. Mee Mukwaluvala, Mee Mukwamhani and Chemistry teachers' engagement were observed and questions were asked for further clarifications. One interesting aspect observed was the respect between the Chemistry teachers and ECMs – when one spoke the others listened and asked questions or explained further. This was because the language used accommodated everyone and they were eager to learn from the ECMs on the SK embedded in the preservation of *Mahangu*, pounding *Mahangu* to make flour, and making of *Oshikundu*. Ma (2008) found that discussions allow learners and teachers to be engaged, to listen, think, and read more to be able to give their thoughts on a topic. Lemke (1990) claimed that learners pay more attention when local language is used in science classrooms than unfamiliar scientific language. Mee Mukwaluvala, Mee Mukwamhani, and the Chemistry teachers worked together in harmony because a familiar language was used. Probyn (2009) clarified that their mother tongue might help learners to understand the concepts. Adding to this, Simasiku and Ngcoza (2019) alluded that indigenous language has more terminologies that have not yet been translated into English. It was noted during practical demonstrations that more terminologies emerged that were difficult to translate to English. Teachers need to cross-fertilise the ideas from concepts that emerge from IK with the ones from WS for learners to have a better conceptual understanding.

Significantly, Mee Mukwaluvala and Mee Mukwamhani also benefited from the practical demonstrations and participatory observation. I observed their confidence that kept growing as the practical demonstrations continued. The language and the thinking capacity of the ECMs improved when they engaged with the Chemistry teachers. They enjoyed teaching qualified teachers about the cultural activities that are applicable in science and this allowed the communication between the teachers and ECMs to improve. The engagement between the ECMs and Chemistry teachers was so amazing that they both learnt from each other. Indigenous people are knowledgeable about the subjects of Agriculture, Biology, Mathematics and Physical Science. The ECMs used the knowledge gained from their ancestors to explain how *Mahangu* grains used to be sundried, separated, and preserved in the *Okaanda*. The *Okaanda* itself is a sphere that can be used to teach Mathematics. From Biology, they knew that high temperatures denature the enzymes and that the *Oshikundu* needed to be at an optimal temperature before adding the *Ongudo* and *Ehete*. For the enzymes to be active they used to place *Oshikundu* in the sun during wintertime and in the shed during summer. Furthermore, in Physical Science specifically in Chemistry, the factors affecting the rate of reactions are done daily when preparing *Oshikundu*. Thus, this helped the ECMs to become more knowledgeable about these factors and they were well explained to the teachers during practical demonstrations. Apart from this, the ECMs felt that their knowledge and cultural wisdom were recognised and would be respected in science classrooms.

7.10 Chapter Summary

In this chapter, we took a journey to the house of one ECM with five Chemistry teachers to be involved in practical demonstrations and participatory observation. The data generated for this chapter came from the participation of Chemistry teachers in practical demonstrations and participatory observation. I also used my observations during participatory observation to judge whether teachers' PCK shifted during and after engaging with the ECMs. It was evident that IK could be used to teach scientific concepts as teachers were explaining to each other how to teach WS using IK. The interactions between Chemistry teachers and the ECMs were made possible by the use of the local language as this allowed them to engage in practical activities without any fear of intimidation.

Mee Mukwaluvala and Mee Mukwamhani engaged the teachers actively and the Chemistry teachers asked questions for further clarification. New terminologies that emerged were explained scientifically using WS and teachers explained SK using locally available materials to teach the rate of reactions, testing of CO_2, and acids and bases.

CHAPTER EIGHT: CO-DEVELOPMENT OF EXEMPLAR LESSONS, LESSON OBSERVATIONS & STIMULATED RECALL INTERVIEWS

> To teach in a culturally relevant way, Chemistry teachers must use a language that allows them to elicit learners' roles that will empower learners to want to do and learn science, this includes ways to engage learners in the knowledge, language, and skills of science formally (in school) and informally (at home) and to make personal connections to science. The goal and content for teaching science must be educationally beneficial such that Chemistry teachers develop and maintain cultural competence for the learners they teach. (Mensah, 2011, p. 301)

8.1 Introduction

In this chapter, I analyse, interpret, and discuss the data generated during the co-development of exemplar lessons that integrated IK, lesson observations, and SRIs. As articulated in the epigraph, teachers should use the language that is known and understood by the learners to create new knowledge during their lessons. Two lessons were observed per teacher at each school. Two secondary schools were involved, and five Chemistry teachers took part in the research. The data generated were intended to provide answers to my research questions 3 and 4:

> *How does a peer-learning community enable and/or constrain Grade 10 Chemistry teachers in using the IK from the ECMs on the preservation and preparing of Mahangu flour, making Oshikundu and other indigenous practices to co-develop exemplar Chemistry lessons?*
>
> *How do the Grade 10 Chemistry teachers selected from the peer-learning community mediate learning of the co-developed exemplar lessons in their Chemistry classrooms?*

In this chapter, co-learning and co-teaching took place as learners were given the chance to learn and teach others in lesson one at both school A and B. In lesson two, teachers presented the lessons.

8.2 Data from Workshop on the Five Components of TSPCK

Before co-developing exemplar lessons with Chemistry teachers, a short workshop was conducted to remind them about the five components of TSPCK (Mavhunga & Rollnick, 2013). The five components firstly were introduced by Geddis and Wood (1997), the teachers' transformation of subject matter as learners' prior concepts, subjects matter presentations, instructional strategies, curriculum materials, and curricular saliency (see Appendix Q, Table 2). Moreover, knowledge of context involves knowledge of the environmental context, knowledge of the school climate, parental knowledge, legal issues, and the social context of the community (Cochran et al., 1993). Parental knowledge includes IK of the community that could be used in science lessons. The peer-learning community advanced the knowledge of Chemistry teachers on the integration of IK into science lessons and helped them to develop skills that could be used in the future to help other science teachers. This knowledge situates itself well in the context of PLCs.

Thus, a CoP between ECMs and Chemistry teachers was created to help teachers learn from MKOs, in this case, the expert community members that had advanced indigenous technologies. This research used the five components of TSPCK to co-develop exemplar lesson plans with the focus on how to use knowledge of context and prior everyday knowledge of learners to teach Chemistry, that is, how teachers could integrate IK into Chemistry teaching. Embedded in TSPCK is ePCK which includes $ePCK_P$, $ePCK_T$ and $ePCK_R$ that were observed during the planning and teaching of lessons and thereafter SRIs (co-reflections after the lessons). As highlighted earlier, from the practical demonstrations and participatory observation, the Chemistry teachers learnt different scientific processes that could be integrated into science classrooms. Thus, the Chemistry teachers developed exemplar lessons based on different indigenous science that could be used as culturally responsive pedagogies (Mhakure & Otulaja, 2017)

8.3 Data from Co-development of Exemplar Lesson Plans

The Chemistry teachers were given the option to choose the topic they wanted to prepare and co-develop exemplar lessons on that they felt they were knowledgeable in to integrate IK apart from the rate of reactions. Two teachers from the same school were grouped to co-develop the lessons that would be taught by one of them. Michael and Sebron were from school A and they were joined by Tala who was alone from School C to co-develop exemplar lessons. Furthermore, Ndeshi and

Shipefi 16 were from School B. Both schools A and B are secondary schools situated in rural areas and are government schools that are supported by the government through [22]universal grants. The lesson plans were co-developed based on the knowledge the Chemistry teachers had acquired during the workshops, practical demonstrations, and participatory observation. As a result, they were able to engage each other on how to introduce the lesson using learners' prior knowledge on the topics.

That is, the workshops and practical demonstrations helped them to be able to plan the lessons based on learners' prior knowledge. The Chemistry teachers seemed to understand the five components of TSPCK very well and their lessons integrated them when planning and teaching. For instance, the enacted PCK for planning ($ePCK_P$) (Alonzo et al., 2019; Carlson & Daehler, 2019) helped them to plan their lessons by starting from what the learners know (learners' prior knowledge). Their understanding of how to plan the lessons based on integration of IK was observed to be mastered. In this regard, Shipefi 16 reflected in his journal:

> *It really helped me a lot with using different teaching methods and mostly the good ideas shared as it helped us to discuss how best IK can be integrated into Chemistry lessons. I understand how to transform western knowledge into real-life situations especially on the rate of reactions e.g., making Oshikundu using Ehete and Ongudo and the process of making Ombike on fractional distillation*.

Interestingly, Michael, Sebron, and Tala in their group deliberated on how lessons should be introduced and how learners should be involved. Such deliberation meant they interacted while co-developing exemplar lesson plans that integrated IK. For instance, Sebron reflected that: *"It helped me to integrate IK because we have different approaches in teaching, so through co-planning, we have exchanged knowledge on how to integrate IK"*.

The Chemistry teachers from School A chose the theme of scientific processes and the topic was experimental techniques (fractional distillation) for lesson one. Lesson two was the rate of reactions so that they could use the knowledge they gained from practical demonstrations and participatory observation to translate it into WS taught in science classrooms. Michael, Sebron,

---

[22] Universal grant is the amount of money that is paid by the government to a school per learner to accomplish free education from primary to secondary school.

and Tala weaved their ideas together on the topics they were sure had IK in them. The lesson plans were aimed at teaching using easily accessible materials (Asheela et al., 2021) *from* and *within* the local environment.

Reflecting on the practical demonstrations, the Chemistry teachers discussed ways they could introduce the topics building from what the learners already know as their prior everyday knowledge (Kuhlane, 2011) that they gained through their interactions with the ECMs. Sebron suggested using the topic of experimental techniques by mixing *Mahangu* and beans and asking the learners to separate them by introducing the lesson with hands-on practical activities as reiterated by Asheela et al. (2021). Learners could sort out the *Mahangu* and beans into two different containers. This would later be linked to the topic of fractional distillation. They also agreed that the learners should draw the apparatus used when making *Ombike* in relation to the one in the Chemistry textbooks. This was evident that teachers were planning their lesson plans based on the five components of TSPCK. In this regard, Michael reflected that:

> *I have learnt that as science teachers we should consider the learners' prior knowledge. Seriously based on IK and build our lesson preparation onward, to make our lesson <u>productive and effective</u> since most of our western sciences that we are teaching or learning from school have been in our community since, but they are not <u>documented yet</u>. Teaching learners what they know from home helps the teachers to present an <u>interesting lesson</u> through <u>integrating the aspects and pre-existing examples or ideas</u> (knowledge) from the communities. Generally, it <u>helped me to understand</u> the importance of lesson preparation and how to use it in everyday lessons. As it is stipulated that lesson plans help the presentation of the lessons. This workshop helped me to take lesson preparation very seriously and do it daily before going to the lesson.* (My emphasis)

The excerpt from Michael further narrated what he had learnt from the workshop on co-developing exemplar lesson plans which helped the Chemistry teachers to plan the lessons based on the prior knowledge of learners and the five components of TSPCK. It could be argued that Michael's $ePCK_P$ seemed to have improved as illuminated in his reflection and also his enacted PCK for reflection ($ePCK_R$) improved (Can, 2021). Three textbooks were used when co-developing the exemplar lesson plans, namely, *Chemistry made clear*, *Living Chemistry*, and *Solid foundations* along with the syllabus that stipulates the content to be covered and specific objectives. The excerpt from the syllabus indicating the topic, the general objectives, and specific objectives that learners must master in the classroom is indicated in Appendix V, Tables 1 & 2.

Distillation was planned to be taught using IK that learners grew up doing at their respective houses or communities. After analysing this topic, teachers concluded that it supported the integration of IK this research was advocating. We used the distillation diagrams and distillation to co-develop exemplar lesson plans. The topic of experimental techniques was found to be relevant, as it could be taught using learners' prior everyday knowledge and easily available resources (Asheela et al., 2021).

8.4 Lesson Observation and Stimulated Recall Interviews

In the next section, I present the lessons I observed from the two Chemistry teachers and SRIs that were done when watching the videos together with other Chemistry teachers who were critical friends. The lessons lasted between 30 minutes to 1 hour and 30 minutes. The lessons were video and audiotaped with the support of the pictures captured during the lessons. Four lessons were observed and analysed using concepts from the SCT and TSPCK. The SCT constructs, PCK and TSPCK were used as analytical frameworks to analyse the data that emerged from the lesson observations. It was observed that in some cases, COVID-19 health precautions were not adhered to at the two schools as some learners and teachers did not wear their masks and social distancing was not adhered to as classrooms were overcrowded.

School A

School A is a semi-rural government school situated in the Endola Circuit of the Ohangwena Region (see Chapter Four, Table 4.1). The school offers technical subjects from Grades 8 to 12. Before the lesson started, due to the COVID-19 pandemic, learners' temperatures were recorded and are presented in Appendix S, Table 1. Due to ethical considerations, learners were coded as L1, L2, etc., and in both lessons, the same learners participated.

8.4.1 Data from lesson 1 and SRI 1 with Michael on the topic: Fractional distillation at School A (1hr 22 minutes)

The lesson was on experimental techniques and the topic was distillation. The lesson that was planned to be taught in 40 minutes, lasted for 1 hour 22 minutes since it was taught during the afternoon and time was not a limiting factor. The lesson was introduced by engaging the learners on how they could separate *Mahangu* and beans when they are mixed as well as grapes and

Eenyandi (African Ebony). The introduction was intended to elicit learners' prior everyday knowledge of how *Mahangu* and beans are separated in their homes. This is a customary practice as *Mahangu* and beans are always found mixed and need to be separated by sorting them into different bowls, each bowl must contain only grains of either *Mahangu* or beans. From this, the teacher introduced the concept of purification that was defined by L7 based on her understanding of separating *Mahangu* and beans. She stated: "*When you are talking about making substance pure, we mean the substance that does not have other substances in it*".

Judging from the explanation of L7, she referred to the way *Mahangu* and beans are separated, and that after sorting them, there would only be a bowl with beans and a bowl with *Mahangu*. The introduction allowed learners to visualise the process of purification by separating mixtures using what is done at home using *Mahangu* and beans. Based on the introduction, I observed that learners were interested in the lesson, and I could hear them explaining different methods used to separate *Mahangu* and beans at home. This shows that learners' interest was triggered by the way the teacher introduced the lesson using local resources before moving on to WS.

Using learners' prior everyday knowledge before introducing WS allowed learners to reflect on the methods used to separate a mixture of substances. The topic of the day was distillation including fractional distillation. The topic was scientifically presented by the teacher as illustrated below:

> Michael: *When you want to purify something using the scientific process, in this case, distillation, it also going to integrate with fractional distillation. We have distillation and fractional distillation; they are similar but not the same. Fractional distillation is components that are involved in fractional distillation. We have the Bunsen burner, distillation flask, thermometer, condenser, and pure liquid component flask. If you look at this setup nicely, where have you seen something similar to this setup outside the school environment?*

Michael distinguished the differences between distillation and fractional distillation by explaining the components that are involved in the distillation process. Using the westernised diagram he explained the process of distillation. He also directed the learners to similar apparatus that are used at home when he stated: "*Where have you seen something similar to this setup outside the school environment?*" This was evidence that the teacher started by building from the prior everyday knowledge of learners when teaching fractional distillation (see Chapter Six, Figure 6.1).

As an attempt to further enhance learners' understanding, they were asked where they might have seen the setup of apparatus similar to the one in Figure 6.1. With IK gained through interactions with community members and the environment where they live, most learners had seen a similar setup of apparatus at their homes or neighbours' houses. One learner responded: "*I have seen this at home when my granny is making the traditional beer that they call Ombike"* (L4). This was interesting because learners seemed to know that the setup of apparatus in the Chemistry textbook was similar to the one used in their homes to make *Ombike.* With the response from the learners, Michael shifted the lesson from WS to catering to the integration of IK. The excerpt below is from lesson 1:

> Michael: *This is becoming interesting now, he explained that this setup is almost similar to what he has seen at home when his parents actually used to prepare Ombike. Ombike is a traditional drink that our parents used to prepare, let me ask, how Ombike is made/prepared; like you said, it looks like the setup that parents used to prepare Ombike. Or maybe what are the things (ingredients) that produce Ombike?*

In response, L2 answered: *"Different types of fruits mixed, and then fermentation takes place, then they heat it to evaporate the steam and they condense it into liquid and that is Ombike"*.

The SMK of learners and teachers were shifting from a westernised classroom setup to indigenous matter knowledge. Then, the teacher gave the learners flipcharts to draw the setup of the apparatus that is used in their homes. Through visualisation, learners were able to draw the setup their granny/parents/neighbours used to make *Ombike*. One learner was given the chance to draw it on the chalkboard and this is what happened while drawing:

> L9: *While drawing, this is a pot inside here are <u>Eenyandi</u> (African Ebony), <u>Endunga</u> (palm fruit), <u>Eembe</u> (Jackal berry/ wild berry), this is Omafiya (fire), and this is the pipe from the pot.* (My emphasis)
>
> Michael: *What do they call that thing you are drawing now?*
>
> Learners: *Okatemba (condenser).*
>
> Michael: *Just call it in any language.*
>
> L9: *This is Oikuni (firewood), and Omafiya (stand) to hold the pot, let's continue on the other side, this is a pipe through Okatemba and where steam will pass through and be <u>condensed in Okatemba.</u>* (My emphasis)

Michael: *Name them also moshiwambo, when you are naming these components, name them in Oshiwambo, we have that one, flask, just say Ombiya in Oshiwambo. That is the way you have seen it. Alright, what is this?*

L9: *This is the bottle where Ombike will be collected.*

In this vignette, Michael emphasised that the learners should name the apparatus in the local language and that resonates with Vygotsky's (1978) SCT. That is, language plays a particularly important role in the mediation of learning, and it allows learners and teachers to communicate without it being a hindrance. Indigenous knowledge (IK) is embedded in the local language as the key component of knowledge. Teachers use language to scaffold learners during the lessons. In support of this, Probyn (2009) averred that teachers seem to 'smuggle' local language into science classrooms to make learning meaningful to the learners. That is, the LoLT from Grade 5-12 in Namibia is English and teachers are not allowed to use local languages. To make meaningful learning, science teachers should use the local languages as IK is embedded in the culture of the communities. Indigenous knowledge (IK) is vital to a cultural identity that also encompasses education, language, the system of classification, resources use practices, and social interaction, embedded within a metaphysical framework (Dziva et al., 2011). Indigenous education and language play vital roles in science classrooms and teachers need to be aware of the value of local language in science classrooms.

The use of different fruits in the *Ombiya*/clay pot was because the community wanted to get the flavour they wanted by mixing different ingredients. This was cemented by L6 when asked why by the teacher: "*To get the different taste from the fruits in the drink they want*". Learners seemed to be knowledgeable about the processes involved in making *Ombike* through the distillation process.

Another learner was allowed to explain the processes involved in making *Ombike*. L10 explained the processes using the drawing: This resonates well with Mavhunga and Rollnick's (2013) component of TSPCK which is presentation and analogies.

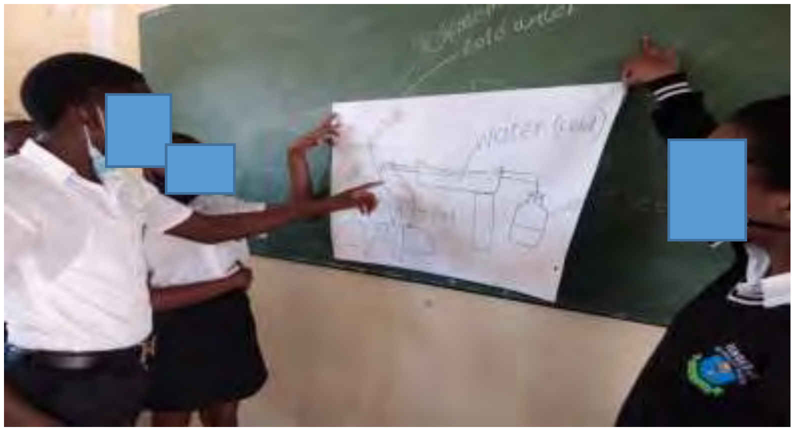


Figure 8.1: L10 explained how *Ombike* is prepared using his experiences

> *This is the method that our parents at home use to make Ombike. In this pot, there is a mixture of different fruits (ingredients) mixed with water. When they are here, they have different boiling points, so when they put it on the fire, they have this we call Okatemba, inside this Okatemba there is cold water. So, when this starts boiling at any temperature … the substance inside this pot starts boiling and steam will go up, since the pot is closed/sealed the steam won't escape, it will go through this pipe; the moment it enters this Okatemba there is cold water that steam will condense. But the steam is just inside the pipe, the pipe does not end up inside the Okatemba, just passes through, so the steam will be condensed, and it will come out as something – a liquid – and the liquid will be collected in this bottle. So, this one is pure Ombike, when the temperature goes beyond 78 ^{0}C, another substance will start boiling, and if you do not remove this one, this will end up being diluted because there will be a mixture of something that boils beyond 78 ^{0}C, that is how they used to do it* (L10). (My emphasis)

This lesson afforded the learners an opportunity to explain what they had observed, using their prior everyday knowledge to explain scientific concepts in Chemistry lessons. By analysing the explanation of L10, it was wonderful to see how knowledgeable the learners were when it came to IK that is happening in their homes or local environments that involve scientific processes. When making *Ombike*, the pot is sealed and when the mixture starts boiling the air pressure inside is high and the steam has to escape out. The only opening is the pipe that is inserted on top of the pot that allows the steam to escape through the *Okatemba*. The cold water in the *Okatemba* is to condense the steam from the pot back to a liquid. Westernised Science (WS) uses a thermometer to measure the temperature of the vapour or steam inside the flask. With reference to this, indigenous people use their observational experiences and their finger to measure the temperature of water in the

Okatemba/condenser; they feel the warmth and if the water in the *Okatemba* needs to be changed. In addition, Ramorogo and Ogunniyi (2010) averred that teachers should be given a good grasp of alternative ways of viewing what is worth knowing so that their learners are afforded the opportunity to consider different ways of knowing and interpreting experiences. This was accorded to the teachers and learners during the lessons.

Interestingly, L19 asked: "*I always wanted to ask my grandmother, why they always keep changing the water in the Okatemba*?" In his response, L20 indicated that "*it is where the cold water is that condenses the steam*". Michael added that:

> *The main reason is that old people/our parents, know that if this water is hot, steam will not be condensed, so they always try to keep this environment cold so that the steam which is coming out from the pot should be condensed. You cannot collect the steam here it will disappear*.

The understanding of learners and teachers on the indigenous practices that occur in their community allowed them to interact and explain the scientific processes using the relevant indigenous artefacts in the community. For example, the water in the *Okatemba* should be cold for condensation to take place inside the pipe that is passing through it. Furthermore, apart from distillation, the teacher asked learners if there is any knowledge that they have learnt at home that is similar to anything they are learning in Biology, Chemistry, Geography, or Physics. This stimulated the learners' thinking and they explained:

> L15: *They used to <u>put Oshikundu in the sunlight</u> and used to <u>add Ongudo</u>, they put it nande pomuntenya nande nashihala kupya (they put it in the sunlight if it does not want to be ready) but at school, we used to learn that in Biology, that enzymes they need to be activated, at the <u>lower temperature enzymes are inactive</u> and again at <u>high temperature, they used to be denatured</u>, so the temperature has to be regulated*. (My emphasis)

> *L9: At home, we experience the process of getting water clean; you know sometimes in rural areas we just take water from different pods, Omufima (borehole), our parents find out that water is not safe to drink, so there are methods that they use to make that water clean. Sometimes we <u>use sand to filter that water</u>, so the dust particles ... will remain in the sand and clean water will pass through, so then we consume it. They also use this <u>process of boiling</u>, when water boils you know some bacteria will be killed. That process is the same as the water that we consume nowadays which is from the tap, they use <u>Chlorine to kill</u> some bacteria and <u>large drums filled with sand particles</u> to filter the water so that we can consume it*. (My emphasis)

From the two excerpts above, it could be hypothesised that the learners seemed to be able to link what is happening at home to what they are taught at school as advocated by Gwekwerere (2016). That is, learners were able to move from the context to content, by explaining the WS using their IK that they are familiar with within their environment. Michael was impressed by the learners' explanations, and he said: *"Very good, wonderful"*. This showed that the teacher appreciated the explanations given by both learners using their life experiences to explain scientific processes.

I observed that learners were logical in whatever they were explaining. The process of making *Ombike* is illustrated in the diagram (see Figure 6.1) and was explained in a sequential form by learners from both schools A and B. Indigenous people use different ingredients to prepare *Ombike*. Figure 8.1 illustrates the ingredients and the steps involved when *Ombike* is brewed. Learners used the figures to explain in detail the processes involved in brewing *Ombike*, similar to the brewing of whisky, although whisky is allowed to mature for a year, *Ombike* is consumed immediately after being brewed. *Ombike* is made to be sold to support the family financially and the demand from customers is very high (Utete et al., 2017; Uushona, 2013).

Indigenous technologies seem to be neglected in science textbooks, yet they can be useful in teaching WS or concepts and thereby ameliorate cognitive dissonance amongst learners (Le Grange, 2007). Integrating IK into school science teaching is one way of maximising the sociocultural relevance of science education to enhance learners' performance (Zinyeka et al., 2016). The IK of learners was maximised during the lessons and learners were actively engaged were observed.

8.4.2 Data from lesson 2 and SRI 2 with Michael on the topic: Chemical reactions: Rate of reactions (1hr 29 minutes)

The second lesson from School A was based on the factors affecting the rate of reactions, similar to the factors that affect the preparation of *Oshikundu*. Michael introduced the lesson by reading the specific objectives that would be covered during the lesson and what learners were expected to know and understand at the end of the lesson. To help learners grasp the essence of the lesson, Michael used different scenarios to get the learners' attention. For instance, one of the scenarios given to the learners was:

> *You are given a tender to build a house, you want to finish that work in a very short period. There are obstacles or things that can pull you down not to do your work. Those factors can be preventable factors and the other ones are natural factors that you cannot control and hide from them. For instance, you are building a house and there is a high temperature, you will not work from 8 up to 3 there it is very hot, you have to rest. Some of these are the factors that can affect you or the process. In reactions, we also have those factors that can slow down the reaction process. These factors can be the nature of the reaction, the concentration of the reactants, the temperature of the system, the pressure around that system, and the catalyst that one can speed up or slow down the reaction.*

Michael wanted to move the learners from WS to IK by giving the scenario of the factors that could limit them when building a house. Then, the factors affecting the rate of reactions were explained by the teacher by linking them to the knowledge gained from the practical demonstrations and participatory observation at Mee Mukwaluvala's house. Each factor was presented separately, showing how Michael engaged IK during the lesson to help learners understand the concepts of the rate of reactions. Learners were less engaged during this lesson and the lesson was theoretical rather than practical.

8.4.2.1 Concentration

Concentration was taught with examples from IK that were useful in helping learners to understand the scientific concepts. The teacher started with WS before integrating IK to strengthen the understanding of learners. Michael explained concentration in terms of collision theory and L7 explained that "*this is because there are many particles of a reactant that will make it collide successfully with reactant species*". Concentration depends on the number of particles that are in constant motion in a given area. The more particles, the higher the rate of reactions and *vice versa*. Concentration was found to be directly proportionate to the rate of reactions. After using westernised examples, the lesson was localised to help learners understand the effects of concentration from the indigenous practices that are done at home.

During the preparation of *Oshikundu, Ongudo* and *Ehete* are added to speed up the rate of reactions. The addition of *Ongudo* and *Ehete* is done in small quantities because *Oshikundu* is usually prepared during sunset so that it has more time to be ready during the night. Using the knowledge gained during the practical demonstrations and participatory observation during the visit to the house of Mee Mukwaluvala (ECM), Michael explained that:

> *Let's say you want to make Oshikundu … and you want that Oshikundu to be ready at a faster rate. You want to see the effect of concentration here, if you add too much Ongudo or too much Ehete that is concentration … then Oshikundu can be ready within a limited time interval. If you add too much Ongudo that is concentration; our parents when making Oshikundu they do not put too much Ongudo, just a very small amount, but Oshikundu that will be produced is a lot in a container. How now if you add five cups of Ongudo in that Oshikundu, which means the concentration of Ongudo will be high, then it means Oshikundu will be ready within a short time … Ehete again, when our parents are making Oshikundu, they do not put too much Ehete, they put a little bit, how if they put too much, it means the concentration will be high or the reaction will be faster.* (My emphasis)

The excerpt above illustrates how indigenous people increase the concentration by the addition of *Ongudo* and *Ehete* to speed up the rate of reactions so that *Oshikundu* can be ready in a short time. This was evident in the practical demonstrations and works as per the collision theory explained in Chemistry textbooks. Interestingly, Michael used the words *our parents*, including himself as one of the learners. In concluding the section, Michael summarised: "*The effect of concentration is directly proportionate to one another, higher concentration means a higher rate of reactions and if the concentration is low the rate of reactions is also limited or low*".

8.4.2.2 Pressure

Michael tried to explain pressure using *Ongudo* and *Ehete*, but this did not translate meaningfully, he indicated that pressure was more about gas particles, and it was difficult to link it to the preparation of *Oshikundu*. Therefore, the pressure was presented using WS only. Michael did not use Oshikundu to explain how air pressure could be understood. When reducing the volume, increases the pressure of air particles that results in more collisions and thereafter, the rate of reactions is increased. The pressure is high when the number of particles is more per limited volume. Michael explained:

> *Pressure increases the concentration of gases which increases the rate of reactions, which means pressure helps the particles to come together and when they concentrate at a certain volume … that concentration now is high. So, pressure helps particles to come together, when they come together, they are concentrated per limited volume; if they are concentrated then the reaction will take place at a faster rate.*

Michael explained how pressure increases the rate of reactions by compressing the gas to increase concentration which will increase the collisions between the particles as they have limited space to move around. Thereafter, Michael introduced particle sizes as one of the factors affecting the rate of reactions.

8.4.2.3 Particle size (surface area)

Michael repeated the specific objectives that learners needed to cover at the end of the lesson. Learners had to describe, in terms of collision theory, the effect of particle sizes on the rate of reactions. Michael encouraged the learners to use practical examples when explaining the effect of particle sizes on the rate of reactions. Michael gave this scenario to the learners.

> Michael: *You want to make porridge, your porridge is generated from Mahangu, let me just say Mahangu or maybe maize; now you want to make oshifima (porridge), one person has Mahangu flour, and one person has Mahangu grains not pounded and the other one Mahangu crushed but not sieved. From those three categories, who will make successful porridge?* (My emphasis)
>
> Learners: *The one with Mahangu flour.* (My emphasis)
>
> Michael: *The one with Mahangu flour, because the particles are in powder form ... the surface area of those particles is high which means they can react very fast with water so that it will produce porridge.* (My emphasis)

The scenario moved learners from the use of Calcium Carbonate ($CaCO_3$) reacting with Hydrochloric Acid (HCl) in the laboratory to the activities that learners do at home that involve particle sizes. The pounding of *Mahangu* grains increases the surface area by making the particle size very small so that the reaction can be faster as explained by Michael. Indigenous people separate the larger particles from the fine particles using an *Oshimbale* by the process called *Okufifwa* (see Figure 7.13).

This reaction is the most used example in all three Chemistry textbooks that were analysed and used.

$$2CaCO_3 + 4HCl \longrightarrow 2CaCl_2 + 2CO_2 + 2H_2O$$

The use of powder and grain to show Calcium Carbonate ($CaCO_3$) reacting with Hydrochloric Acid (HCl) in the laboratory is similar to the use of *Mahangu* flour and *Mahangu* grains at home when preparing *Oshikundu*. The particle size was linked to the surface area using the flour and the grain of *Mahangu*. Regarding collision theory, the teacher explained the use of powder and grain in terms of particle size and surface area that increases the rate of reactions. Michael explained:

> *The smaller the particle sizes that means the surface area is greater; if the surface area is greater that means the rate of reactions can be done at a faster rate and vice versa, if the particle size is big that means the surface area is small then the rate of reactions is limited or slow. It will take place at a slower pace*.

The understanding that the teacher gained from practical demonstrations and participatory observation was useful in terms of increasing the surface area by pounding *Mahangu* seeds and sieving them. Even though the Chemistry teacher could not link it to the pounding of *Mahangu* when making *Oshikundu*, the scenario used clarified the concept of particle size that increases the surface area and then increases concentration, resulting in particles colliding and thereafter, the reaction taking place. I observed that the teacher was not confident in using the pounding of *Mahangu* to explain the effect of particle size or surface area on the rate of reactions which would have helped learners visualise and contextualise WS. Learners are part of the community and pounding is part of the daily activities they do at home.

8.4.2.4 Catalyst

The concept of catalyst was introduced by asking learners to name three catalysts that they knew from home. To further help learners to understand what a catalyst is, L1 defined the catalyst as, "*the substance that increases the rate of reaction without it being changed at the end of the reaction*". The understanding of a catalyst from western science did not help learners to link it to the cultural practices happening at home. Learners struggled to name any catalysts and they could not link the preparation of *Oshikundu* to the lesson that was being taught. L4 said: "*water"*, L9 named a "*cooking stick"*, L6 named "*sunlight"* and L4 explained: "*When you want to get fat from milk, you put in Omunghudi/Boscia albitrunca roots*". This became interesting because Michael further explained the process of how indigenous people used to make fat from milk by clotting. *Omunghudi/Boscia albitrunca* roots or barks act as a catalyst to speed up the rate of reactions to clot milk. Michael averred that "*there is science involved there because the roots will act as a* *catalyst to speed up the clotting process*". Michael could not explain more about how clotting happens when removing fat from the milk, even though he acknowledged *Omunghudi/Boscia albitrunca* roots or barks as a catalyst that speeds up the clotting process of milk. In his study, Bille (2009) found that *Omunghudi* is used by indigenous people to "*improve the quality of milk in terms of flavour, smell and consistency compared to other traditional fermented milk products*" (p. vii). Learners were aware that *Omunghudi* acts as a catalyst. *Omunghudi* is known for its strong smell and different communities use it differently.

Furthermore, the Chemistry teacher used common catalysts that learners were familiar with from home. *Ongudo* and *Ehete* were used as examples to explain catalysts that are used when making *Oshikundu* at home to speed up the reaction. Interestingly, learners were not convinced that *Ongudo* and *Ehete* were catalysts because the definition of a catalyst says that it is "*not used up in the reaction"*. Learners were convinced that *Ongudo* and *Ehete* are used up during the process of fermentation. This caused cognitive dissonance (Le Grange, 2007) in the minds of the learners and Michael could not build a strong link between IK and WS for learners to traverse when such dissonance arises in the classroom. In a nutshell, Michael explained *Ongudo* and *Ehete* using the colour of sorghum as they are reddish. Michael narrated: "*It is normally coloured particles because Ongudo is coloured … it is not like Mahangu flour or particles, they are purple or this colour (pointing at the black board), and I don't know what colour is this, Ongudo is of this colour*". Michael referred to the dregs that are found at the bottom of the container. *Ongudo* and *Ehete* are made from sorghum flour and *Mahangu* flour is made from *Mahangu*, thus they differ in colour and function. Sorghum is rich in carbohydrates that are digested by enzymes that are active in the *Ehete*.

In Chapters Seven and Eight, we were made to understand that *Ongudo* has dormant enzymes that need time to activate and *Ehete* has enzymes that are active and ready to digest carbohydrates in *Ongudo*. The lesson was interesting because learners argued that *Ongudo* and *Ehete* were not catalysts and Michael tried to make learners understand the function of *Ongudo* and *Ehete* in the making of *Oshikundu*. To further help learners to understand this, I interjected and explained to the learners using practical examples. To avoid cognitive dissonance (Le Grange, 2007), I explained catalysts using practical visualisations on what is done at home.

Me: *When they add warm water with Mahangu flour to make a paste before they add Ongudo they have to dilute the paste with cold water to bring it to a lukewarm temperature or solution, then is when they will add Ongudo; and at the end, if there is Ehete then they will add Ehete. Why are they doing that? Because enzymes are present in Ongudo and Ehete and enzymes are catalysts that speed up the reaction. If you go home and you make Oshikundu, take three bottles, put Oshikundu in the first one without Ongudo, and the second one with Ongudo and the third one with Ongudo and Ehete. The next day you have to see which Oshikundu will be ready. Which one will you drink first?* (My emphasis)

Learners: *The one with Ongudo and Ehete.*

Me: *Then you have to understand that Ongudo and Ehete are catalysts that speed up the rate of reactions. This one without Ongudo and Ehete, if you look at it will be like Etepi, you will find the flour will settle at the bottom.* (My emphasis)

Learners: *Yes.*

Me: *But this one with Ongudo and Ehete, there will be a reaction, you can see particles moving up and Mahangu flour are moving inside there. Why are they moving? Because there is a reaction which is taking place inside; there is a reaction taking place because of the catalyst that was added. If Ongudo or Ehete are not catalysts, then it means all this Oshikundu should be ready at the same time.*

I used the knowledge gained during practical demonstrations and participatory observation to explain the effect of *Ongudo* and *Ehete* in *Oshikundu*. After my explanation, learners were observed shaking their heads and explaining it to each other to further their understanding of using *Ongudo* and *Ehete* as catalysts when preparing *Oshikundu*. With no further explanation, Michael moved to the next variable that affects the rate of reactions which was temperature.

8.4.2.5 Temperature

Michael explained temperature using the practical example of making *Oshikundu* that learners were familiar with. He used enzymes instead of catalysts so that the learners could understand the concepts well from a biological point of view. Michael narrated:

Under high temperature enzymes become denatured, they are not going to be in their natural shape. Enzymes are like this, if those enzymes are being denatured if exposed to high temperature, their shape will not be like this, it will be denatured and change to another – so that substrate will no longer fit in such enzymes so that the rate of reactions can take place. At optimal temperature, all the enzymes are excited which means the substances can fit there and the collision theory is also involved, if the enzymes are like this (points on the drawing) and they're moving – and that temperature is also involved in *collision theory as the particles are moving. That is temperature; meanwhile, when the temperature is low, enzymes are inactive which means they are not even moving fast and they are not happy because they are feeling the cold. They are not colliding successfully, and enzymes are not meeting with the substrate for the reaction to take place*. (My emphasis)

To further help learners understand how the temperature can affect the rate of reactions, Michael used the preparation of *Oshikundu*. He elaborated that:

> *At home when making Oshikundu, if I want my Oshikundu to be ready I will expose it to a temperature optimal, which is more or less equal to optimal temperature so that the collision theory will take place at a faster rate. But if you put Oshikundu in the sun directly after 13:00, that Oshikundu will just be hot but not ready*.

Oshikundu was used as an exemplar to explain and help learners contextualise the concepts from an IK point of view. At home, *Oshikundu* is exposed to optimal temperatures for enzymes to work best. For *Oshikundu* to be ready it needs a gradual increase in temperature that will not denature the enzymes quickly. Michael illustrated that by putting *Oshikundu* in the sun at 13:00, the temperature of the *Oshikundu* will get hot within a short time and enzymes will be denatured. Similarly, in factories, temperature is regulated at an optimal temperature not to denature the enzymes. The use of *Oshikundu* to integrate IK allowed learners to be able to link WS to activities they do at home. This enhanced the understanding of learners using their prior everyday knowledge (Kuhlane, 2011; Roschelle, 1995) to teach concepts that are practical in the learner's life experiences. The last factor was light intensity.

8.4.2.6 Light intensity

Light intensity was presented as to how plants make their food using sunlight through the process called photosynthesis. The reaction that happens when the process of photosynthesis takes place was used to explain light intensity:

$$\text{Carbon Dioxide} + \text{Water} \longrightarrow \text{Sugar} + \text{Oxygen}$$

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

The topic was not linked to IK because it was difficult to explain using indigenous practices. Michael could not become a cultural knowledge broker (Wyatt et al., 2017) during this topic and avoided cognitive dissonance (Le Grange, 2007) in the mind of the learners. Even though Michael did not give examples from the IK point of view, learners might have thought of something where light intensity could be used from the African perspective. Ignoring IK in science teaching does not guarantee that cognitive dissonance will not happen in the mind of the learners. However, Michael was in line with what Ndeshi said when she warned others during the workshops that if the concepts could not be taught using IK, they need to be taught the way they appear in the textbooks.

In conclusion, Michael summarised the factors that affect the rate of reactions and indicated that the lesson was more theoretical than practical, as it would have been better if the learners could have made *Oshikundu* and thereafter explained the rate of reactions.

School B

School B is a semi-rural government school that is situated in the Endola Circuit of the Ohangwena Region (see Chapter Four, Table 4.1). Unlike School A, School B used two different class groups during the research and in each class group, the learners' temperatures were recorded. Learners at School B were coded according to the lesson they attended. For example, lesson 1 learner 1 (L1L1, etc.) and lesson 2 learner 1 (L2L1, etc.) (See Appendix S, Table 1).

8.4.3 Data from lesson 1 and SRI 1 with Shipefi 16 on the topic: Methods of purifying: Distillation at School B (56 minutes)

The lesson started with the teacher asking learners how they purify water that they get from the *Oshana* (pod). The learners' prior everyday knowledge was engaged at the beginning of the lesson as they reflected on how purification is done at home before being introduced to WS. Learners used their life experiences to answer the question that was asked by the teacher. For example, L3 responded by saying "*boiling*" without further explanation of the boiling process. The teacher insisted that the learners explain their answers. In the same vein, L7 averred that "*we boil water then after we add ash, then we let the ash to settle down at the bottom*". Adding to this, L10 indicated that, "*we filter with the clothes*". Adding ash into water is believed to be one way of killing the bacteria that are in water which makes the water safe to drink. Learners answered the question based on the life experiences that they had observed and acquired from elderly people through social interactions with them. Ash/*Omutoko* as an alkaline works similarly to *Chlorine*, which is added to tap water to kill germs and bacteria. The learner could not explain why adding ash to water purified it, and the teacher also could not further explain the reason for using ash when purifying water to make it safe to drink.

Kibirige and van Rooyen (2006) reiterated that if we integrate IK into our science lessons it will encourage learners to participate with the notion being that to educate, is to change the meaning of experiences and that meaning is constructed through shared experiences. Learners were given the chance to present the topic using their WS understanding and IK. This allowed learners to contextualise scientific knowledge to unearth the science embedded in IK. Seehawer (2018) designated that integrating IK is aimed at contributing to decolonising education on a practical level in the classroom. Giving the learners a chance in the classroom helped them become researchers that were willing to further their understanding of certain indigenous practices that occur in their local environments. In my personal life history, I alluded to some cultural practices that we used to do at home but never thought were helpful or scientific in science classrooms. Using learners as resources or custodians of IK creates learning opportunities for the teachers and learners.

Shipefi 16 introduced the topic of the day as distillation and crystallisation and further clarified the two concepts as methods of purification. Shipefi 16 explained when introducing the topics:

> *Then today we are going to look at these two. Distillation is the process of separating miscible liquid and crystallisation where we are separating what? Who can define for us what crystallisation is? To separate soluble content from the solution or soluble solid from the solvent or a solution and that is what we are going to do today*.

The first topic was distillation which was presented by L1 using WS knowledge and understanding without referencing any indigenous technology during the presentation. L1 presented the distillation process as indicated in the excerpt below which shows the interaction that happened with other learners. Judging from her understanding, it showed a strong foundation based on the making of the *Ombike*. I could observe how confident she was when explaining the concepts of distillation. Even though the learner did not use the local language to explain the process, it was amazing how the concepts were explained and the understanding the learner had of the process.

L1: *We are going to learn simple distillation. But before, how do we get the pure solvent from the solution? This is a solution right; in this solution, we have a solvent. How do we get a pure solvent from this solution? You people, you don't understand the process of distillation or what? We just get the pure solvent from the solution by using simple distillation. The process of getting a pure solvent by simple distillation. This is heat, this is a distillation flask, here we have our solution, and the solution which is here is a saltwater solution. Now, here we have the heat, and this solution now is boiling. What happens here? Here it changes from a liquid to gas/vapour/steam/. This boiling flask is covered, what is the reason, guys? One person at a time, please.*

L10: *To prevent steam from escaping out.*

L1: *Yes, to prevent steam from getting out; the main idea is to get the pure solvent. If you let the steam evaporate into the atmosphere, will you get the solvent?*

L1 was confident when presenting the lesson to other learners using WS and I observed that other learners respected her as a teacher. Throughout the lesson, L1 did not refer to any IK; for example, the making of *Ombike* to mediate learning of distillation as expected in my mind. The lesson engaged other learners and they were actively involved as was observed throughout the lesson. I observed that L1 kept on emphasising the functions of each apparatus in the setup and repeatedly explained the process more than twice for other learners to understand it clearly. Learners' ZPD shifted from the level where the learners were before the presentation, to the next level where the curriculum requires them to be, after the explanation of simple distillation. L1 used the right concepts throughout the lesson and guided other learners to understand the concepts. The lesson was learner-learner collaboration and negotiation of meaning (Lave & Wenger, 1991).

The next concept of the lesson was crystallisation, with no further explanation from the teacher on the previous topic that was presented by L1. Shipefi 16 gave L2 a chance to present the lesson on crystallisation. L2 drew the process of crystallisation on the chalkboard and used the drawing to explain the process of separating soluble solids from the solution using crystallisation. Four concepts emerged during the lesson; crystals, solvent, solute, and solution which were well explained by L2. The lesson went well as the learner-teacher engaged other learners during the lesson and his explanation is stated below:

L2: *Fine, I am going to demonstrate the experiment of crystallisation. Crystallisation is the process where we heat the solution, for example, I can say the <u>salt solution</u> to obtain salt crystals. We want to obtain the salt crystals from the solution of salt water. Here is salt, can you see, here is water, <u>water is a solvent</u>. This is an evaporation dish (Etiti), a* *traditional evaporation dish. We do not have firewood here; I want all of you to look on the chalkboard. This is the Bunsen burner, traditionally we use firewood to produce heat. This is the evaporation dish; it contains a solution of saltwater. We take the Bunsen burner and heat the solution; you know different liquids have different boiling points?* (My emphasis)

Learners: *Yes.*

L2: *Water's boiling point is 100 ^{0}C, if the temperature reaches 100 ^{0}C water will start to evaporate into the air, leaving salt crystals here. When water evaporates completely, then you take out your evaporation dish to take your salt crystals. It is another simple way of collecting or obtaining the solute crystals from the solution.* (My emphasis)

The lesson was firstly explained theoretically using the drawing that was on the chalkboard to illustrate how the crystallisation process is done to obtain crystals. On analysing the presentation, it showed that L2 was knowledgeable about the process of crystallisation. Emphatically, L2 told other learners to look at the chalkboard: *"I want all of you to look on the chalkboard"* as he was explaining the process using the pictures on the chalkboard and he wanted the learners to understand the process by seeing how crystals are formed.

After the theoretical presentation, learners were taken to a practical demonstration of how crystals are formed. Learners observed and internalised how crystals are formed when heating the solution. During the practical demonstration that lasted between 15-20 minutes, there was silence, and L2 did not use the opportunity to further explain the process of crystallisation, nor did Shipefi 16 use the opportunity to explain further and make learning meaningful through the practical demonstration.

An *Etiti* or calabash was used as the evaporating flask that contained the solution of salt water. An *Etiti* is a traditional dish made out of clay soil that is sundried and heated to make it strong. After it is sundried, it is heated at a high temperature using a traditional heating chamber, using cattle dung or firewood. The process of heating makes the clay soil strong so that it does not break when heated or when used as a water container.

Figure 8.2: Learners observing the crystallisation process; saltwater solution boiling; crystals formed after the water evaporated

Learners observed the crystallisation process happening in front of them outside the classroom. In most cases, practical demonstrations or experiments are associated with laboratory apparatus but that was not the case at School B when the demonstration was done in an open space. Learners used hands-on, minds-on and words-on (Asheela et al., 2021) during the practical demonstration and they observed and explained (OE) (Shinana et al., 2021) the process of crystallisation. This process of OE was internalised by the learners and a few learners were heard explaining to each other during the demonstration what was happening.

In Figure 8.2, corrugated iron metal was used to block the wind from blowing through the fire and one learner explained that "*we want the flame of fire to be perpendicular to the bottom of the calabash (Etiti), for the heat not to be wasted and for the process to be fast*". The corrugated iron was placed on the side where the wind was coming from and before the zinc was put up, the flame was blowing randomly in all directions. This was also observed when we visited the ECM, where corrugated iron was placed in the direction where the wind was blowing from (see Figure 7.10). In a nutshell, learners observed the process from beginning to the end and during the crystallisation process learners engaged each other to further understand the process. The teacher was unaware of the PEEOE concept proposed by Shinana et al. (2021) that can be used during practical demonstrations and experiments, thus it was not used.

After the salt crystals were observed, learners were told to go back to the class for the last presentation on simple distillation integrating IK. Shipefi 16 did not emphasise or stress the most important points during the lesson before moving on to the next presentation. The next topic was simple distillation integrating IK through the making of *Ombike*. L13 was given the chance to present the topic and Shipefi 16 encouraged the learners to use the local language in case the western terminologies they wanted to explain were not available in their minds. Indigenous knowledge (IK) is embedded in the local language, and the use of local language creates room for questioning and further discussion between learner-learners and teacher-learners. This resonates with the SCT (Vygotsky, 1978), in that language plays an important role in the mediation of learning. L13 presented the topic of integrating IK she had acquired from home/local environment through social interactions with elderly indigenous people. Using her drawing, L13 explained the process of brewing *Ombike* done by indigenous people. She exemplified:

> L13: *Let's go ahead with our lesson; a simple distillation process can also be used to produce some of the alcohol brewed such as whisky by distillation, in this case, Ombike. I have a poster so that I can show you guys. This is the process; firstly, we ferment, and when fermentation is done. We make Ombike using fruit like <u>Eembe</u> (Jackal berry/wild berry), <u>Eenyandi</u> (African Ebony), <u>Eenghekete</u> (Buffalo Thorn fruit) and grapes. Let's talk about <u>Eendunga</u> (palm fruit) now, they are <u>crushed off (increase surface area)</u>, and the small pieces that are crushed off, are fermented in a drum with water. They remain in that drum for about two weeks (14 days)*. (My emphasis)
>
> Learners: *No, maybe five days.*
>
> L13: *It depends; for you to know that now the fermented fruit is ready for Ombike to be distilled out, you taste it, it will <u>taste sour,</u> or it will have an <u>alcoholic taste</u>. Before distillation, <u>sugar is added</u> to the solution in the drum so that it will <u>provide a sour taste</u> when added to the mixture. Ok, it is then cooked, after the solution produces an alcoholic taste. It is put in the clay pot which is covered with clay soil on top. Do you have ideas about why it is covered?* (My emphasis)

Similarly to School A, learners seemed to be knowledgeable about the process of making *Ombike* and they explained it similarly. IK is passed on orally and through practical demonstrations and is still compelling to the learners that are in rural areas. Learners are loaded with science knowledge (Mukwambo et al., 2014) from home that the teacher needs to extract and link to WS to make learning meaningful to them. The lesson was concluded with Shipefi 16 emphasising the use of traditional apparatus that is accessible to the learners. He enlightened:

> *Learners, you need to know the apparatus that you have to use, at home, in case you find yourself without apparatus that you can make use of. Like in our case, we found that we don't have apparatus in the lab, we can come up with any traditional apparatus that we can use instead of lab apparatus. That's why we have used an Etiti as an example of an evaporating dish. What we need is to know the materials, locally available materials that we can use in our science classroom*.

Shipefi 16 emphasised that it is not only lab apparatus that can be used to conduct experiments for the learners to contextualise WS in science classrooms but locally accessible resources or materials (Asheela et al., 2021) should be made available and used. For example, the *Etiti*/calabash was used as an evaporating dish and firewood as a Bunsen burner to mediate the concepts of crystallisation.

8.4.4 Data from lesson 2 and SRI 2 with Shipefi 16 on the topic: Chemical reaction: Rate of reactions (29 minutes)

The lesson was introduced by the teacher by asking what the factors are that affect the rate of reactions. Learners' prior knowledge was tested by the teacher to see whether they had any background knowledge on the rate of reactions. Learners responded by giving the factors that affect the rate of reactions as, catalyst, temperature, light intensity, pressure, surface area, concentration, and particle size. It seemed that learners were aware of the factors that affect the rate of reactions from their previous grades. Each factor was presented separately during the lesson. The lesson was theoretical, WS was predominant during the lesson and the teacher did not engage with IK in his lesson. The practical demonstrations and participatory observation that we attended on the preparation and making of *Oshikundu* were useful in this lesson, yet the teacher seemed to give less attention to IK and learners were less engaged. The factors that affect the rate of reactions were presented by Shipefi 16 as follows:

8.4.4.1 Concentration

The concentration as a factor that affects the rate of reactions was presented to the learners based on the westernised summary the teacher had at hand. Learners were not engaged on this factor as the teacher seemed to focus more on the summary without giving practical examples that learners were familiar with. The use of a westernised example limited the engagement between the teacher and the learners during the lesson, even though Shipefi 16 asked learners to relate concentration to any practical examples that happen at home. Unfortunately, learners could not think of any practices that they do that increase concentration. This is how Shipefi 16 tried to bring IK to the science classroom, but learners were not able to connect *Oshikundu* to the lesson:

> *Like at home in terms of concentration what can we do, what can we relate to now. At home in terms of concentration... there is nothing you can remember where you increased the concentration so that the reaction can take place so fast. You cannot remember anything about increasing the rate of reaction so that a certain reaction can take place so faster. You cannot remember, can we relate something under concentration?* (My emphasis)

Analysing the above excerpt, Shipefi 16 directed the learners to engage with the concepts of concentration from an IK perspective. Learners could not link the making of *Oshikundu* by adding *Ongudo* and *Ehete* as examples of concentration and the teacher could not unearth that knowledge for the learners to understand the factor of concentration. Shipefi 16 used westernised examples to explain the concepts of concentration to the learners. He used mol/dm^3 to explain concentration to further confuse the learners. The use of *Ongudo* and *Ehete* and mol/dm^3 caused cognitive dissonance (Le Grange, 2007) since the link was not well explained by Shipefi 16. Learners were left wondering if *Ongudo* and *Ehete* were the mol/dm^3. Shipefi 16 did not allows learners to traverse between IK and WS because he did not become a cultural knowledge broker during this topic. Even though learners seemed to understand concentration from scientific explanations, they could not explain what mol/dm^3 meant.

8.4.4.2 Temperature

The temperature was the second factor to be looked at. This was interesting to the learners because they could link the cultural activities that happen at home to how temperature could speed up the rate of reactions. Several learners explained how temperature could do this.

> L16: *At home when we were very young, we used to go to school with Oshikundu and we used to put our bottles outside. Because when we were coming to school Oshikundu was not ready; by the time we go to the break Oshikundu was ready because outside the temperature was higher than in the classroom and the reaction was faster.*
>
> L13: *The temperature increases the kinetic particles' energy in Oshikundu for it to be ready.*

Learners were aware that temperature increases the rate of reaction and that exposing *Oshikundu* to sunlight helps to speed up the rate of reaction. Similarly, when *Oshikundu* is prepared, warm water is used to activate the enzymes that speed up the rate of reactions.

8.4.4.3 Particle size (surface area)

The particle size or surface area of the solid reactant increases the rate of reaction when the reactant is in a powder form which increases the surface area. Shipefi 16 explained surface area using WS without referring to the pounding of *Mahangu* and sorghum to increase the surface area. One learner, when given a chance, narrated this: *"When we make our Oshikundu, at our house we use to pound sorghum grains to become powder which increases the rate of reaction, which increases the surface area of sorghum that increases the rate of reaction"* (L19).

Adding to this, Shipefi 16 further explained: *"It is also a good point, that when we are making our Oshikundu at home we used to pound sorghum for it to be in the form of powder so that we increase the surface area that speeds up the rate of reactions for Oshikundu to get ready faster*". Shipefi 16 did not use the knowledge gained during practical demonstrations and participatory observation with Mee Mukwaluvala and Mee Mukwamhani to elaborate on particle size and surface area more clearly to the learners. L12 recalled how her parents used to crush salt to increase the surface area. She stated: "*At home our parents if they want salt grains to dissolve faster, they use to pound them in powder form to treat a cough*". Moreover, Shipefi 16 showed no interest in the example the learner gave and diverted to what was documented in the textbook to explain the surface area. Teachers are influenced by the curriculum and the language used as the LoLT. This was observed when Shipefi 16 explained particle size. He illustrated that:

> *There is a reaction between Hydrochloric Acid and Calcium Carbonate to give us Calcium Chloride, Carbon Dioxide and water which is salt, water and Carbon Dioxide. There is a graph where they use large marble chips and small marble chips; now by looking at the graph you can see that the small marble chips give us a steeper graph than large marble chips. Just like we have a piece of chalk, if I put this solid chalk in water, it will take time to dissolve, but if we put them in the form of powder it will dissolve faster and easier.*

Shipefi 16 was not confident when integrating IK to help learners understand the concepts. Even though learners on different occasions gave examples of indigenous technology, he could not explain further to help them to understand the concepts from an IK worldview.

8.4.4.4 Catalyst

Shipefi 16 explained the following: "*We have a catalyst which is Ehete, and you also have the catalyst which is Ongudo. These are the things we add in Oshikundu for it to be ready faster"*. *Ongudo* and *Ehete* were extensively discussed in Chapter Six during document analysis, and it showed that he had enough knowledge on the two ingredients used as a dormant catalyst (*Ongudo*) and an active catalyst (*Ehete*). In explaining how *Ongudo* and *Ehete* are catalysts, he theorised that there were three bottles and learners had to visualise the bottles to understand the effect of *Ongudo* and *Ehete* when preparing *Oshikundu*. Theoretical learners could understand the concepts of catalysts because they were aware of *Ongudo* and *Ehete* from home. Learners could correctly answer that *Oshikundu* with *Ehete* and *Ongudo* would be ready first.

> Shipefi 16: *Now let me say you have three bottles. One, you add Ehete and Ongudo, second, you only add Ongudo, and the third, there is nothing. Which one do you think will get ready faster?*
>
> L4: *The first one with Ehete and Ongudo.*
>
> Shipefi 16: *The first one is because you added two catalysts at the same time and Ehete, Ongudo two of them at the same time. It will speed up what?*
>
> Learners: *The rate of reaction.*
>
> Shipefi 16: *Here this one will also take some time to be ready because the added catalyst is Ongudo, but if you did not add anything it will take about, how many hours? Even three to four days, because no catalyst to speed up the reaction to take place. The catalyst simply speeds up the rate of reaction.*

The vignette above illustrated how the teacher integrated IK for the learners to be able to contextualise the WS. Learners used their experiences to answer the question that was asked without observing the practical activities.

8.4.4.5 Light intensity

The light intensity was explained using the photosynthesis process. This was similar to how Michael's learner, lesson 2 school A, explained light intensity. Two learners used their experiences to show how they understood that IK could explain light intensity:

L14: *When we are home, we put Mahangu in water then after we have to dry it, we expose it to sunlight for it to dry faster.*

Shipefi 16: *In our tradition, if we want to have our Mahangu flour, we soak Mahangu grains in a bucket of water, but you have to expose it to light so that it increases the temperature that allows those grains to get ready for pounding. That means if you put the bucket outside it will receive the light and increase the temperature.*

L6: *Washing clothes and putting them on the line outside.*

Shipefi 16: *Washing clothes, if you keep your clothes inside the room and the other ones you put them outside. The ones outside will dry first than those inside the room.*

After the examples given by the learners, Shipefi 16 did not relate the concept of light from IK to WS. He explained the concept using WS as if learners did not give examples of their knowledge of the concepts. Ignoring learners' prior everyday knowledge in science lessons could make learners conclude that this knowledge is not valuable in science teaching. Learners were aware of how light could be used at home – since Shipefi 16 did not build from their responses to explain light intensity, it might have caused what Le Grange (2007) called cognitive dissonance. This could be the result when science teachers ignore learners' life experiences when teaching science. Shipefi 16 could not use the ePCK, pPCK and cPCK that he gained during the practical demonstrations and peer-learning communities. The lesson was concluded, by summarising it. Shipefi 16 explained the lesson in a few words as follows:

> *If you increase the concentration, you increase the rate of reaction … the higher the temperature the higher the rate of reaction, and the higher the surface area which means if you have more particles, they are in close vicinity … collision theory … they will have a successful collision. Then under the catalyst, if you have more catalysts your reaction will take faster than the one without the catalyst*.

The four lessons observed were analysed using the five components of TSPCK (Mavhunga & Rollnick, 2013).

8.5 Data Revealed the Use of the Five Components of TSPCK

The five components of TSPCK were used to analyse the lesson observed in two Chemistry lessons. Four lessons were analysed to look at how Chemistry teachers integrated IK using the five components of TSPCK. Sebron reflected that *"it helped me to understand topic-specific methods* *because learners have knowledge on the topic from home and helped me to know that science start from home".* This teacher acknowledged that learners were loaded with IK that was relevant to Chemistry topics. The five TSPCK components were presented to the teachers during the workshop when co-developing exemplar lessons for them to have a better understanding of how to plan and teach the lessons that integrated IK, based on the five components.

8.5.1 Prior everyday knowledge

Michael and Shipefi 16 from schools A and B respectively started their lessons by asking learners about their prior everyday knowledge of the topics. For example, Shipefi 16's learner, Shipefi 16 lesson 1 school B, asked the learners how they purify the water that they get from the *Omifima* (borehole) that is not safe to drink. The introduction of the lesson engaged learners to think about the indigenous way of separating mixtures based on what they do at home. The lessons attracted the attention of the learners when the questions that probed their life experiences were asked of them. The misconceptions that learners had on distillation and rate of reactions were cleared by other learners and teachers. Shipefi 16 reflected in his journal:

> *I started by asking learners their prior knowledge which is what they knew from their surroundings in this case, I asked them to explain how they purify water at home before I introduced new concepts and explained the process of crystallisation outside the classroom – and learners learnt a lot that even if they use seawater, they will get salt*.

This excerpt illustrated that the teacher learnt to start teaching topics starting from learners' prior everyday knowledge for them to be able to connect WS and IK, all the lessons observed showed that Chemistry teachers started them from what the learners knew from home, before moving to WS. Building from what learners knew allowed them to be active participants during the lessons and engage in the discussions. Learners were able to visualise the process by drawing the apparatus setup in the process of making *Ombike*. Engaging learners in the lessons proved that learners were able to present the lessons using the IK they gained during the interactions with indigenous people. It was impressive how learners used their prior everyday knowledge to explain the facts of distillation, rate of reactions, and crystallisation based on the understanding from home. The use of *Oshikundu* to teach the rate of reactions, the making of *Ombike* to teach distillation, and the experiment of crystallisation elicited learners' life experiences.

The elicitation of learners' prior knowledge was done in such a way that learners were not comparing the two worldviews that are strong in their domains and can supplement each other during Chemistry lessons. Shinana (2019) averred that teachers should start from learners' prior everyday knowledge to provoke their thoughts on the topic. Westernised Science (WS) and indigenous science are not counter-antagonistic forms of knowledge. They do not oppose each other but work in harmony with each other, and attention must be paid to correcting the misconceptions that might have been brought about by indigenous science since it is not documented. Mavhunga and Rollnick (2013) and Mavhunga et al. (2016) advocated for the idea of integrating learners' prior everyday knowledge as the start for every lesson that integrates IK.

Scholars call for cross-fertilisation of ideas to unearth misunderstandings and avoid the misconceptions that learners bring into science classrooms. Misconceptions can cause conflict in the minds of the learners if not handled properly at the beginning of the lessons. Furthermore, Mavuru and Ramnarain (2017) emphasised that science teachers need to consider using the learners' cultural backgrounds to elicit learners' engagement in the lessons. The contradictions in the minds of the learners can occur if teachers fail to use collateral learning (Jegede, 1995). Collateral learning can save teachers and learners from dissonance and perturbation that can be caused by WS and indigenous technologies in the minds of the learners. Regarding this, Chemistry teachers were able to introduce the lessons and explained the concepts based on IK that was known to the learners.

8.5.2 Curricular saliency

Curricular saliency demands that teachers have to identify the major concepts for the topics to be taught and these could be taught by linking them to IK. Drawing from Mavhunga and Rollnick (2013), teachers need to identify the concepts to be taught first and which ones to be taught later. The sequence of concepts is very important so that the learners do not become confused. In addition, Shinana (2019) indicated that teachers need to consider the interrelatedness between the concepts, and how to sequence them, and the understanding of what should be taught first and what needs to be taught later is pivotal. The practical demonstrations with Mee Mukwaluvala (ECM) and Mee Mukwamhani proved as when making the *Oshikundu,* the community members started explaining how the *Mahangu* is harvested, then taking the *Mahangu* from the

Okaanda/granary, the pounding of *Mahangu* to make flour, and then after that the process of making *Ongudo* was explained in a logical sequence for us to understand. This helped us to follow the process and the concepts that emerged throughout the process. They did not start with adding *Ehete* to *Oshikundu* which was the last step in the practical demonstrations, knowing that we would be confused and that would not help us to understand. The practical demonstrations and explanations were done in an order that made it easier for us to understand the sequence and steps that are followed when making *Oshikundu*. Curricular saliency was important during practical demonstrations and community members without knowing this component of TSPCK presented the process of making *Oshikundu* in a logical sequence for participants to follow and understand. Thus, during lesson 1 at schools A & B, learners (L9SA, L10SA & L13SB) presented the concepts in distillation using the brewing of *Ombike*.

Learners started with the ingredients that indigenous people use when making *Ombike*. All the learners explained the fermentation process that happens before the heating process starts. Learners knew that without explaining the process in the logical sequence they might bring confusion and disagreement among the learners which could bring discomfort in the classroom. The concepts were logically explained by the learners. The heating process is followed by evaporation, then condensation using cold water and the dripping of *Ombike* as the final process. Learners were able to link the concepts in chronological order according to the procedure of making an *Ombike*. For example, ingredients (*Eenyandi, Eembe, Eendunga* and others) were left to ferment using water (fermentation process), heating with controlled fire, evaporation (vapour & steam) condensation (using cold water), and *Ombike* (final production). The sequence was important to the learners, and they did not want to mix up the processes and learners had adequate indigenous matter knowledge that helped them to explain the concepts in order.

This crucial aspect was also observed when Chemistry teachers narrated what learners had presented. Michael and Shipefi 16 were able to amalgamate IK and WS to cement learners' understanding of distillation and the rate of reactions. Mavhunga and Rollnick (2013) explained that in cases when the teacher has inadequate SMK on the topics, the teacher might bring confusion and undesirable classroom talk that will not yield any learning. To this, Chemistry teachers were knowledgeable about WS documented in the Chemistry textbooks and indigenous matter knowledge. The PCK of teachers improved during the visit to Mee Mukwaluvala's house and that allowed teachers to be able to present the lessons that integrated IK using learners' prior everyday knowledge. The teachers' PCK levels were often observed and were evident in the way the teachers transformed the content they taught (Shinana, 2019). Even though learners did not attend the workshops for them to learn, it was evident that through interactions and observing local practices, they could present the lessons in sequential order. Teachers with poor SMK which is influenced by low PCK have poor knowledge of curricular saliency (Mavhunga & Rollnick, 2013). Pre-concepts that emerged from local knowledge during the presentation to learners were used by the teachers to elevate particular concepts to scientific concepts. Sequential presentations were also observed when the teachers used what the learners presented to stress the most important points in the lessons. According to Mavhunga et al. (2016), pre-concepts and sequencing are crucial in lesson presentation to promote classroom discussion that is not in conflict with learners' prior everyday knowledge.

8.5.3 What is difficult to understand?

According to Mavhunga et al. (2016), this component describes teachers' insights into the concepts in a topic that are difficult to teach; for example, the misconceptions that learners have that could hamper their understanding (Shinana, 2019). In explaining certain scientific concepts, during the practical demonstrations Mee Mukwaluvala and Mee Mukwamhani used the examples from making *Oshikundu* explain the concepts that teachers could not understand; for example, the scientific process of *Okupepela* (blowing air into the fire to make warm water) Chemistry teachers came to learn that air that community members blew onto the fire is a mixture of oxygen and other gases. Oxygen supports combustion as documented in Chemistry and Physics textbooks, but community members learnt that blowing air on the fire would make the fire flame. CO_2 does not combust with less reactive metal but with more reactive metal, a displacement reaction could take place.

The concept was explained to the teachers practically and they could observe that after *Okupepela*, flames were made. The use of practical demonstrations and experiments helped make difficult concepts understood by the teachers. The evidence that *Ehete* and *Ongudo* were active and dormant catalysts respectively, was demonstrated during practical demonstrations and Chemistry teachers could observe and explain the results. *Oshikundu* with only *Ongudo* could not ferment because

Ongudo has dormant enzymes that need time to become active for the fermentation process to take place. *Oshikundu* with *Ehete* and *Ongudo* fermented because *Ehete* has enzymes that are active and ready to affect the reaction but is itself not involved. The concepts of dormant and active enzymes are difficult to understand without the help of experiments to clarify the two concepts.

During Chemistry lessons, learners explained concepts that were difficult for the other learners using analogies. Even the concepts in the local language were understood by the learners; the learner-teacher explained the concepts and the process of making *Ombike* repeatedly to make other learners understand the concept of distillation and other concepts that emerged during the lessons. Concerning factors affecting the rate of reactions, Michael and Shipefi 16 gave examples of temperature, size of particles, catalyst, and concentration using the *Oshikundu* process. The factors were explained using local examples and learners were very familiar with the concepts that emerge from the making of *Oshikundu*. Chemistry teachers could not do practical demonstrations but explaining the factors by linking them to the making of the *Oshikundu* allowed learners to understand the concepts clearly. Conceptual understanding of learners was improved using prior knowledge of learners on factors affecting the rate of reactions, for example, the catalysts (*Ehete & Ongudo*), particle size or surface area (*Mahangu flour*), concentration (adding more *Ehete & Ongudo*) and temperature (exposing *Oshikundu to sunlight*). It was difficult for Michael and Shipefi 16 to link pressure to any IK associated with the making of *Oshikundu*.

The crystallisation process was practically demonstrated to teach the abstract concepts that need to be well understood by the learners. Learners were able to internalise the process and the concepts that were abstract to them during the theoretical lesson. The concepts were clearly explained using the diagram and practical demonstration. Teaching Chemistry concepts using artefacts from indigenous technologies and those from western ones can make abstract concepts more relevant to the learners which shows that concepts that appear to be more abstract to learners can be taught using artefacts from indigenous and westernised demonstrations. The concepts that are embedded in the making of *Ombike* (distillation) and the rate of reactions help learners towards a better understanding of the concepts (Mavuru & Ramnarain, 2017).

Workshops we had helped Chemistry teachers to share their pedagogical strategies on topics such as distillation, and the rate of reaction, specifically, the explanation and understanding of the *Ongudo* and *Ehete* (catalyst/enzymes) from a biological point of view. For further understanding of how to teach difficult concepts, Chemistry teachers came up with concept maps that improved their PCK. The mind maps allowed me to understand how teachers PCK shifted towards teaching topics that integrate IK. I observed that the concepts that emerged during practical demonstrations and workshops were integrated for the teachers to develop a better understanding. I might say, the mind maps and concept map allowed Chemistry teachers to see the links between concepts and connect them. Kaseke and Nyamupangedengu (2019) illustrated that in concept maps, concepts are connected with a line and the concepts that are interconnected are reflected in Chapter Nine, Section 9.2 (see Figure 9.2).

8.5.4 Presentations and analogies

Presentations and analogies showed how the concepts should be taught from learners' prior everyday knowledge to something that is not known to the learners – teaching from the known to the unknown (Nhase, 2019). Mavhunga and Rollnick (2013) explained that presentations and analogies indicate how the lesson is presented and what artefacts are used to further help learners understand the concepts. Likewise, Mavhunga et al. (2016) indicated that presentations and analogies can be demonstrations, experiments, models, illustrations, metaphors, and stimulations that teachers could use during the lessons to further help learners to connect IK with WS. The topic of distillation was presented by learners at both schools A and B. The concepts were explained in chronological order and that yielded a positive impact on other learners. For example, L6's lesson 1 at School A explained the process of making an *Ombike*. She itemised:

> L6: *Let me use the one I drew. This one illustrates how different substances can be purified. Say for example we have <u>water and different fruits</u> that are allowed to <u>ferment</u>, as you <u>heat</u> it*. (My emphasis)
>
> Michael: *Can I ask you why they use fruits?*
>
> L6: *Just <u>to get different tastes from the fruits in the drink they want</u>. As they put it in the pot and heat it on the fire <u>but not at a high temperature</u>. The top of the pot has to be sealed to <u>prevent steam from escaping (evaporation)</u> so the steam has to go through the pipe, and the <u>pipe passes through</u> this <u>cold water</u>, as it passes through the cold water it <u>condenses</u> and collected as <u>liquid (pure Ombike)</u>*. (My emphasis)

When the learner was explaining in sequential form, she used her drawing to illustrate how *Ombike* is brewed at home. Using analogies helped learners to master the concepts from two worldviews and made science relevant to the learners' home science. Analogies used brought science from the home of learners where *Ombike* is prepared to science in the classroom. Instead of using the westernised drawing of distillation, teachers requested learners to draw what they knew from home. It was amazing how learners drew their diagrams and presented the process of distillation. These diagrams are from Chemistry textbooks, learners from School A and School B.

Figure 8.3: Illustrates three diagrams for the distillation process from a) a Chemistry textbook b) drawing from a learner at School A c) drawing from a learner at School B

Moreover, instead of explaining the process of distillation in the westernised textbooks, learners presented the topic of distillation concerning to the process of making *Ombike* and teachers when explaining the rate of reactions, gave examples from the factors that affect the *Oshikundu* from becoming ready. The similarities between the apparatus were conclusive that any one of them could be used in place of the others. Both learners and teachers used analogies when presenting the lessons. Using analogies helped learners to explain the processes very clearly by visualising what they had observed or done at home in the westernised classroom setup. The analogies helped other learners engage actively in classroom talk. Adding to this, Shinana (2019) and Nhase (2019) observed teachers using analogies to teach scientific concepts. Henceforth, Naidoo and Vital (2014) illustrated that IK and science can be taught side-by-side in science classrooms without favouring one over the other which learners did when teaching using IK in Chemistry lessons. Curricular saliency is also important during the presentation of concepts. Learners and teachers demonstrated their understanding of curricular saliency and the use of analogies during learners' presentations.

8.5.5 Conceptual teaching strategies

The methods used to teach certain topics depend on the learners' prior everyday knowledge and teachers' PCK on the topics. After deliberating on the first four TSPCK components, we decided to give the learners the chance to present the topic of distillation. The teaching strategies were influenced by LCE that is used in Namibia. Learner-centred pedagogy means a democratic pedagogy that is flexible, where teaching and learning are responsive to the learning needs of individual learners in terms of learning content, methods of instruction used and pacing, and time is given to the learners to construct their knowledge; unlike in teacher-centred education, where teachers do not give time to the learners to re-contextualise what they are taught (Nyambe, 2008). The policy for LCE by the NIED (1999, p. 5) defined LCE:

> *This means that activities which put the learner at the centre of teaching and learning must begin by using or finding out the learners' existing knowledge, skills and understanding of the topic. The teacher is responsible for developing different activities to find out what the learners already know about the topic. Then teachers develop more activities that build on and extend the learners' knowledge.* (My emphasis)

Learner-centred education (LCE) advocates for learners to be the centre of every activity happening in the classroom for them to be engaged in the lessons. I observed that during the lessons, the learners were engaged, and the teachers' role was just to give a chance to the learners to present the lessons and clarify any misconceptions. The lessons started from learners' existing knowledge and the lessons presented by the learners were based on science understanding from home on the practical activity of making *Ombike*. Learners explained the processes and involved other learners through questions and answers.

According to Chisholm and Leyendecker (2008), LCE is faithful to the way the mind works. Its main tenets are:

- Knowledge is not transmitted; it is constructed in the mind of the learner. Learning is a mentally active process and learning results from personal interpretation of knowledge.
- Learning is a process in which meaning is developed based on prior everyday knowledge and experience. Prior everyday knowledge and experience are determined by culture and social contexts. In these contexts, aspects of the experience that the learners have had can be referred to as local/traditional knowledge (IK).
- Language influences culture and thinking and are central to learning and the development of higher cognitive processes (Chisholm & Leyendecker, 2008, p. 197).

These key features of LCE were integrated into teachers' decisions to give learners the chance to present the lesson on the topic of distillation, influenced by the five components of TSPCK and LCE. The topic presented by learners was relevant to them and they are involved in the daily activities that they do and observe when at home. Chemistry teachers were made aware of the five TSPCK components (learners' prior knowledge, curricular saliency, what is difficult to understand, presentation and analogies, and conceptual teaching strategies) that influenced us during co-developing exemplar lesson plans to allow the topic to be taught by learners. It was manifest that the strategies we opted for worked wonders as learners presented the distillation topic. The integration of LCE with analogies helped the learners progressively present the topic as required by curricular saliency. Additionally, the use of the local language gave the freedom to learners to unearth the concepts that are embedded in the process of making *Ombike*. The total engagement was observed as teachers encouraged learners to use the local language.

8.6 PLCs and ECMs Leveraging the Integration of IK

After observing the four lessons that were taught by Michael and Shipefi 16, I came to realise that the PLCs and EMCs helped teachers to be able to become cultural knowledge brokers (Aikenhead & Jegede, 1999; Cooper et al., 1999; Meyer, 2010; Wyatt et al., 2017). Through the PLCs, the Chemistry teachers were able to learn from each other on how to transverse learners between their lived experiences and Chemistry taught in schools. The use of *Oshikundu* was the best example that allowed teachers and learners to cross borders between the two knowledge systems that are disjointed (Aikenead & Jegede, 1999).

Similarly, during co-curriculum analysis documents, the Chemistry teachers were involved in determining how certain topics could be taught using IK. This was reflected during the lessons when learners were given the opportunity to present the lessons on fractional distillations at both schools. Both PLCs and ECMs enabled the Chemistry teachers to guide learners on what examples were relevant to the topics. The results revealed that a peer-learning community and ECMs are important in helping science teachers to work amongst themselves and the indigenous elders on learning and teaching Chemistry. This reflects that PLCs are a cornerstone when working with indigenous elders for the implementation of IK integration to be realized. The Chemistry teachers involved in this study lacked some of the terminologies from indigenous knowledge system. Working with indigenous elders helped them to learn and be able to become cultural knowledge brokers (Aikenhead & Jegede, 1999; Cooper et al., 1999; Meyer, 2010; Wyatt et al., 2017). PLCs empowered the Chemistry teachers and were thus transformed during the practical demonstrations on how the integration of IK could be done in classrooms. The empowerment was the result of teachers engaged in peer-learning community and the practical activities they were engaged with the EMCs.

8.7 Findings that Emerged from Co-developing Exemplar Lesson Plans, Lesson Observations, and Stimulated Recall Interviews

The data generated from the workshop on the five components of TSPCK on how to plan lessons based on them, co-develop exemplar lessons, lesson observations, and SRIs were analysed using PCK and SCT, that is, with TSPCK and constructs of SCT as analytical tools. Two themes emerged from the data (Appendix T, Table 5).

8.7.1 Indigenous knowledge brings about the active engagement of learners

The LCE policy in Namibia requires learners to be at the centre of classroom talk. The integration of IK into science lessons allows learners to contextualise their knowledge and engage in classroom talk. The introduction of IK into science classrooms might engage learners and make science more relevant to them in culturally diverse classrooms (Cronje et al., 2015). Simasiku (2016) showed that when teachers integrate the IK of learners into science lessons, it brings about the participation of learners. The participation of learners increased when teachers used IK practices to engage learners in science lessons. As highlighted by Nikodemus (2017) in his research, it also resulted in active participation and understanding due to the contextualisation of classroom science concepts, through the integration of IK. Furthermore, the intervention encouraged learners to respect their culture and ways of doing things (indigenous practices). Ogunniyi (2007b) posited that learners must, therefore, be able to negotiate the meaning between the two distinct worldviews.

However, as posited by Le Grange (2007), the main idea is to integrate WS and IK systems to invite active participation and engagement for effective learning to take place in the classroom. It was observed in lesson 1 at School A, two learners were given the chance to explain how *Ombike* was made using the diagram they drew in the classroom. These diagrams looked almost the same as the ones in the textbooks, the functions of labelled parts, showing how they knew that [23]*Omachacha* was coming out. When observing the smoke coming out of the pipe, where drops of *Ombike* were falling, learners also observed indigenous people changing the water in the *Okatemba* as the condensation process must not take place completely. The smoke out of the pipe is an indication that *Ombike* is wasted, and indigenous people will quickly change the water. Learners were confident in explaining the process as they were familiar with making *Ombike* and the classroom was actively engaged. Learners helped other learners to explain the process and contextualise Chemistry.

At School B, lesson 1, three different concepts were presented by learners. Distillation was explained by the learners without referring to any local examples; separation of mixtures (solution of salt and water) was scientifically explained and practically demonstrated using locally available materials for the learners to observe how crystals of salts were formed. Interestingly, the lesson ended with linking the first explanation of distillation to how *Ombike* is made. This lesson engaged most of the learners as they responded to the questions posed by the learner-teacher. Learners contextualised WS by explaining fractional distillation using locally available materials and artefacts. Through visualisation, learners explained the fractional distillation process in Chemistry

---

[23] *Omachacha* is the diluted *Ombike* that is not strong (alcoholic) that is not for sale and is consumed by the brewer.

textbooks by linking it to the daily process of making *Ombike* (Chapter Six, Figure 6.1), happening in the local communities of which learners are part. Roschelle (1995) called for IK to go through three steps before being introduced in science classrooms, to clear the misconceptions that are attached to it. The topics needed to be contextualise-prioritise-refine (C-P-R) before the concepts are integrated into science (Roschelle, 1995).

Chemistry teachers re-contextualised the topics during the workshops and practical demonstrations that helped them to understand the concepts and clear up the misconceptions. For example, the topic of distillation was prioritised by the teachers as it has scientific explanations that are involved in the process of making *Ombike* and learners presented the lessons in such a way that they engaged other learners. Refining allowed the learner-teacher to know the concepts that might confuse other learners and these concepts were explained using IK and later using WS.

In lesson 2 at both schools, the factors that affect the rate of reactions. The pressure was not explained well by the Chemistry teachers and Shipefi 16's L2SB omitted the concepts because he could not link them to any IK that was familiar to the learners. Chemistry teachers could not re-contextualise the concepts from IK that could be used to explain pressure. Thus, they opted to omit the concept or teach it using WS only, as Michael indicated that it was difficult to link pressure to IK. Pressure could be explained using an understanding of a bottle of *Oshikundu*. When indigenous people put *Oshikundu* in a bottle where the lid is not tightly closed, they allow the CO_2 produced during fermentation to escape. If the bottle is tightly closed, the gas (CO_2) cannot escape and that can lead to the bottle bursting. Air pressure can cause the bottle or container to burst. The other example could be (see Chapter Seven, Section 7.9) when we placed balloons on the bottles to collect the gases produced when we came to find that one of the balloons had burst due to the high pressure. In the Zambezi, pressure could be taught using flowing water as explained by Mukwambo (2017) in his study. Regarding the IK of indigenous people, for example, people cross the Zambezi River where it is wide, knowing that the pressure is less and the water is not spinning, unlike in the narrow areas. In Chapter Six, Ndeshi warned other participants that some concepts cannot be linked to IK and needs to be taught the way they appear in the textbooks (WS). Contextualise-prioritise-refine (C-P-R) (Roschelle, 1995) was observed in both lessons presented by the learners and teachers to explain the concepts.

When teachers scaffold learners from the known to the unknown (Kuhlane, 2011), they need to be aware of the conflict IK could bring to the minds of learners and guided them in the right direction. Millar (2009) emphasised that it is important to make these connections in science classrooms and then learning is more likely to be successful. When these links are made explicit, learning through social environments supports development in the way that, what can be done collaboratively will be accomplished independently at a later stage. Thus, PLCs of teachers on the integration of IK and WS need to be given more attention and promoted by institutions of higher learning. Learners talked from their hearts when something familiar to their experiences unfolded in the science classrooms. It was observed that learners' classroom talk improved when teachers taught the topic of acids and bases by using IK practices on substances that are sour and bitter found in learners' homes (Kambeyo, 2012). The use of *Oshikundu* in science lessons as an acid allowed learners to find an explanation for how it tastes when drinking it. "When learners bring to the classroom what they already know, and are acknowledged as knowers, the classroom becomes an interactive environment for knowledge production which engages both the learners and the teacher" (Kreisler & Semali, 2001, p. 12). The construction of understanding and meaning is a complex process that involves:

- Bringing each learner's prior knowledge and experiences to the subject area;
- Actively participating in learning experiences that challenge, elaborate on, and revise the learners' ideas and thinking, thus expanding or redesigning their knowledge;
- Teaching by guiding the students to question, ponder, discuss, and reach conclusions; and
- Teaching by providing a fair, open, honest, and supportive learning environment (Kreisler & Semali, 2001, p. 11).

The goal of integrating IK is to foster new conceptions of knowledge, both international and indigenous, as well as to establish a basis for lifelong science learning. That will be informed by educational practices that enable learners to be constructors of their knowledge with the help and guidance of teachers (Spork, 1992). During the discussions, the teachers and learners contributed their knowledge expertise, examining ways to connect what they knew with their IK. In his lesson reflection, Michael reflected that "*due to the integration of different indigenous knowledge, learners were fully engaged, and the class was actively engaged through class activities that were* *done in the class that was excellent*". The teacher showed that learners were actively engaged, not only in-class activities but throughout the lessons when they explained the scientific processes involved in the making of the *Ombike*. Presenting the lessons using analogies improved learner participation and provoked their thoughts about indigenous science happening at home. This provocation resulted in the emergence of equipollent conception.

An equipollent conception occurs when two competing ideas or worldviews tend to co-exist in the mind of the learners resulting in a conflict and the teacher needs to avoid this conflict (Dziva, Mpofu & Kusure, 2011). Ogunniyi (2007a) illustrates that the equipollent cognitive state occurs when two competing ideas from two worldviews, IK and science worldviews have comparably equal intellectual force intensively, and the ideas tend to co-exist without necessarily resulting in a conflict. Learners are always having IK or prior everyday knowledge that might antagonize western science in the mind of the learners. Learners presented their minds out when given the chance to explain how *Ombike* was made, similarly to fractional distillation. The artefacts used by indigenous people and the WS are similar and the teacher used analogies when teaching the concepts.

Teachers that are trained on the integration of IK with WS are able to control the classroom talk in their science lessons and balance the two worldviews without them competing. After the workshops with participating teachers and the practical demonstration that was attended, teachers were confident when integrating IK in science classrooms and the use of local language was prominent. Similarly, I observed that learners who were given the chance to present the lesson were confident because they knew the content (knowledge) from home, and they used local language where WS or concepts was not known. For example, teaching the scientific perspective that lighting is caused by the discharge of electricity between clouds or from a cloud to the earth conflicts with learners' cultural beliefs that lighting is caused by witchcraft (Le Grange, 2007). Science teachers need to become cultural knowledge brokers in order to avoid cognitive dissonance (Le Grange, 2007). Without the strong bridge where learners are allowed to traverse between their lived world and the science world, it might be difficult to convince them about scientific facts. When teaching these topics to learners who are well equipped with their cultural heritage, it will bring about classroom talk. Classroom talk is enacted very well in the SCT when teachers use IK in science classrooms. Abah et al. (2015) state that:

> For the African learners to learn with meaningful practical application within their communities, there is need to extend science teaching in Africa beyond the current practice of 'transmission and indoctrination' to facilitating subject matter learning through integration of the learners' indigenous knowledge system in order to transform the subject matter knowledge into comprehensible form that the learners can grasp and apply (p. 669).

Teaching science with the help of indigenous people, allowed the use of indigenous language where IK is mostly embedded. A CoP intends to help teachers to work together and incorporate community members that are well knowledgeable in certain IKP that have scientific concepts in them in the classroom situation. The teacher and learners will be the translator of concepts from their indigenous language into scientific concepts. Certain scientific concepts can be best understood by the learners and the meaning can be easily contextualised within the learners' minds when the scientific concepts are translated into an IK using indigenous language (Abah et al., 2015). Progression in learners understanding was observed when learners explained the fractional distillation and engagement that resulted from the use of local language. Learners acted professionally, and they had enough knowledge to explain the concepts using analogies.

The observation made on the topics/concepts that did not integrate IK, for example, pressure, and the use of a traditional teaching method (teacher-centred education) where the teachers are regarded as the source of knowledge without considering learners as the pillar of knowledge construction, can make learners' learning ineffective in science classrooms. Deslauriers et al. (2011) figured out that the use of the traditional teaching approach remains the prevailing method for teaching science at the post-secondary level, although several studies indicate that other instructional approaches are more effective. In comparison, two classes taught using traditional approaches (teacher-centred education) and an interactive learning style (LCE) were observed, and the results showed that learners being taught using an interactive learning style showed improvement in learning, more than learners taught in traditional approaches (Deslauriers et al., 2011). Classroom talk is the key when IK is integrated into science lessons. Contextualising science calls for the education system to transform LCE into transformative for the teachers to be able to explicitly understand the integration of IK in Chemistry teaching. Nevertheless, in both lessons, schools A and B learners were engaged, and their thoughts were stimulated on how WS could be related to the activities that happen in the local communities. Learners were not shy to explain WS concepts using IK. This made the lesson interesting and classroom talk improved as learners were willing to explain how homemade fractional distillation apparatus works similarly to the ones in the Chemistry textbooks.

Hence, both teachers summarised the topics by emphasising the importance of learning from what learners know and linking it to WS, from known to unknown using artefacts from IK and knowledge gained from the local community. Science is embedded in cultural practices that local people do daily, for example, explaining distillation using homemade artefacts. I observed that Chemistry teachers were confident when helping learners explain the scientific processes using IK practices to help learners understand the concepts. Michael used the dialogical argumentation instruction (Diwu & Ogunniyi, 2012) approach to make the lessons more interesting by allowing learners to ask questions and challenge the WS or challenge the IK and reach a consensus. This argumentation addresses the barriers that hinder the integration of IK in science classrooms (Kaya, 2013). In the same vein, Matemba and Lilemba (2015) indicated that using traditional activities such as [24]*kanamundame* and [25]*mulabalaba* enhanced learners' reasoning, logic, numeracy, and mathematical skills (Lilemba, 2009). These traditional activities can help learners engage in classroom talk if used in Mathematics lessons. Similarly, Michael and Shipefi 16 used local artefacts to increase the reasoning and logical thinking of learners during the lessons. From my personal experiences, I learnt counting and multiplication when playing *kanamundame* and *mulabalaba*.

Similarly, learners that have been exposed to the way that *Ombike* and *Oshikundu* are made, acquire indigenous SK that allowed them to explain the processes by visualising how they are done at home. Finally, the processes that occur in brewing *Ombike* are similar to the western brewing of whisky as explained by Utete et al. (2017, p. 79):

- **Malting**: Barley contains starch, and it is this which needs to be converted to simple soluble sugar (glucose). For this to occur, barley must undergo germination like sorghum. Indigenous people use different ingredients that are rich in starch.

---

[24] Kanamundame is a traditional Chess game that is played by two people competing to see who will finish the dice for anoother member. This game involves cognitive thinking, logic and mathematical skills in order to compete with one another. The game is commonly played in Zambezi Region (Former Caprivi region).

[25] Mulabalaba Similarly to Kanamundame, Mulabalaba is also a traditional chess game.

- **Mashing**: Ground down malt is now added to warm water to begin the extraction of soluble sugar.
- **Fermentation**: The yeast is added to the mash and fermentation begins (yeast converts the sugar to alcohol-ethanol).
- **Distillation**: Taller still with longer necks will give finer, lighter spirits while shorter and fatter stills produce richer and fuller spirits.
- **Maturation**: The spirit is stored in oak casks. It must mature in the casks for three years before it is legally allowed to be called whisky.

The process above illustrates how whisky is made which is very similar to how *Ombike* is made, even though indigenous people never allow *Ombike* to mature. *Ombike* is consumed immediately after production while whisky is left to mature for three years. Utete et al. (2017) argued that maturation was not allowed in the brewing of *Ombike* as the demand from customers is very high and the sale of *Ombike* is for financial gain to support the family.

8.7.2 Indigenous knowledge improved teachers' conceptual understanding

The integration of IK in Chemistry lessons yielded positive results as both learners and Chemistry teachers were able to present lessons using IK as a bridge to understanding WS concepts. Local concepts are gatekeeping concepts that allowed Chemistry teachers to explain western concepts. The lesson on distillation was presented by learners from both schools. It was evident that learners were knowledgeable about IK that is happening in the community. Learners portrayed that using IK to teach Chemistry concepts enhanced the understanding of other learners and teachers. The use of analogies to explain distillation by the learners allowed them to visualise the processes that happen at home when brewing *Ombike*. It was noted that learners were confident when engaging other learners on the concepts of distillation.

Thus, total engagement was observed in the classroom between learner-learners and teacher-learners. I observed that the learners who were given the chance to present the lessons were confident because they knew the content and the processes that they were presenting to other learners. They had knowledge of the concepts, and they logically presented them without leaving out any processes that occur. When observing learners presenting the lessons, I had to agree with Mukwambo et al. (2014) that learners are loaded with cultural knowledge from home that is useful in science classrooms. Scientific concepts were explained based on their IK understanding and they clearly explained this to other learners. Learners were knowledgeable about scientific processes happening at home that could be used as gatekeeping processes to explain westernised processes. The process of making *Ombike* through distillation was logically explained using the drawings that learners drew which were similar to the ones in the Chemistry textbooks. This helped learners to be confident when presenting the lessons.

The other aspect was the use of the local language. Michael and Shipefi 16 gave the learners the freedom to use the local language. Indigenous knowledge (IK) is embedded in the local language and giving the learners the option to present the topics in their local language allowed them to unearth the science in their cultural practices. The use of the local language helped learners to understand and link the westernised concepts to local concepts. For example, learners were able to see a condenser in the *Okatemba* from its function. Building from their knowledge of the *Okatemba* to explain the function of a condenser allowed learners to understand the concepts better than just teaching about a condenser without referring to the locally used artefacts that work similarly. This was evident, even though learners were given the chance to use the local language, in most cases they explained the processes in the LoLT.

This was influenced by the education system that has opted for English as the LoLT and learners often feel uncomfortable using the local language in the classroom. The dominance of English in science classrooms has allowed WS to be seen as superior to IK. Probyn (2009) indicated that the dominance of English will erode the local language and the culture of learners. The learners who preferred to present the lessons in English still used the local language to explain some concepts which helped the other learners to relate the westernised concepts to the local concepts. Shipefi 16 indicated during the SRI: "*Learners favoured English over the local language, and I kept encouraging them to use the local language during the lessons, but they did not want to use the local language; however, I am happy that most of the concepts were in the local language*". The concepts that Shipefi 16 referred to are the artefacts that are used in making *Ombike*. Adding to this, Sebron alluded that, learners were very knowledgeable on IK as they are always in contact with their parents who brew *Ombike* at their homesteads.

Moreover, Michael and Shipefi 16 presented lesson 2 on factors affecting the rate of reactions. The lesson was more westernised, with fewer examples given to the learners to help them understand the concepts. Teachers visited the ECMs to observe the practical demonstration on the making of *Oshikundu* that was presented by Mee Mukwaluvala and Mee Mukwamhani. The process started with explaining and demonstrating the cultivating of *Mahangu*, the preserving of *Mahangu*, the pounding of *Mahangu* to make flour, and the making the *Oshikundu*. The concepts on the rate of reactions were mostly covered during the practical demonstrations. The factors that affect the rate of reactions, like concentration, temperature, surface area (particle size), and catalyst were covered from the pounding of *Mahangu* until the final product was produced. Even though teachers attended the practical demonstrations, they were not that confident to explain the concepts using the local language and examples that were familiar to the learners from home, even though some learners showed their understanding of some of the factors using IK. Even though the process of pounding was to increase the surface area of the reactants that speed up the rate of reactions, teachers feared confusing the learners. Michael indicated during the SRI that:

> *I was not that confident to explain to them using local examples because I felt I might confuse them, and they might end up writing Ongudo or Ehete during the examination which examiners might not know*.

The mindset of the Chemistry teachers favoured WS over local practical activities that are done daily that learners are part of as evidenced by Michael. Learners struggled to come up with catalysts used at home when making *Oshikundu* when asked by Shipefi 16. At School A, learners understood the concept very well when Michael used the dregs that remain at the bottom of the container of the *Oshikundu*, as the *Ongudo* and *Ehete* that local people used as their catalysts to speed up the reactions. Michael and Shipefi 16 did not emphasise the IK further when learners gave local examples that they knew from home, to help the learners understand the relevance of local concepts to the westernised concepts. Learners were able to explain the concept well, unlike the Chemistry teachers who felt they might be teaching the incorrect content to their learners. It emerged that learners were able to link IK to WS. For example, it was interesting to hear this during lesson 1 at School A:

> Michael: *How do they regulate the water in the Okatemba?*
>
> L15: *They keep removing it when it becomes hot, and they also place the oshilapi (clothes) to circulate the water around in the Okatemba.*

Michael: *Do mean when the water is becoming hot, they remove it and replace it with the cold one?*

Learners: *Yes.*

L19: *I always wanted to ask my grandmother, why they always keep changing the water in Okatemba.*

From IK, learners were able to explain how the water was regulated in the *Okatemba* to make sure that condensation was still taking place. This knowledge could be linked with WS on how the water in the condenser is regulated. L1 at School B explained the function of the condenser in WS since she presented her topic without any reference to IK. She stated: "*The function of the condenser is just to condense the gas/steam to liquid. This is condensation and it is cooling steam to liquid by letting cold water in and warm water out. Coldwater will get in here to cool steam this side; do you understand?*" While L10 (see Figure 8.1) explained the function of the *Okatemba* as condensing the *Ombike* in the pipe that is passing through it as there is cold water in the *Okatemba*. The two explanations did not confuse the learners but harmonised IK and WS. Michael and Shipefi 16 tried to bridge the gap between WS and IK to help learners understand science from local examples.

It was interesting to notice that local people have their thermometers to use when they want to measure the temperature. Michael asked the learners in lesson one, School A the following:

Michael: *How do they know that this is now hot water and needs to be replaced or they to wait until it boils?*

L6: *They use their finger.*

L22: *They use their finger.*

Michael: *Just to check the hotness of that water, yes and also what?*

L9: *When water is hot, they will see steam (smoke) coming out.*

Michael: *The water in the Okatemba they will see the steam coming out.*

L9: *No from the pipe, instead of the liquid dropping out, the steam will start coming out.*

The use of the finger to measure the temperature is commonly used by indigenous people. Learners indicated how the indigenous people used to measure water in the *Okatemba* for them to be able to replace it. From my experience, I used to observe my mother whenever someone was sick, she used to place her finger on the neck of the sick person to feel the temperature. This is similar to the use of the finger to measure the water temperature in the *Okatemba*.

8.8 Chapter Summary

This chapter analysed, interpreted, and discussed the data that emerged from the workshops on the five components of TSPCK, the co-developed exemplar lessons, lesson presentations, and SRIs that were conducted after the lessons. Chemistry teachers learnt how the five components of TSPCK could help them plan an exemplar lesson plan that integrated IK as prior everyday knowledge of learners. They were also able to plan and present the lessons that integrated IK. The PCK of teachers shifted after attending the workshops as revealed in this chapter. Chemistry teachers were also allowed to choose the topics they wanted to teach using IK by building from learners' prior everyday knowledge.

The findings in this chapter reflect the importance of integrating IK as it improved the thinking capacity of learners and helped learners to have a better understanding. It was found that learners were knowledgeable in presenting the concepts that had IK in them. The way that some learners were given the chance to present the lessons, helped them to understand the concepts better than those who just listened to them. The learners need to be given more opportunities to present the lessons to others for them to be able to learn and teach others.

Chemistry teachers need to engage more in PLCs to share ideas on how concepts in Chemistry could be taught using locally available resources and improve their PCK. Learners should not be seen as empty vessels as they have proven that they can present lessons that are locally related better than the teachers who feared confusing them.

CHAPTER NINE: REFLECTIVE SPACE

> Reflection in the context of learning is a generic term for those intellectual and affective activities in which individuals engage to explore their experiences to lead to new understandings and appreciations and reflection is portrayed as an individual activity leading to an enhanced mental or affective state of that person. (Chikamori et al., 2013, p. 15)

9.1 Introduction

This chapter addresses the intervention after all six research phases were completed. The last phase of this study focused on reflecting and developing mind maps and concept maps using concepts that emerged during the practical demonstrations and participatory observation and also from other workshops. The aim of this phase, therefore, was to reflect on the research process that took six months and it sought to address the research question 5:

> *How do discussions and group reflections in the peer-learning community influence (or not) Grade 10 Chemistry teachers' understanding of integrating IK from the ECMs in facilitating teaching and learning?*

The reflective space was necessary to allow the participants to share their experiences and reflect on what went well and those aspects that needed to be improved. Likewise, it also allowed me to reflect and enjoy the final moments with the participants who were actively engaged throughout this research process.

As reflected in the epigraph, reflection enhanced the participants' intellectual capacity and engaged them to explore their experiences which led to further understanding. The chapter covers participants' reflections on the new knowledge gained during the research process. I present the mind maps and concepts map that came from the collaboration with Michael, Sebron, Ndeshi, Shipefi 16, and Tala.

9.2 Data from Mind Maps and Concept Maps that Emerged from the Reflective Space

The reflective workshop allowed the teachers to come up with some mind maps on the concepts that emerged during practical demonstrations and participatory observation. During this process, some scientific concepts were presented by ECMs that allowed Chemistry teachers to write them down during the reflective space. The Chemistry teachers were divided into two groups of two and three. Group 1 consisted of Sebron and Shipefi 16 and group 2 consisted of Michael, Ndeshi, and Tala.

All group members were involved during this activity and two mind maps were produced. The two mind maps looked similar with similar concepts from both groups. Only one group presented their mind map to avoid repeating the same things that were already presented. The concepts that emerged from the workshops, practical demonstrations, and participatory observation revealed that the Chemistry teachers were knowledgeable and had learnt something new. This coheres with Shinana (2019), who indicated that the identification of science concepts from workshops and practical demonstrations can help teachers to teach science.

Throughout the collaboration, the Chemistry teachers helped each other to understand the concepts that emerged during the research process. Similarly to Nhase's (2019) study conducted in South Africa, social interactions took place during a reflective space workshop and the Chemistry teachers interacted to learn from each other and acquire new knowledge. Through social interactions and collaboration, the Chemistry teachers came up with mind maps developed from the concepts acquired from the workshops. Mensah (2011) argued that collaboration helps group members value the inputs from other teachers when brainstorming as a group; in this study, it helped them with what they needed to write on the mind maps. It could be argued that the concepts were developed because the language used during the practical demonstrations allowed the ECMs to express themselves freely without feeling intimidated by the use of the LoLT. The interactions that took place during the workshops and practical demonstrations allowed teachers to conceptualise different concepts that were used.

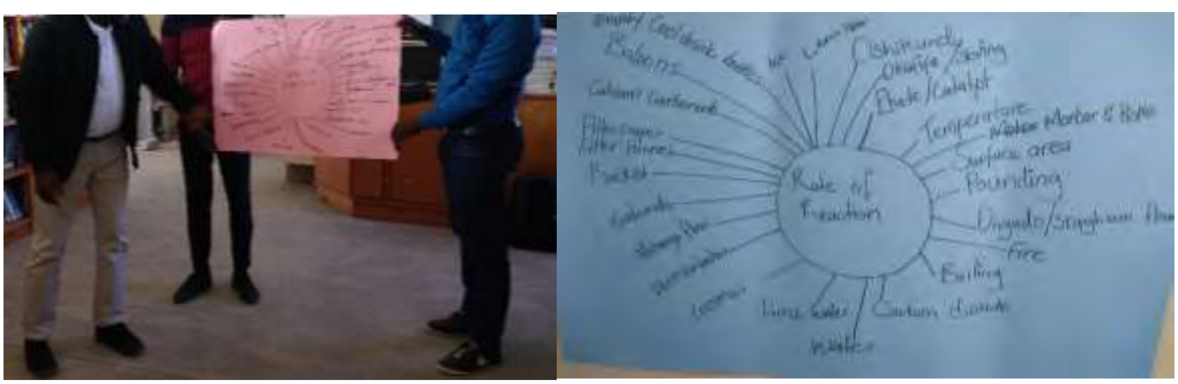
The indigenous language (*Oshikwanyama*) used during practical demonstrations was evident in the mind maps as some of the concepts were in English and *Oshikwanyama*. For example, *Okufifa*/sieving, *Ongudo*/sorghum flour and the catalyst/*Ehete.* The concepts were used by the ECMs during their presentations and teachers were intellectualising and visualising the concepts in their minds and linking it to WS concepts. In Chapter Seven, I indicated that concepts that emerged during practical demonstrations were not translated to English by the Chemistry teachers, fearing that they might confuse the ECMs. For instance, when the concept of enzymes emerged, participants conceptualised it and reflected later after the demonstrations were done. The teachers could not translate the concept of enzymes/*Oitungifi* on the mind maps. The concept might have been forgotten by teachers because it just emerged at one stage during the practical demonstrations.

Vygotsky (1978) explained that the social interactions that occur in social settings have a potential to help teachers to learn from each other and the ECMs. The SMK of Chemistry teachers improved through using mind maps as teachers argued and reached consensus on different concepts that emerged and how to integrate them into Chemistry teaching. For example the teachers could not distinguish the difference between hot and warm water to be used when making *Oshikundu*. Since they did not know how hot the water was, they agreed to use luke-warm water that could be tested using the finger. In support of this, Rollnick et al. (2008) affirmed that when teachers have sound SMK, they will be in a position to integrate learners' prior everyday knowledge into the concepts being taught.

Indigenous knowledge (IK) of learners helps teachers to build from what is known and explain the westernised concepts. In this regard, Mavhunga and Rollnick (2013) postulated that teachers' conceptual understanding helps them to mediate learning of Chemistry topic, for example, chemical equilibrium in their study. Using the five components of TSPCK, the Chemistry teachers showed an improvement in understanding how certain concepts could be introduced in the lessons. During the co-development of exemplar lessons, Michael, Sebron and Tala argued about the best methods they could use to introduce the lesson of purification to the learners. They suggested started by mixing *Mahangu* and beans and letting the learners explain the methods used to separate the two. Shipefi 16 asked "*Is it possible to allow learners to come up with the mind maps during the lesson?*" In her response, Ndeshi indicated that "*it is possible for them to come up with the mind maps*". Michael indicated that "*I will be allowing learners to come up with mind maps after the lessons*". The concept map resonated very well with what Mavhunga and Rollnick (2013) introduced as curricular saliency. Ndeshi presented the concept map by linking the concepts in sequential order by starting with the concepts that were related to the rate of reactions. Ndeshi elaborated that:

> *Under rate of reactions, since we used Oshikundu is directly connected to the rate of reactions. Under Oshikundu there are so many braches that are going out. The first one I will start with as a major is pounding where we used pestle and mortar, the arrows that are connecting mortar and pestle are those one (pointing at the arrows). The purpose of pounding with pestle was to make small particles, to increase rate of reactions during making Oshikundu. Ongudo is also connected to Oshikundu as the catalyst. Where is my surface area on this concept map, we were supposed to have it here, because we were supposed to connect pounding with surface area. We have Mahangu flour and Ongudo, then we come to mixture. Oshikundu as it is connected here, is mixture of Mahangu flour, Ongudo from sorghum and water. Initially we use warm water, then we add cold water at the later stage.*

Ndeshi's explanation above when presenting the concept map revealed that she presented the concepts in a certain sequence (curricular saliency) and could find the concepts that were missing on the concept map and other concepts that were not connected to each other. Figure 9.1 illustrates how Chemistry teachers connected the concepts to each other. Concepts emerged one after the other in sequential form and that helped the Chemistry teachers to connect the mind maps to the practical demonstrations as they added making *Oshikundu* to teach rate of reactions. *Oshikundu* was relevant to be used to teach the factors affecting the rate of reactions as it involves almost all the factors under this topic. The mind maps below illustrate the concepts from the topic on the rate of reactions. Some of the concepts could be explained very well in Biology/Life Science.



Group 1 **Group 2**

Figure 9.1: Mind maps from groups 1 & 2 on the rate of reactions

Group 1 presented their mind map and Sebron clarified how concepts were put together on the mind map. Sebron presented the concepts in sequential form by linking concepts that were relevant. I observed that even though the concepts were not written in a chronological order, he tried to present them in sequential form. Table 9.1 below clarifies the concepts that emerged from group 1 (Sebron and Shipefi 16) and group 2 (Michael, Ndeshi, and Tala).

Table 9.1: Mind maps concepts on the rates of reactions

Group 1 concepts		**Group 2 concepts**	
Oshikundu	*Ongalo/Okufifa/Sieve*	*Oshikundu*	*Enzymes*
Cold water	*Catalyst/Ehete*	*Okufifa/sieving*	*Fermentation*
Temperature	*Empty cool drink bottle*	*Ehete/ Catalyst*	*Mahangu flour*
Mahangu meal/flour	*Beaker*	*Temperature*	*Omhindo*
Fire	*Buckets*	*Mortar & Pestle*	*Bucket*
Pot/container	*Pounding/particle size*	*Surface Area*	*Filter funnel*
Mortar	*Balloons*	*Pounding*	*Filter paper*
Limewater	*Ongudo/sorghum*	*Ongudo/sorghum flour*	*Calcium Carbonate*
Firewood	*Pestle*	*Fire*	*Balloons*
Stirring/Mixing	*Fermentation*	*Boiling*	*Empty cool drink bottles*
Test tube	*Omhindo*	*Carbon Dioxide*	*Acid*
$CaCO_3$	*Enzymes*	*Water*	*Litmus paper*
Gas released	*Filter paper*	*Lime water*	
A Stirrer			
Warm water			

Table 9.1 shows the major concepts that were highlighted by both groups that could help Chemistry teachers integrate IK into Chemistry teaching of the topic rate of reactions in particular. The concepts were connected to the rate of reactions on making *Oshikundu* to contextualise Chemistry

teaching. Both groups came up with similar concepts that showed that they learnt those concepts during the practical demonstrations and participatory observation. By doing this, it allowed them to reflect and visualise the processes during the teaching of the rate of reactions. However, even though both groups came up with the major concepts that could be used to teach the rate of reactions, there were some discrepancies in how some of the concepts were mentioned. For example, in group 2 they indicated the gas released during fermentation was CO_2, while group 1 could not distinguish the name of the '*gas released*'. Furthermore, group 1 averred that "*cold water"* and "*warm water"* were involved during the practical demonstrations, and group 2 just mentioned "*water*" without specifying it. A generalisation can confuse learners if Chemistry teachers are not explicit about the concepts. The use of general concepts like "*gas released" and "water"* might confuse learners in science classrooms. Thus, the use of correct concepts as observed during the practical demonstrations and participatory observation with ECMs allowed Chemistry teachers to grasp the correct concepts.

After the presentation of the mind maps, the two groups were joined together to come up with a concept map using their mind maps. The concept map demonstrated the understanding of Chemistry teachers on different concepts that are linked or connected and have the same meaning or build on other concepts. Curricular saliency was evident in this activity because Chemistry teachers linked the familiar concepts. Shinana (2019) alluded that concept maps show a good way of sequencing the concepts associated with the rate of reactions, which would allow teachers to understand the concepts. This could be further translated into the lessons where learners have to come up with a concept map to enhance their understanding. The concept map was derived from the topic of the rate of reactions and the making of *Oshikundu* where most of the concepts were generated from and then were interconnected.

Figure 9.2: Ndeshi presenting the concept map created during the reflective space workshop

It was indeed interesting to observe how Ndeshi interpreted the concept map. Ndeshi seemed to show a great understanding of the concepts during her presentation and could identify concepts that were not linked or omitted in the concept map. This was great because the concepts were well presented during the practical demonstrations using a local language that helped Chemistry teachers understand the relevance of the concepts. This was done when Chemistry teachers were joining concepts to come up with the concept map. They understood the concepts from both the IK and WS perspectives and understood how the concepts could be joined with each other. For example, the rate of reactions was used to explain the making of *Oshikundu*; the gas that was released was tested with lime water that was made from $CaCO_3$ and distilled water and filtered using filter paper. The gas released was bubbled in lime water and it turned the lime water milky, which meant that the gas released was CO_2.

The PEEOE approach (Shinana et al., 2021) was used during day 2 as Chemistry teachers used a hands-on, minds-on and words-on approach when the experiment was conducted (Asheela et al., 2021). They experimented and while busy with it they engaged each other for further explanations that allowed them to come to logical conclusions. As was noted by Sebron in his journal: "*I have come to know that the gas released from Oshikundu is carbon dioxide; this was proven when the gas was bubbled in the limewater and turned milky*". To support this, Shipefi 16 wrote in his journal: "*To add to that I got to learn that the gas released from Oshikundu during fermentation is Carbon Dioxide. This was proven when the gas formed was bubbled through $Ca(OH)_2$ and the lime water turned milky"*. The two teachers showed that they learnt from the making of *Oshikundu* that was prepared by Mee Mukwaluvala and Mee Mukwamhani and additionally, from the collection of gas in the balloon and later the testing of the gas released when it was bubbled in Calcium Hydroxide ($Ca(OH)_2$) done by the teachers

All the concepts presented in the concept map were used during the practical demonstrations with the further understanding gained during the workshops. Most of the concepts were in a local language and Chemistry teachers translated them into English because they were influenced by the LoLT. This outlines that, teachers were biased against the local language and preferred to use English. The only concept that was not translated to science language was *Omhindo* (Chapter Seven, Figure 7.12). The concept was not readily available in science language for science teachers to translate. Chemistry teachers could not hide the use of English, even though the concepts emerged when the local language was used. Local language has some shortfalls as some of the concepts are not readily available in the language. One such concept is Calcium Hydroxide ($Ca(OH)_2$) which was referred to as *Oshima* (thing) or *Omeva* (water) and Calcium Carbonate ($CaCO_3$); Chemistry teachers could not translate these into the local language. This is exemplified in Chapter Seven, Section 7.9.2. These two concepts are WS, and Chemistry teachers could not find the concepts in the local language to use. The use of both languages in science classrooms will help Chemistry teachers integrate both IK and WS in science classrooms. The use of local languages will help teachers and learners understand the concepts better and interact more with each other.

9.3 Findings that Emerged from the Reflective Space

Similarly to Nhase's (2019) study, data from the reflective space were analysed and two themes emerged. The themes that emerged from the data generated during mind maps and concept maps are discussed below (see Appendix T, Table 5).

9.3.1 Mind maps and a concept map enhanced understanding of Chemistry teachers

The mind maps and concept map helped Chemistry teachers to conceptualise the concepts that emerged during the practical demonstrations and workshops. During the reflective space workshop, Chemistry teachers conceptualised each concept that emerged for further understanding. It emerged that teachers were analysing the misconceptions that come with IK to make it clearer and more understandable to other teachers (Mukwambo et al., 2014). That is, misconceptions that might hinder the understanding of concepts were made clearer by other Chemistry teachers.

Interestingly, Tala asked if it was possible to allow learners to come up with mind maps and concept maps after each lesson. In her response, Ndeshi highlighted that it would be possible to let the learners come up with their mind maps and later develop them into concept maps that would help them learn the concepts that emerged during the lessons. Adding to this, Shipefi 16 indicated that it would help learners to concentrate during the lessons and they should do it in groups so that they can share knowledge, just like what they were doing now. Even though this seemed possible, Sebron argued that there would probably not be enough time in the lessons to complete the maps.

In the context of this study, mind maps and the concept map changed the way Chemistry teachers viewed the form of teaching and learning that they use to present their lessons. Regarding the exercise of coming up with mind maps and the concept map, Chemistry teachers were afforded an opportunity to discuss and learn and in return, that improved their SMK and enhanced their TSPCK (Mavhunga & Rollnick, 2013). The Chemistry teachers were able to reflect on what happened during the practical demonstrations and participatory observation with ECMs so that they could come up with the concepts that emerged. It helped them to link WS with IK during the development of mind and concept maps. Reflection essentially became part of connecting and re-connecting WS and IK. Vygotsky's (1978) SCT and Shulman's (1986) PCK were very helpful during the reflective space workshops. The interactions between teachers helped them to be able to explain the concepts from both worldviews (indigenous and western).

Vygotsky's (1978) SCT allowed teachers to interact in a social setting and learn with the help of MKOs. The ZPD was observed in that teachers could contextualise the concepts from WS to IK without doubting their ability to do so. The ZPD of the Chemistry teachers was assisted by the use of a local language when teachers struggled to explain the concepts in English. The room created by participants during the reflective workshop allowed them to engage, contextualise, and reflect on the knowledge they gained and the concepts that were learnt.

Challenging the status quo provoked Chemistry teachers to learn new knowledge that was unearthed in local communities. The use of the making of *Oshikundu* challenged the dominance of using hydrochloric acid reacting with marble chips or powder to explain particle size/surface area as a factor affecting the rate of reactions. Using *Mahangu* flour is similar to the use of powder that increases the surface area which makes the reaction speed up. Teachers are challenged and have to implement a curriculum that does not specify which IK is to be integrated into the science lessons. This research found that teachers have to use their life experiences when teaching certain topics that include IK. Engaging other Chemistry teachers at school could help them to come up with easily accessible materials (Asheela et al., 2021) that could help them learn new concepts and pedagogical strategies before going to the classroom.

The presentation of mind maps and a concept map helped the teachers to further understand the concepts that emerged from the ECMs' practical demonstrations. The understanding of concepts was helped by their involvement in PLCs and CoPs at their schools and on the way to and from the workshops centre and house of the ECM. For example, Shipefi 16 reflected:

> *The interaction with the community members helped me to understand that there are steps to follow when preparing Oshikundu and it really tells us that adults in our communities when we engage with them in science education, will make us understand better the reactions involved in Oshikundu making, rather than using Western knowledge from the textbooks. This tells us that science starts at home, and it is very important for teachers to make learners aware of using this knowledge from real-life experiences that they have from home.* (My emphasis)

As reflected in the excerpt above, engaging community members in practical demonstrations helped teachers to decolonise WS and give them a platform for further discussions. Further discussions helped both teachers and community members to understand the concepts and challenged the misconceptions. The mind and concept maps gave the teachers such a platform to discuss the concepts and understand them from the IK and WS worldviews. A concept map helped the Chemistry teachers to master the TSPCK. In their study, Shinana et al. (2021) revealed that concept maps helped teachers to address the components of TSPCK on the topic of enzymes. Thus, the concept map allowed teachers to contextualise the concepts and how they are interlinked. Concepts on the concept map emerged during the practical demonstrations, observation workshops, and workshops that were done during co-analysing curriculum documents. In this research, the concept map helped the Chemistry teachers to further understand the five components of TSPCK and how each concept that emerged during the research could be used to teach WS on the rate of reactions.

9.3.2 Chemistry teachers gained new PCK

All five Chemistry teachers involved in this research indicated that they learnt new knowledge from the workshops and practical demonstrations done by the ECMs as evidenced in their journals. Their PCK and understanding of the topic that was covered improved. These excerpts from some of the Chemistry teachers' journal reflections evidence this:

> Ndeshi: *Integrating the local knowledge in teaching Chemistry. I now know the Oshikundu part, and it opened up my mind to think about other local practices that may be suitable for Chemistry.*
>
> *Shipefi 16: I have learnt that local knowledge should be used to introduce concepts before we embark upon the scientific knowledge (western knowledge) as this will help learners to see the importance and value of the knowledge used by our forefathers. It is also the duty of every teacher to consider the pre-knowledge of the learners before introducing new concepts and ideas.*

From the two excerpts above, it was evident that the Chemistry teachers learnt new approaches to teaching Chemistry that were not there before and most importantly, how IK could be integrated into science classrooms which would help learners have a better understanding of scientific concepts. For instance, Michael indicated that his Chemistry knowledge moved to the next level that was brought about by the workshops we had together. This was discussed in Chapters Six and Seven when the curriculum documents were analysed, and they participated in practical demonstrations where they explained different concepts using IK and WS to help each other understand the concepts from an indigenous point of view. Seehawer (2018a) deduced that teachers were able to internalise ideas and integrate IK which allowed them to decolonise education from theoretical to practical. IK was found to be more practical than theoretical. Thus, Chemistry teachers in this research were exposed to hands-on practical activities that helped them to acquire new knowledge (Asheela et al., 2021; Mavuru & Dudu, 2021). The use of the making of *Oshikundu* to teach the rate of reactions helped teachers to position all concepts by building from learners' prior everyday knowledge and the knowledge they acquired during social interactions with the ECMs.

According to Shulman (1986), PCK focuses on the teaching strategies and the knowledge teachers possess to help learners have a better understanding of a particular topic; in this case, the rate of reactions and distillation that were discussed during workshops and practical demonstrations. Indeed, teachers portrayed enough knowledge and their teaching strategies changed from teachers' talking and learners' listening and responding to the questions. Learners were given the chance to explain the concepts of distillation linking it to the practical activity of making *Ombike* done in their households. Even though the education system in Namibia advocates for learner-centred methods it is only applicable to well-resourced schools in urban areas that are equipped with westernised materials. In lesson 1 at both schools, learners were given the chance to teach other learners the processes involved in making *Ombike*. Chemistry lessons moved from teachers as the centre of knowledge to learners as the centre of knowledge. Learners were able to integrate IK in their explanations which helped other learners to understand the concepts much better. The PCK of learners who presented the lessons improved because they visualised and explained how *Ombike* was brewed. They were able to connect and reconnect IK with WS. Giving the learners the chance to present the topics that were related to their life experiences allowed them to enhance their understanding and SMK.

In lesson two, both lessons at schools A and B were presented by Chemistry teachers. Chemistry teachers were able to relate the WS to IK, something that they seemed not to do before. Observing Chemistry teachers explaining western concepts using local examples reminded me of the ECMs explaining to us during the practical demonstrations on how to make *Oshikundu* using local ingredients and artefacts. Indigenous knowledge (IK) helped teachers to make learners understand the factors that affect the rate of reactions from an IK point of view. The teaching strategies of teachers changed, and they allowed learners to be given local examples that are related to the factors affecting the rate of reactions in Chemistry textbooks and also the indigenous technologies on how *Ombike* is prepared. The comprehensive practical demonstrations and workshops allowed Chemistry teachers to acquire new teaching strategies of allowing the learners' voice to be dominant in the lessons and build from there. The use of IK allowed learners to be more involved in the lessons and they became more vocal. Learners were able to explain the process of making *Ombike* in chronological order, as they were exposed to the activities at home.

Chikamori et al. (2013) posited that reflections can be one of the key elements to improving educational practices. Chemistry teachers were able to deliberate, make choices, and come to decisions (Chikamori et al., 2013) about the methods to use when teaching certain concepts. For example, when fractional distillation was taught, both teachers at schools A and B opted for the learners to present the lesson with the help of the teachers. There are topics that learners are knowledgeable about and it was easy for learners to teach such topics to others in the classroom (see section 8.4.1 & 8.4.3). The SMK of learners who presented the lessons improved and thus, learning should start from what the learners know (MoE, 2018). The PK of teachers shifted from the teachers as the centre of knowledge to learners as knowledgeable in science classrooms. Pedagogical strategies that were used during the lessons revolved around IK pedagogical strategies, where learners used their knowledge gained and observed when interacting with indigenous people to explain concepts surrounding distillation. The knowledge of teaching and learning revolved around learners' experiences and knowledge acquired at home when interacting with community members. Essentially, it is important to realise that teachers with deep PK understand how learners construct knowledge, acquire skills, develop habits of the mind, and have positive dispositions towards learning (Mishra & Koehler, 2006). This was evident when learners were given the chance to present the lessons on distillation because the PK of teachers trusted the learners to be able to present the lessons.

The SMK acquired from the practical demonstrations and workshops allowed teachers to be aware of how certain concepts could be presented to make learners understand them better. The workshops helped teachers to improve their SMK when they were engaged in explaining how the concepts of rate of reactions and distillation could be taught using IK. The lengthy discussions helped other Chemistry teachers to improve their SMK. Analysing the practical demonstrations, teachers' knowledge on the teaching rate of reactions using the making of *Oshikundu* improved and they were able to integrate IK during the lessons to enhance learners' understanding. The use of *Ehete* as the catalyst to teach the rate of reactions worked very well with both learners and teachers. Teachers engaged learners during the lessons and learners could be observed using local examples to explain factors affecting the rate of reactions.

9.4 Findings from Research Participants' Reflections

Chemistry teachers involved in this study reflected on the research process and that helped me to analyse their thoughts and learn from them. Ndeshi alluded, "*I never knew Oshikundu making has so much science in it, I learnt how to integrate our local knowledge in my Chemistry lessons*". The knowledge that was unearthed during the practical demonstrations helped Chemistry teachers to be able to integrate IK from the local environment as is stipulated in the curriculum.

Adding to Ndeshi, Tala further reflected that:

> *I have learnt that as a teacher I should use easily accessible resources to demonstrate and explain new ideas. I have also learnt that a community member can be a good teacher that can be used to explain topics to learners and can explain the importance of IK in science.*

From this excerpt, it seems Tala valued the importance of using community members in the lessons after attending the practical demonstrations on the making of *Oshikundu* that enhanced the conceptual understanding of teachers. He referred to the community members as "*good teachers"* as he witnessed how they presented the topic on the rate of reactions using the making of *Oshikundu*.

This reflection has an affinity with Asheela et al. (2021) who emphasised the importance of using easily accessible resources to do hands-on practical activities. Concurring and extending on Asheela et al.'s (2021) seminal work, Shinana et al. (2021) also reiterated that indigenous technologies such as the making of *Oshikundu* have the potential to be used as authentic resources during science lessons. For instance, Chemistry teachers learnt new pedagogical strategies that could help them to present lessons and integrate IK. The use of IK in Chemistry classrooms will help teachers to reflect on their teaching strategies. Indigenous knowledge (IK) of local people will help teachers to engage learners in their science lessons without fearing the challenges brought about by the use of scientific language and English.

Furthermore, Chemistry teachers were brought to work together as illustrated by Michael: "*general teamwork and cooperation among ourselves*". It is very important for teachers to work as a team by planning together and helping each other come up with learning materials. The planned PCK of teachers generally improved and they started planning together and developing materials that helped them to integrate IK. For example, Shipefi 16 explained that *"I really enjoyed it very much* *since I gained new knowledge when we shared ideas with colleagues (other Chemistry teachers) on different topics more especially on the workshops and the knowledge that I gained from the community members"*. In support of Shipefi 16, Ndeshi explained that *"I learnt that researching does not only benefit the researcher but allows the participants to expand their horizons*". As a master's student herself, she learnt something that helped her work with participants and not only that, her knowledge was also broadened. The teachers benefited from participating in this research, as all of them indicated: "*I learnt".* New knowledge was gained, their pedagogical strategies improved, they valued IK at the same level as WS, they could work as a team (CoP), they engaged ECMs in science lessons and lastly, they could use IK in practical activities. Indigenous knowledge (IK) pedagogical strategies (Mukwambo, 2017) were availed to them in this research.

Apart from the new knowledge, Chemistry teachers exulted to be part of the research and they stated:

> *Shipefi 16: I feel very proud to be part of the research and I am very happy that from the beginning of next year I will be a different teacher from who I am now, and it also taught me how research is being done in case I get admitted at Rhodes University one day.*
>
> Sebron: *I felt very happy as this research process helped me to gain more knowledge and how to integrate IK in the lesson that will enable learners to understand and love the lesson.*
>
> Michael: *I feel blessed to be part of this amazing process it is really improved my knowledge plus the way of presenting lessons*.

The three excerpts from these Chemistry teachers point out that they were blessed to be part of the research, not only about the knowledge gained but also the lifelong learning opportunity for them as they further their studies. Research does not only empower the researcher, but the participants should benefit more than the researcher. Engaging teachers in a peer-learning community helped them to improve their PCK, its components as well as pedagogical strategies. Integration of IK was one of the key ingredients that Chemistry teachers were looking for to improve their pedagogical strategies. A peer-learning community helped them to *"improve their knowledge and lessons presentation strategies"* (Michael). This is in agreement with Chauraya and Brodie (2018) and Tam (2015), that PLCs help teachers improve their instructional clarity, quality of discourse, and interaction with learners. This was evident in Chapter Eight when learners and teachers engaged in the lessons. The three excerpts showed the peer-learning community threads that teachers gained during the research process.

The study helped Chemistry teachers to value the knowledge that the ECMs imparted to them, as it could help them integrate IK into their lessons. It helped Chemistry teachers to view their teaching from both sides of the coin (WS and IK). Both ECMs and Chemistry teachers benefited from this research, not only in that they gained knowledge but by working together and through the interactions that happened during the research. The research was immersed in the Ubuntu paradigm. The ECMs benefited from teaching qualified teachers about the cultural practices that helped them improve their thinking and taught them how to make *Oshikundu*. Even though the research was amazing to the participants, they suggested the following:

> Ndeshi: *I suggest that the researcher gives more time/starts the research process right at the beginning of the growing Mahangu season. There might be also other scientific concepts to be discovered.*
>
> Michael: *The number of participants needs to be increased to get more different views.*
>
> Shipefi 16: *We need to have more Chemistry teachers to know the good part of the research so that it attracts them to join Rhodes University like I did and to know the use of IK.*

Tala was convinced that the research process and the activities that were done were the best and that there was "*nothing to be done differently. I am convinced that this (presentation) project was the best I ever involved*". Tala was confidently convinced that the research project helped him to acquire and learn from other participants how IK should be integrated into Chemistry teaching.

9.5 Chapter Summary

This chapter gave a detailed account of the reflective space that allowed Chemistry teachers to further learn from each other. Reflecting on the research process and developing mind maps and a concept map helped the teachers to be able to learn and further understand how IK could be integrated into Chemistry classrooms in rural schools. I analysed the mind maps that were developed by participants in two groups and the concept map that was developed by all participants using their mind maps. Allowing Chemistry teachers to reflect helped them enhance their conceptual understandings. The social interactions were amazing, and this was enabled by the fact that they could express themselves in any language they felt comfortable with when explaining the concepts. The process of showing the links or connections between concepts created the platform for further explanations of how concepts are linked together, thus, the chapter ended by discussing two themes that emerged from the data. In the next chapter, I provide a summary of my study.

CHAPTER TEN: SUMMARY OF THE FINDINGS, RECOMMENDATIONS, AND CONCLUSIONS

> The relationship between indigenous and conventional methods is thus ambiguous, much indigenous knowledge stems from processes of many years of systematic observation which, though based on different epistemological underpinnings, might not conflict with conventional scientific methods. (Seehawer, 2018a, p. 3)

10.1 Introduction

This chapter compromises the major findings that emerged from Chapters five to nine of the research project. It thus presents the summary of my findings, new knowledge that emerged during the research process, implications to local and broader contexts in the field, recommendations and improvements that need to be done in future, my reflections on the research process, and the conclusion of the chapter. The summary of findings are presented in accordance with my research questions.

10.2 Overview of the Study

This research was conducted at a time when there were calls for the decolonisation of the science curriculum (Mukwambo et al., 2014; Mutanho, 2021; Seehawer, 2021). Essentially, the contextualisation of WS calls for indigenous people to be involved in science teaching. It is against the backdrop that the main goal of my study was to explore the leveraging of PLCs and ECMs in the integration of IK into the learning and teaching of Grade 10 Chemistry on the rate of reactions. This study was guided by the broad overarching research question:

> How does a peer-learning community and expert community members leverage the integration of indigenous knowledge into the learning and teaching of Grade 10 Chemistry on the rate of reactions?

To achieve this goal and broad overarching research question, the following research questions were addressed:

1. What are Grade 10 Chemistry teachers' experiences and pedagogical insights on the use of IK in Chemistry learning and teaching before they were engaged in a peer-learning community and with the ECMs?

2. (a) What lessons can Grade 10 Chemistry teachers learn (or not) in their peer-learning community when co-analysing the Chemistry curriculum documents?

   (b) How do Grade 10 Chemistry teachers interact, participate, and learn (or not) during the ECMs' practical demonstrations and explanations on the preservation and pounding of *Mahangu* and making of *Oshikundu*?

3. How does a peer-learning community enable and/or constrain Grade 10 Chemistry teachers in using the IK from the ECMs on the preservation and pounding of *Mahangu* and making of *Oshikundu* and other indigenous practices to co- develop exemplar Chemistry lessons?

4. How do the Grade 10 Chemistry teachers selected from the peer-learning community mediate learning of the co-developed exemplar lessons in their Chemistry classrooms?

5. How do discussions and group reflections in the peer-learning community influence (or not) Grade 10 Chemistry teachers' understanding of integrating IK from the expert community members?

The study followed seven phases during the data generation process. The first phase was face-to-face semi-structured interviews; the second phase was the orientation workshop; the third phase focused on co-analysing curriculum documents; the fourth phase was the practical demonstrations and participatory observation; the fifth phase was co-developing exemplar lesson plans; the sixth phase was lesson observations and SRIs, and the seventh phase was the reflective space. Data sets that emerged from these aforementioned phases were analysed using concepts from SCT, PCK and TSPCK.

10.3 Summary of the Findings

In the next section, I present the major findings of the study which answered my research questions above.

10.3.1 Findings related to research question 1

Chapter Five presented the findings that answered the research question 1: *What are Grade 10 Chemistry teachers' experiences and pedagogical insights on the use of IK in Chemistry learning and teaching before they were engaged in a peer-learning community and with the ECMs?*

The experiences, and pedagogical insights of the Chemistry teachers were analysed and their views on whether to integrate IK or not in their teaching. The experiences of teachers on the integration of IK in science classrooms were noted during their responses. Three Chemistry teachers involved in this study elaborated on their experiences of integrating IK in Chemistry into different topics. For example, when teaching fermentation in Chemistry, Sebron explained that using IK during lessons enhanced the understanding of learners. The brewing of local alcohol such as (*Tombo, Epwaka, Okatokele, Efau, Omagongo, Omalovu, Ombike, and Chikontini*) and traditional non-alcoholic beverages (*Oshikundu*) undergo fermentation that Chemistry teachers could use to explain the fermentation process. That is, that could afford the Chemistry teachers to use learners' prior everyday knowledge in their lessons as reiterated by Kuhlane (2011). This suggests that Science teachers need to build from learners' life experiences in their lessons or classrooms as that might enable them to have a better understanding of WS (Botha, 2010; Gwekwerere, 2016).

The findings from the three Chemistry teachers were consistent that they have had experiences with integrating IK in their classrooms. This resonates with Kota (2006) who suggested that teachers should feel free to use any resources they find relevant to the lessons they are teaching. Adding to this, Asheela et al. (2021) suggested the use of easily available resources to enhance the conceptual understanding of teachers and learners in science classrooms. The evidence was observed during the semi-structured interviews when Shipefi 16 and Tala explained how they teach distillation using learners' local experiences on making *Ombike*. Their explanations showed the experiences these two teachers had with the use of local artefacts and resources to help learners understand the concepts in their science classrooms. However, two Chemistry teachers were not knowledgeable about integration of IK in Chemistry teaching. It was interesting to keep an eye on Tala and Michael during the other research phases to see if they would have a shift in knowledge.

There were, however, some hindrances highlighted that prevent the full integration of IK in science classrooms, for example, that the textbooks that do not support the integration of IK in science (Shizha, 2007). Moreover, the terminologies are not fully developed in local languages, and this hinders the integration of IK. While there are challenges that hinder the integration of IK, they could be overcome when introducing Chemistry teachers to PLCs who work with ECMs.

Further evidence confirmed that those Chemistry teachers who were qualified seemed to love teaching Chemistry, and this was attested by Michael and Ndeshi as they had majored in Chemistry. These two Chemistry teachers revealed that they enjoyed teaching Chemistry when learners are actively engaged in the classroom. This suggests that learners should be at the centre of classroom discourse.

10.3.2 Findings related to research question 2 (a)

The findings related to research question 2(a) were narrated in Chapter Six of this thesis. The question was: *What lessons can Grade 10 Chemistry teachers learn (or not) in their peer-learning community when co-analysing the Chemistry curriculum documents?*

Five Chemistry teachers and the researcher were engaged in a peer-learning community to co-analyse curriculum documents. Co-analysing curriculum documents helped teachers to understand the concepts and how best they could be taught in science classrooms. As expected, the findings from co-analysing the NCBE (MoE, 2018) revealed that teachers are allowed to start teaching by building on the life experiences of learners (Gwekwerere, 2016). Life experiences of learners comprise the IK that learners acquire from their local environment, community, and parents. This knowledge portrays the activities done in the local environment and learners are part of the communities.

However, some teachers were not aware that the the NCBE allows them to integrate IK into their lessons. For instance, Michael was surprised and said: "*Ooh, yes I see the curriculum is supporting our local knowledge"*. The peer-learning community thus helped the teachers to view the curriculum differently and understand that IK should form part of the science classroom discussion. Without integrating IK to teach some of the concepts that are familiar to learners, it might confuse them as they will view home and school as separate entities resulting in cognitive dissonance (Le Grange, 2007). Neglecting IK might make learners hate what is done at school as it does not link to their environment. Hence, in his study, Webb (2013) suggested that the link between science and culture should be visible in science classrooms.

The Chemistry syllabus also fails to guide teachers on the specific objectives that they should be aware of when using IK. In relation to the textbooks, three Chemistry textbooks were co-analysed.

The rate of reactions was linked to the making of *Oshikundu* and teachers understood the topic from an IK point of view. The three textbooks do not mention or relate any content to IK, but teachers were able to explain the factors affecting the rate of reactions using local examples such as the making of *Oshikundu*.

Lastly, the examiners' reports for Physical Science's previous examination question papers for Grade 12 for the past six (2015-2020) years were co-analysed to see how learners performed and the questions that were used to integrate IK. The findings from all Physical Science question papers seemed to be consistent. For instance, IK was not explicitly clear in the NCBE (MoE, 2018), but teachers were able to explain some questions using the life experiences of learners in answering them.

10.3.3 Findings related to Research Question 2 (b)

After co-analysing the curriculum documents, it was time for us to visit the ECM to understand the cultural activities that could be integrated into science classrooms. Research question 2(b) stated: *How do Grade 10 Chemistry teachers interact, participate, and learn (or not) during the ECMs' practical demonstrations and explanations on the preservation and pounding of Mahangu flour and making of Oshikundu?*

To answer the question, teachers were involved in practical demonstrations and participatory observation. Essentially, tapping into the cultural heritage of community members was the focus of this research to contextualise WS. The practical activities started with ploughing of *Mahangu* and sorghum, harvesting and preservation, and lastly the making of *Oshikundu*. All five Chemistry teachers were actively engaged in all the activities as illustrated in Figures 7.2, 7.3, 7.4, 7.5, & 7.6, meaning that they were interacting with ECMs throughout the research process. It was amazing to see the bond that was formed between the ECMs and the Chemistry teachers during those three days and this is consistent with the Ubuntu perspective (see Section 4.2.2). The interactions were observed as the Chemistry teachers asked questions and engaged in the practical activities that ECMs were doing that helped them to learn. Where their knowledge was not advanced, they asked the ECMs for explanations so that they were able to align it to WS.

As purported by Vygotsky (1978), the social interactions that happened between the ECMs and Chemistry teachers and me were amazing. Most importantly, learning was observed during such social interactions. For instance, taking Chemistry from context to content was evident during practical demonstrations. This was summarised in Figure 4.1 where Chikamori et al.'s (2019) TMESD was adapted to suit the integration of IK. It was interesting to observe how teachers shared knowledge and asked the ECMs questions on the preservation, making of *Mahangu* flour, and preparing of *Oshikundu*. The local language used also played a vital role during the interactions, as the language used was friendly to all participants and the ECMs. That allowed everybody to interact without any threat of being judged based on language.

Throughout my observations, I could see how the teachers participated and interacted with the ECMs that allowed them to acquire new knowledge. Notably, it was Tala and Michael, who had indicated that they were not knowledgeable about IK, who were very active in the practical demonstrations. For instance, Tala asked many questions so that he could understand the relevance of IK to WS.

The practical demonstrations enhanced and motivated the Chemistry teachers to engage and learn from the ECMs. Ahbar's (2012) findings supported the findings in this research that practical activities stimulate excitement to think critically. Teachers were able to visualise the processes that were occurring and link them to what was documented in the Chemistry textbooks, which allowed them to contextualise their thinking.

10.3.4 Findings related to research questions 3 and 4

This section presents the findings that answered research questions 3 and 4. Chapter Eight explored the co-development of exemplar lessons, lesson observations, and SRIs. Before co-developing the exemplar lesson, a refresher workshop on TSPCK was done to ensure that all the Chemistry teachers were familiar with it. The research questions answered in Chapter Eight are: *How does a peer-learning community enable and/or constrain Grade 10 Chemistry teachers in using the IK from the ECMs on the preservation and pounding of Mahangu and making of Oshikundu and other indigenous practices to co-develop exemplar Chemistry lessons? How do the Grade 10 Chemistry teachers selected from the peer-learning community mediate learning of the co-developed exemplar lessons in their Chemistry classrooms?*

The ECMs were the custodians of IK during the practical demonstrations that had the process that could be explained to the learners in the science classroom. The ECMs became confident when explaining to the Chemistry teachers the processes involved in making *Oshikundu*. The social interactions with teachers improved as they had not been accorded such an opportunity to work with other teachers in their lifetime. In this regard, the peer-learning community helped the Chemistry teachers to discuss and choose the topics that could be taught using IK. Before being engaged in the peer-learning community, two Chemistry teachers perceived that IK was not useful in school science. After the practical demonstrations, however, they indicated that they were willing to explain it to the learners.

The findings further confirmed that the Chemistry teachers' understanding on the integration of IK improved. They were given the option to choose the topic that was relevant to them using IK. Using the knowledge gained during practical demonstrations, teachers chose distillation which was not part of the practical demonstrations. This was a surprise to me because teachers from the same school were in one group, far from the other group but they both chose distillation.

The co-development of exemplar lessons helped the Chemistry teachers to evaluate their way of teaching Chemistry when integrating IK. This revealed that ePCK for planning allowed Chemistry teachers to plan the lessons based on five components of TSPCK by building from learners' life experiences (Gwekwerere, 2016) on the topic of rate of reactions. It was also noted during the discussions that teachers were willing to involve the community members in teaching distillation, but time was limited to do so as the practical demonstration could take between one to two weeks. This meant teachers had to teach the lessons to learners and were given the opportunity to explain the process of distillation by drawing the artefacts used by indigenous people.

It also emerged that the drawings from schools A and B were similar to the conventional apparatus from Chemistry textbooks (see Figure 8.1). Even though the co-developed exemplar lessons did not portray all knowledge components required, the five components of TSPCK as presented (see Appendix Q, Tables 1 & 2) were displayed during the lessons. The Chemistry teachers were able to internalise them and use them during their lesson presentations. The findings from lesson observations were in line with Mukwambo et al.'s (2014) study that learners are loaded with science knowledge even before starting to learn school science. This was proven when the

Chemistry teachers at schools A and B gave learners the chance to present the topic of distillation. The presentations from learners were similar as if they were trained to present the lessons similarly. The use of analogies helped them to explain the lesson sequentially. Learners were afforded an opportunity to observe the making of *Ombike* and *Oshikundu* which helped them to learn and master the knowledge based on those activities. For the learners who presented the lessons, their PK and SMK improved, and they had a better understanding of the distillation concepts.

After analysing the lessons using the five components of TSPCK, it was found that learners and teachers were able to integrate them into their lessons. Mavhunga and Rollnick (2013) and Mavhunga et al. (2016) advocated for the use of the five components of TSPCK to help teachers align the contents they are teaching to IK that learners are familiar with at home. This was consistent with the results of the four lessons observed in the two schools. The peer-learning community helped the participants to understand how the five components of TSPCK were useful in teaching Chemistry. The integration of IK improved, and teachers were familiar with the knowledge that was relevant to the topics they were teaching. For example, when teaching distillation and rate of reactions, IK can be used to explain the concepts that will help learners and teachers engage in classroom discourse.

10.3.5 Findings related to Research Question 5

After all the workshops were completed during this research, it was time for the Chemistry teachers to reflect on the research process. The data generated from this reflective space answered question 5: *How do discussions and group reflections in the peer-learning community influence (or not) Grade 10 Chemistry teachers' understanding of integrating IK from the ECMs?*

It was evident from the observations made during the reflective workshops that Chemistry teachers created space for themselves to reflect on the concepts that emerged from the workshops when co-analysing curriculum documents, during practical demonstrations and participatory observation with the ECMs, and lastly during co-developing exemplar lesson plans. Mind maps and a concept map helped the Chemistry teachers to learn from each other how to explain the concepts to the learners. This was observed when teachers argued about how concepts could be linked or connected to each other. This helped them to explain the concepts further and they helped each other to understand how concepts could be related. The concepts were in English and some in the local language which portrayed how Chemistry teachers acquired the knowledge.

10.4 New Knowledge in the Study

The first contribution to new knowledge that emerged in this research relates to the methodologies used. The use of the indigenous research paradigm allowed the ECMs and the Chemistry teachers to work together without the fear of intimidation. It helped us to work together using the Ubuntu perspective. The use of indigenous methodologies that involved the Chemistry teachers being taught by indigenous people was something that did not happen easily due to the superiority of scientific knowledge over IK. The ECMs are knowledge holders of different indigenous technologies that Chemistry teachers were not aware of, that could be used in science teaching. The interactions that took place between the ECMs and Chemistry teachers allowed the teachers to express their views and ask questions for further understanding. Although the NCBE (MoE, 2018) allows teachers to build from learners' prior knowledge that they gained from home or community, yet two Chemistry teachers involved in this study were not aware that IK was allowed to be integrated into the lessons/classrooms. In this research, I vehemently argue that teaching science should start with learners' prior everyday knowledge and the use of relevant locally available materials to enhance conceptual understanding as was done in this research.

The involvement of the Chemistry teachers in co-analysing curriculum documents helped them improve their understanding and increased their confidence on how IK could be integrated into science teaching. The $ePCK_P$ for Chemistry teachers improved as they planned lessons that integrated IK by starting from learners' life experiences (Gwekwerere, 2016). The use of the five components of TSPCK helped us to understand the curriculum from an IK perspective. This study viewed the curriculum critically, focusing on how it supports the integration of IK. The Chemistry teachers were able to look at the sections that allow them to integrate IK in the different available documents, which they had not noticed before. The peer-learning community enabled the Chemistry teachers to integrate IK by explaining the concepts from known to unknown and from context to content. This shift in thinking was a result of teachers being involved in a peer-learning community when co-analysing curriculum documents.

Notwithstanding, I feel that the integration of IK could be nurtured and instilled in science teachers by conducting long-term PLCs for them to be able to master the concepts from different cultural technologies that could be integrated into science classrooms. The PLCs need to include the contribution of ECMs to build from what local people are doing and link that to WS. The finding also challenges the thinking of teachers that WS can only be taught using laboratory apparatus; the study showed that it can also be taught using easily available resources and materials from the environment (Asheela et al., 2021; Shinana et al., 2021). Furthermore, there is a need to use both conventional and traditional apparatus during Chemistry examinations to make it easier for learners to relate to what they know when answering questions as suggested by Tala.

The new knowledge in science education was that the Chemistry teachers being taught by the ECMs helped them to engage in cultural technologies. The voices of ECMs were very useful in this study as they created learning opportunity for the Chemistry teachers. The notion that indigenous people are less knowledgeable when it comes to science subjects was proven to be incorrect as the ECMs involved in this research were knowledge holders (Lavallee, 2009). They could explain scientific concepts from an IK point of view. The respect that the Chemistry teachers and ECMs portrayed helped them to learn from each other. The research was conducted in an environment where the ECMs were free to express themselves and the use of their artefacts helped them to be more confident. Taking ECMs to different environments to explain/demonstrate their IK that might reduce their level of comfort. The way the ECMs and Chemistry teachers communicated without interrupting each other when explaining the indigenous technologies and the use of artefacts left me marvelled, and that shows indigenous people have a sense of respect.

Indigenous knowledge (IK) was acquired when teachers and community members engaged in practical demonstrations on the preservation and pounding of *Mahangu* and the making of *Oshikundu*. It emerged that the rate of reactions could be taught using IK that includes scientific processes that are done daily by community members. The evidence that was portrayed by the ECMs, shows that science knowledge is embedded in local activities and there is a need to start documenting them to be used in Chemistry and other science-related subjects. The Chemistry teachers could not hold back their joy at the knowledge they learnt through the practical demonstrations and participatory observation and that helped them to teach the rate of reactions using learners' prior everyday knowledge. Thus, a CoP between the Chemistry teachers involved in this study was created to help them learn from the MKOs, in this case, Chemistry teachers that had better SMK on the integration of IK into Chemistry teaching. This challenges the superiority of WS, particularly in science textbooks.

Relating to new knowledge in this study, apart from the peer-learning community co-analysing curriculum documents, Chemistry teachers were involved in co-analysing the NCBE and co-development of exemplar lesson plans using TSPCK components by Mavhunga and Rollnick (2013). Planning lessons based on indigenous knowledge using the five components of TSPCK helped the Chemistry teachers to understand how IK could be used to teach some topics in Chemistry and other science subjects. The Chemistry teachers were not aware of the components of TSPCK before preparing the lessons and presenting the lessons using the five components of TSPCK. The peer-learning community helped teachers to understand the five components of TSPCK in planning the lessons and how the lessons could be presented starting with learners' prior knowledge. It could be argued that integration of IK would be possible through the peer-learning community of science teachers using the five components of TSPCK. From the data analysis, I concluded that Chemistry teachers acquired knowledge on the topic of the rate of reactions. For example, after the workshops, Ndeshi and Sebron alluded that they would re-teach the lessons before they forgot what was discussed.

This study helped the Chemistry teachers to improve their PCK, as was observed during practical demonstrations and lesson observations. Hence, it could be argued that the realms of PCK, cPCK, pPCK, and ePCK of Chemistry teachers' knowledge, shifted without them knowing. It was, however, inconsistent from teacher to teacher as this could not be measured and only teachers that presented the lessons could be observed and their PCK analysed to see how it improved. The PK of Chemistry teachers was deepened, as teachers' teaching practices or methods of teaching and learning were observed and showed that their teaching pedagogy changed from teacher-focused to learner-focused. The unique teaching methods were observed when Chemistry teachers allowed learners to be learner-teachers to explain the process of making *Ombike* to other learners.

The new knowledge revealed that learners need to be exposed to cultural identities/indigenous technologies that can be integrated into science teaching. The cultural border crossing between home (IK) and school (scientific knowledge) was strengthened as the topics taught were based on how indigenous knowledge could be helpful in science classrooms. Giving learners the chance to explain the topic of fractional distillation was something amazing as learners used their IK to explain science concepts. It was evident that learners were able to explain scientific processes using indigenous technologies they had acquired at home. The generic of this knowledge involves issues of learner learning, classroom management, lesson plan development, and its implementation in the science classroom. The interaction between the learners themselves was amazing as they could explain the processes based on their understanding. This type of knowledge is unique only to the teachers that attended the peer-learning community workshops on how to implement the curriculum that allows IK to be integrated into science teaching. Pedagogical knowledge (PK), ePCK, $ePCK_P$, and $ePCK_T$ allowed Chemistry teachers to develop strategies that are suitable in science classrooms. Learner-teachers' SMK improved as they engaged in active discussions with other learners during the lessons.

It is important to realise that teachers with deep PK and SMK understand how learners construct knowledge, acquire skills, and develop habits of mind and positive dispositions towards learning. The PK of the Chemistry teachers shifted from mental cognitive, where learners were taught things that they could only imagine visualising, to what was done at home. Chemistry teachers had a fear of misleading learners, and that fear had culminated in them ignoring IK completely. After the peer-learning community, as is evident in this research, Chemistry teachers were able to explain science concepts using indigenous terminologies. That is, the future of science teaching should build from IK to explain WS. It is evident that IK is the root of WS.

The study created a space for the participants to reflect. Reflective spaces created new knowledge as participants were able to reflect after every research phase and keep their reflective journals. This created room for the participants to be able to see how and what they had learnt throughout the research process. The study promoted a reflective space, as Chemistry teachers were given journals to reflect on after every engagement in the peer-learning community and the practical demonstrations with the ECMs. Reflective space strengthened the methods I used to generate data. Reflective space should become one of the common methods used to generate data as the participants in this study felt more comfortable when reflecting on what happened and how they could change their teaching methods in the future. This indicated that their knowledge of enacted PCK for reflection ($ePCK_R$) improved without them noticing it. The use of journal reflections allowed the participants to have more time to reflect and new knowledge emerged through their reflections.

Lastly, similar to Nhase's (2019) study conducted in South Africa, the reflective space afforded the Chemistry teachers an opportunity to reflect on their practices. Further, the development of mind and concept maps allowed them to engage in constructive discussions. The use of mind and concept maps helped the Chemistry teachers to embrace the importance of focusing on conceptual understanding during teaching and learning. This was evidenced by Shipefi 16 asking if learners were allowed to come up with mind and concept maps after the lessons. This showed that after the reflective space, he felt that learners needed to come up with concept maps and present them to other learners for further understanding as evidenced in Mayana's (2020) conducted in South Africa. Reflective space created room for learning and further understanding of concepts that were acquired during the research process.

10.5 Implications for the Study

The use of IK in science lessons seems to be less understood by most science teachers. The findings pointed out that there is a need for the NCBE to be unpacked since teachers are not familiar with what the documents address. I suggest that CPD be conducted with science teachers to help them understand how the NCBE addresses the integration of IK. Indigenous knowledge (IK) is embedded in the cultural artefacts, activities, and language of a local community. Thus, the findings from three Chemistry textbooks showed that they do not integrate any indigenous knowledge or practical activities that are practised in the local communities so that learners and teachers can learn from what is known to unknown (Kuhlane, 2011).

The Chemistry teachers were able to link the WS to IK after they were exposed to the practical demonstrations and explanations by the ECMs. It could be argued then that this study illuminated that it is time that IK and artefacts are documented in science textbooks in order for indigenous epistemology to be advanced. Doing this might help teachers to integrate IK in their classrooms and hence contextualise the Chemistry content. Chemistry textbooks, syllabus, and examination question papers need to address what the NCBE advocates for, and teaching should start from the life experiences of learners (Gwekwerere, 2016). Doing this might help science teachers to align other documents to the umbrella document NCBE (MoE, 2018). I also suggest that Chemistry teachers need to establish peer-learning communities at the cluster or circuit level to learn from each other how WS could be contextualised. For now, these groups are non-existent and it is time that teachers become involved and understand how the NCBE allows them to integrate IK.

I further propose that science teachers need to be involved in PLCs for them to be aware of the IK the community members practice daily. The findings that emerged from our visits to the ECM's home and the practical demonstrations that were done highlighted that science knowledge is embedded in the activities that are done in the local communities. Science teachers need to engage peer-learning communities to teach topics such as distillation (Shifafure, 2013; Uushona, 2013), rate of reactions (Nikodemus, 2017), enzymes (Shinana, 2019), and sound and waves (Liveve, 2017; 2022) that promote the use of local language and artefacts used by the communities that are similar to scientific knowledge. We need to bring science from context to content and that can only be achieved when science teachers understand the role of community members in science lessons.

As inferred by participants, the number of Chemistry teachers needs to be increased for them to be aware of how scientific knowledge could be contextualised. Workshops on how IK could be used in science need to be planned for Grades 10 and 11 Chemistry teachers in the region to undergo a similar process. The two ECMs and five Chemistry teachers would be resourceful during the workshops as they are knowledgeable about how WS could be contextualised. Thus, the senior education officers (Chemistry subject advisors) need to be involved to help Chemistry teachers to teach the new curriculum with the help of the ECMs.

The CPD needs to be enhanced and teachers must start valuing the knowledge from the local community and integrating it into their Chemistry/science teaching. The CPD should cover all possible content that includes IK so that teachers will be able to unpack the knowledge embedded in local science. The use of artefacts from the local community in science classrooms should be encouraged and Chemistry teachers need to be aware of the value they add to enhancing learners' understanding. Lastly, science teachers should form an indigenous science club at the school, circuit, and regional level to share ideas on how IK could be integrated into science.

10.6 My Reflections

The findings from the master's study triggered and motivated me to further my research at the PhD level with the interest of integrating IK in science, specifically in Chemistry. The findings from my master's thesis, for instance, paved the way for me to involve Chemistry teachers in a peer-learning community and work with ECMs on the practical activities on preservation and pounding of *Mahangu* and the making of *Oshikundu*. This paved the way for Chemistry teachers to be engaged in the practical demonstrations and participatory observation. This was an opportunity to learn and acquire new IK that could be integrated into science lessons my personal knowledge I gained at home when I was growing up and at school. In my master's and PhD, it was interesting that I was learning the culture of the community and the language while researching the integration of IK into science teaching.

The research process taught me a lot of things that helped me to work together with the participants. The willingness of the Chemistry teachers and ECMs during the research process was amazing. I learnt that humbleness was key for the participants to be willing to be part of the research process and the mutual benefits we experienced with the Chemistry teachers was amazing it made them eager to learn and enjoy the research process. The participants were active, and they did not miss any workshop or practical demonstration. The ECMs were willing to share their knowledge and working with qualified teachers did not intimidate them because they were knowledgeable about what they were doing. Vygotsky's (1978) SCT allowed the Chemistry teachers and ECMs to work together during practical demonstrations that helped me to acquire new knowledge on how IK could be integrated. They never complained of the hectic schedules we endured or demanded to be paid extra cash apart from the transport money that was given to the teachers with cars. The ECMs shared their knowledge freely and they enjoyed working with Chemistry teachers.

On reflection, if I could do this research again, I would do the following differently. I would interview the ECMs on their experiences of making *Oshikundu* that could consolidate with the interview data from the Chemistry teachers. This would have allowed me to gain insight into the ECMs' understanding of how they were taught to make *Oshikundu*. This could have helped me to further understand how knowledge is transmitted from generation to generation in the context of IK (Kibirige & van Rooyen, 2006). Furthermore, the practical demonstrations could include both learners and teachers outside the classroom context who would be taught by the ECMs. During this process (practical demonstrations and participatory observation), the Chemistry teachers could serve as cultural knowledge brokers (Cooper et al., 1999; Cooper, 2014). Chemistry teachers as cultural brokers could connect IK with scientific knowledge during practical demonstrations to enhance learners' conceptual understanding. Lastly, the ECMs could be invited to observe some lessons on how IK is used in a classroom setup. This could make ECMs proud of the knowledge they possess and help them understand it better and advance their conceptual understanding.

As a researcher I have benefited in many ways from this research by working with the ECMs and the Chemistry teachers in our peer-learning community. As a non-Oshikwanyama speaking researcher, I benefited a lot by learning many science concepts that are relevant to the topic of rate of reactions. Personally, I grew as a researcher as it helped me to work in different contexts and to learn the culture and the language of the community where IK is embedded. The research became a wonderful learning journey for me that included growing spiritually. It emerged in this study that indigenous people have a good connection with God and they believe that whatever they ask for will be received. For instance, praying before going planting was one of the outstanding beliefs that caught my attention because in our culture, it was not done. It is recognised, however, that spirituality cannot be explained scientifically (Simpson, 2014).

Since I worked with indigenous elders, I had to understand their identity that was slightly different from my cultural identity. Also, I had to learn their cultural identity and understand how things are done in the *Oshiwambo/Aawambo* culture. This made me to be a co-learner during the research process. The knowledge I gained during practical demonstrations and participatory observation were cross-examined with the knowledge I gained through observation and practical engagement on making *Maheu* in Zambezi region. Even though the ingredients are slightly different, the process is similar to the one I used to observe my late mother doing when preparing *Maheu*. Lastly, I received uncountable knowledge that is very useful in science. As a researcher, I have to confess that my PCK was transformed, specifically ePCK for planning (ePCKP), ePCK for teaching (ePCKT) and ePCK for reflecting (ePCKR) after working with the ECMs and Chemistry teachers.

10.7 Decolonising and Africanisation of Chemistry Curriculum

The current curriculum of education in Namibia (MoE, 2018) does not explicitly explain how Chemistry concepts could be taught using learners' life experiences even though it encourages teachers to start from learners' life experiences. The Namibian curriculum adopted western ways of knowing and epistemology. The 'two-eyed seeing' in this study was used to look at how IK and WS could be taught simultaneously in Chemistry classrooms. Onwu and Mufundirwa (2020, p. 229) used 'two-eyed seeing' with reference to co-learning and integrating IK. They elaborate that the 'two-eyed seeing' approach as the process of co-learning for incorporating elements of indigenous knowledge into school science teaching". The African way of knowing was and is still ignored in the NCBE. This has been influenced by the mode of education that Namibia opted for after independence in 1990. The curriculum was regulated by Cambridge University that played a role on what was to be taught in science classrooms. Le Grange (2016) indicated that most universities in South Africa seem to follow the western disciplinary knowledge that was used during apartheid and after independence. As a result, very few universities have tried to decolonise their science curriculum. Similarly, the Namibian education system has not done a lot to decolonise the curriculum.

The findings from this research explicitly explained how IK could be integrated into Chemistry teaching and learning to help learners understand WS and avoid the cognitive dissonance that happens in the minds of learners (Le Grange, 2007). Essentially, in the context of my study, decolonising the curriculum was intended to help us to understand the concepts of rate of reactions through using the indigenous practices of preserving and pounding of *Mahangu* and the making of *Oshikundu*. Through decolonising the Chemistry curriculum, the Chemistry teachers were empowered to teach Chemistry topics by integrating IK. This was revealed in the first lesson when Michael and Shipefi 16 taught the topic on fractional distillation by using local artefacts that were used by indigenous elders to make *Ombike*. The lesson was interesting because in both schools A and B learners presented the lesson to other learners. This enabled the learners who presented the lessons to be empowered and they were able to contextualise the lessons by explaining WS building from IK.

During the lessons, learners were able to traverse between IK and WS. In consequence, cognitive dissonance (Le Grange, 2007) was avoided by the way the learners who presented the first lesson at both schools linked both worldviews. Moreover, examples from local communities were given to enrich the conceptual understanding of other learners. Using examples from within the local environment fulfilled the aim of decolonisation in this study. Learners at both schools A and B were using both the indigenous language (*Oshikwanyama*) and English to explain the science concepts. The use of both languages helped the learners and teachers to explain the concepts with confidence and that allowed them to link the two knowledges very well.

The second lesson observed was presented by Michael and Shipefi 16 from schools A and B respectively. The Chemistry teachers were empowered and transformed when they attended the practical demonstrations of the ECMs on preserving and pounding of *Mahangu* and making of *Oshikundu* to contextualise Chemistry teaching and learning on the topic of rate of reactions. The factors that affect the rate of reactions were well explained using IK. However, not all factors were well explained and linked to indigenous practices that they acquired during the practical demonstrations. This imbalance in favouring western science over IK influenced the Chemistry teachers not explaining the concepts using the knowledge that was gained during the practical demonstrations. Similarly to what Shizha (2007) observed in Zimbabwe about teachers not interested in integrating IK because the curriculum doe not allow them to do so. The curriculum that does not explicitly explicate how IK should be integrated cannot help teachers to decolonise science concepts by explaining them using learners' life experiences (Gwekwerere, 2016).

In this regard, Seehawer (2018b) indicated that decolonisation can be attained through using learners' communities as resources in teaching science. Similarly, this study used indigenous elders as the custodians of IK. That is, the Chemistry teachers were involved in practical activities that enabled them to contextualise Chemistry teaching and learning. Chemistry teachers were afforded an opportunity to work with ECMs and learn the indigenous science that could be used in teaching rate of reactions. This allowed the Chemistry teachers to be transformed and teach Chemistry using 'bottom-up' approaches (Mutanho, 2021, Seehawer, 2021). For instance, learners were afforded ab opportunity to present the lessons using the indigenous knowledge before western concepts were introduced. I can confidently say that the pedagogical strategies of the Chemistry teachers were transformed from textbook bound teaching to initiate activities that could make the lessons more interesting. In her study in South Africa, Seehawer (2018b) indicated that "through collaborating and co-researching with teachers, learners, parents, communities, elders, traditional healers, teacher educators, or local authorities, integration strategies can be explored and solutions to challenges be developed" (p. 105). For decolonising the curriculum to be fully attended to, as indicated by Seehawer, different stakeholders need to be involved and not only teachers and learners. Indeed, that was the contention in this study. Along with the little effort that has been done with the NCBE, decolonising the curriculum needs to be visible in science textbooks and other documents that would allow science teachers to integrate IK.

Even though decolonisation of the science curriculum has received little attention in Namibia, this study might give direction on how science could be taught using IK. The use of IK to contextualise Chemistry helped Chemistry teachers to guide learners using examples that were familiar to them from home. It was evident that when learners explained fractional distillation they showed confidence, knowledgeable about science and explained the processes in chorological order. The use of indigenous artefacts that were drawn by the learners helped them to contextualise the topic of fractional distillation.

On the aspect of Africanisation of the Chemistry curriculum, due to the limited time we had for our visits to the ECMs, IK from other cultures was not part of the discussion. For instance, we could not look at other African cultures on how the factors affecting rate of reactions could be contextualised in Chemistry teaching and learning.

10.8 Areas for Further Research

This research serves as a stepping-stone for further research that advocates for the integration of indigenous technologies in science and other subjects. Further suggestions for research on the integration of IK are:

1. Research on the role of IK in Chemistry, Physics, Biology, Agriculture and other related field on the role of indigenous people in the classroom setting.
2. A study on the knowledge shifts of science teachers on collective PCK (cPCK), personal PCK (pPCK), and enacted PCK (ePCK) in science subjects.

3. A study on the roles of learners and indigenous people in science subjects when IK is integrated.
4. A study on the professional learning communities of science teachers as cultural brokers when using indigenous technologies during teaching and learning.
5. A study that would follow the same process as this study but further allow the ECMs to observe how teachers integrate IK into their teaching.

10.9 Conclusion of the Study

This formative interventionist study employed a qualitative case study research design to explore how to mobilise IK to contextualise Chemistry teaching in rural schools in Namibia. I discovered that taking Chemistry teachers to learn IK that is practised by the community helped them to contextualise Chemistry teaching. Using indigenous artefacts helped the community members and the Chemistry teachers to work together and learn from each other. Vygotsky's (1978) SCT which includes social interaction, language and the ZPD were observed during the engagement between the Chemistry teachers and ECMs and Chemistry teachers with learners. Thus, learning took place in social settings where the MKOs engaged the Chemistry teachers in practical demonstrations to acquire new levels of knowledge. The Chemistry teachers became cultural knowledge brokers when enacting the exemplar lessons during teaching and learning. This allowed Michael and Shipefi 16 to avoid cognitive dissonance (Le Grange, 2007) as learners understood the concepts.

In this study, IK was used to enhance the conceptual understanding of teachers when visiting Mee Mukwaluvalas' house and engaging in practical demonstrations and participatory observation. The PCK of teachers on the topic of rate of reactions improved and they mastered how IK could be integrated. The interventionist approach in this study helped the teachers to engage and benefit from social interactions with the ECMs; these also helped them to teach Chemistry using IK as learners' life experiences as advocated in the NCBE (MoE, 2018). It was evident that learners benefited from the lessons as they could explain the distillation process using local examples.

EPILOGUE

> There are many who increasingly believe that, through self-organization and small ruptures, we can actually create myriad "tipping points" that may lead to deep alterations in the direction that both the continent and the planet take. (Mbembe, 2021, p. 10)

Firstly, by situating myself in this study I had hoped that my *voice* would permeate throughout my thesis so that it could be heard. That was important as colonialism and later apartheid silenced or marginalised other ways of knowing in Namibia. However, it dawned on me that I was still entangled in the westernised ways of doing things and self-emancipation proved to be a tall order. In hindsight, I realised that my biggest barrier was that I lacked the language which resonates with indigenous research methodologies as espoused by Chilisa (2012) and Smith (1999). Resultantly, I was caught up in the colonial ways of doing research as evidenced, for instance, by my over-reliance on the intepretivist paradigm, which I used initially, whose focus is on understanding contexts from an individual perspective. Perhaps, there was a place for this especially at the beginning of this study, as the Chemistry teachers involved in it came from diverse school contexts and have similarly been socialised in traditional approaches which foster independence and individualism at the expense of collaboration as cautioned by Ngcoza and Southwood (2019) in their study. To ameliorate this dilemma, I replaced the interpretivist paradigm with the transfomative research paradigm. The question that bothered me, though, was: What would not be known if this study was not conducted in Namibia?

Firstly, this study was conducted at the time when there was transformation of curriculum in Namibia central to which was the integration of IK to make science accessible and relevant to learners (Asheela et al., 2021). Essentially, the NCBE (MoE, 2018) allows teachers to build from learners' life experiences that they know from home or the community (Gwekwerere, 2016). Notwithstanding such ideals, however, there have been tensions between curriculum formulation and implementation compounded in part by the fact that the curriculum is not explicit on how science teachers should go about integrating IK into their classrooms. My assumption is that such a conundrum seems to be exacerbated by the fact that the science curriculum is designed by subject advisors who are no longer classroom teachers. Moreover, and as alluded to earlier, science teachers seem to have been socialised in traditional approaches to teaching and learning and as a result are not used to working collaboratively as illustrated in a transformative research paradigm.

Central to this study, therefore, was the formation of a peer-learning community which by its nature is collaborative. Such self-organisation (Mbembe, 2021) was critical in this study central to which was transformative learning. Thus, it sought to explore leveraging a peer-learning community and expert community members (ECMs) in integrating IK into Grade 10 Chemistry learning and teaching of the rate of reactions. I acknowledge, however, that my study constitutes a small stone in a huge wall of research in the Chemistry education field. Notwithstanding, if you were to remove my stone, the wall would not fall but instead there would be a yawning gap visible. So, what could the contribution of my study be in this broad field then?

A first mark on my stone pertains to *ownership*. Taking heed of Snively and Williams' (2008) advice that for professional development of teachers to be meaningful, researchers need to take into consideration their needs. To achieve this, I first interviewed these teachers individually to understand their pedagogical insights regarding the integration of IK. Their pedagogical insights were varied as some teachers seemed to understand the need to integrate IK into the teaching and learning of science whereas some seemed to be clueless. The latter emphasised the importance of this study. To further strengthen the notion of ownership, I conducted an orientation workshop so that these teachers could see that they were central and important in the peer-learning community I highlighted earlier. The implication for this finding is that the Department of Education in Namibia needs to revisit its top-down and 'one-size-fits all' workshops and instead centre science teachers in their professional development programmes.

A second mark on the stone had to do with co-analysing the curriculum documents including textbooks. Once more, these teachers' zone of proximal development (ZPD) (Vygotsky, 1978) regarding engaging with the curriculum were at different levels. For instance, some Chemistry teachers involved in this study indicated that they were familiar with the curriculum and some were not. Such disparity in understanding the curriculum could then result in tensions between curriculum formulation and implementation. Through collaboratively co-analysing the curriculum documents these teachers realised that they were resources for one another.

My significant contribution, therefore, pertains to the peer-learning community that was formed in my study, central to which was *co-learning* on how to integrate IK into Chemistry teaching. Through the peer-learning community the teachers realised the importance of working together to overcome the curriculum challenges. That is, they realised that for transformation in curriculum to occur they needed to be agents of change and take responsibility for their teaching and learning. Arguably, such an enabling environment would not have been possible without this study.

Thus, it could be surmised that the peer-learning community afforded the Chemistry teachers an opportunity to learn from one other to understand the integration of IK. Before the peer-learning community, the Chemistry teachers were working in isolation without helping one another. The findings of this study, therefore, revealed that the role and importance of a peer-learning community cannot be overstated since it is not a foregone conclusion that when the curriculum encourages teachers to integrate IK it will automatically happen without any form of intervention. Herein lies the importance and uniqueness of my study.

Moreover, there seems to be very little literature on how to tap into the cultural heritage of community members to enable Chemistry teachers to become cultural knowledge brokers (Aikehead & Jegede, 1999); Wyatt et al., 2017). In the context of this study, the highlight was when our peer-learning community worked *with* the ECMs to mobilise the indigenous technologies of preserving, pounding *Mahangu* and making *Oshikundu*. What was unique in this study was that the Ubuntu perspective was used when we tapped into the cultural heritage of the ECMs. That enabled us to effortlessly become cultural knowledge brokers (Aikenhead & Jegede, 1999; Wyatt et al., 2017) who could deal with the issues of cognitive dissonance that seem to affect most African learners (Le Grange, 2007) especially in under-resourced and disadvantaged rural schools where this study was situated. This was indeed a cutting edge and a tipping point in this study as Mbembe (2021) pointed out in the epigraph.

That is, during the practical demonstrations and participatory observation, we worked with the ECMs and that allowed us to learn from them the cultural heritage that could be applicable in Chemistry teaching. This allowed us to learn indigenous way of knowing. Indigenous knowledge is transmitted from generation to generation using music, stories, arts and other artefacts. We were subsequently able to collaboratively develop our own resources that integrated IK by using easily accessible resources from the environment to make learning and teaching science accessible and relevant to the learners instead of solely relying on prescribed textbooks as had been happening in the past. Albeit that was a small step or small ruptures (Mbembe, 2021) towards documenting IK ourselves as Chemistry teachers, it still made a huge difference.

Moreover, we learnt ways on how IK could be used to enrich learning of science. For instance, storytelling allowed us to learn how knowledge was transmitted from generation to generation by referring to how they were told. Songs were also used for communication (Liveve, 2022) and also to talk to ancestors, something which WS does not recognise as knowledge. Indigenous elders believe that the dead could still hear us when we talked to them by asking them. Similarly, when the ECMs requested for the wind during *Okuyela* (winnowing), the wind started blowing – this could not be proved since WS does not accommodate such types of knowledge. The above-mentioned experiences emphasise that there are other ways of knowing, doing and being which need to be factored into science classrooms. This can be achieved through giving *voice* to the ECMs as it was illuminated in this study.

Notable is that classrooms are secret spaces for teachers and that the teachers and their learners are enclosed and insulated by the four walls. In this regard, it emerged from this study that co-developing exemplar lessons, enacting them and reflecting on them further strengthened our understanding of how to integrate IK into Chemistry teaching. On reflection, though, what was a lost opportunity in this study was that we did not invite the ECMs to come and observe some lessons so that they could see how valuable their cultural heritage is. I regret this but we will use this to sustain our relationship with these ECMs and that is consistent with the indigenous research methodologies (Chilisa, 2012). Scholars such as Mutanho (2021) and Seehawer (2021) refer to working with science teachers and ECMs focusing on integration of IK as 'bottom-up' decolonisation. That is, science teachers and community members are at the core of the process of integration rather than relying on the Department of Education. The implication for this to the curriculum developers, in particular, is that there is a need for continuing professional development for Chemistry teachers.

From the foregoing discussions, therefore, it could be surmised that my study makes a significant practical contribution to the current debates on the decolonisation agenda of the science curriculum. However, it should be noted that decolonisation does not mean that we should throw away everything from the past. Rather it means that we should embrace diversity and acknowledge other ways of doing, knowing and being. Also, we need to acknowledge that these knowledges, IK and WS, are not oppositional and mutually exclusive but rather complementary (Ogunniyi, 2007a). It is precisely for that reason that scholars such as Seehawer and Breidlid (2021) reiterate that there should be a dialogue between these knowledges. That is, we need to take the past, the present and focus to the future (Chikamori et al., 2019). I would like to conclude my epigraph with the following quote:

> Even behind the greatest scholars there is always a human being, with his story, his myths, and his fears. (Tibika, 2013, p.12)

Reflecting on my research journey, literally, the above quote highlights what transpired for me during my research. The fears and myths that I had about the challenges that I would encounter when conducting this research helped me understand that behind this project my supervisors were there to encourage me to work extra hard to achieve and obtain this qualification. Essentially, it shows how *Ubuntu* works in an African context.

The peer-learning community helped me to learn from both the Chemistry teachers and ECMs during the practical demonstrations and participatory observation on preserving and pounding *Mahangu* and making of *Oshikundu* to contextualise the topic of rate of reactions. The social interactions we had helped me to reflect on the understanding I had before I was involved in this research with the Chemistry teachers and ECMs because learning in this research was based on group interaction and mutual trust of participants. It helped me to be transformed on how Chemistry can be taught using indigenous knowledge *within* and *in* the community – that is, taking the community and their cultural heritage to the classroom.

REFERENCES

Abah, J., Mashebe, P., & Denunga, D. D. (2015). Prospect of integrating African indigenous knowledge systems into the teaching of science in Africa. *American Journal of Educational Research, 3,* 668-673.

Abrahams, I., & Millar, R. (2008). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International Journal of Science Education, 30*, 1945-1969.

Abrahams, I., & Saglam, M. (2010). A Study of Teachers' Views on Practical Work in Secondary Schools in England and Wales. *International Journal of Science Education, 32*, 753-768, https://doi.org/10.1080/09500690902777410

Adam, D., Hussein, E. K., & Joe, A-A. (2018). Theoretical and conceptual framework: Mandatory ingredients of a quality research. *International Journal of Science Research, 7*, 437-441.

Afonso-Nhalevilo, A. (2013). Rethinking the history of inclusion of IKS in school curricula: Endeavoring to legitimate the subject. *International Journal of Science and Mathematics Education, 11*(1), 23-42.

Agea, J. G., Lugangwa, E., Obua, J., & Kambungu, R. K. (2008*).* Role of indigenous knowledge in enhancing household food security: A case study of Mukungwe, Masaka district, central Uganda. *Indilinga: African Journal of Indigenous Knowledge Systems*, *7*(1), 64-71. https://doi.org/10.4314/indilinga.v7i1.26394

Agrifoglio, R. (2015). *Knowledge preservation through community of practice*. Springer Briefs in Information Systems.

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural Science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*, 269-287.

Akbar, R. A. (2012). Mind the fact: Teaching science without practical as body without soul. *Journal of Elementary Education, 22*, 1-08.

Alonzo, A. C., Berry, A., & Nilsson, P. (2019). Unpacking the complexity of science teachers' PCK in action: Enacted and personal PCK. In A. Hume, R. Cooper & A. Borowski (Eds.), *Repositioning pedagogical content knowledge in teachers' knowledge for teaching science* (pp. 271-286). Springer. https://doi.org/10.1007/978-981-13-5898-2_12

Ameri, M. (2020). Criticism of the sociocultural theory. *Budapest International Research and Critics Institute-Journal, 3*, 1530-1540.

Angaama, D., Fatoba, A. F., Riffel, A. D., & Ogunniyi, M. B. (2016). Harnessing Indigenous knowledge for science teaching: The voices of learners. In *Proceedings of the 2nd International Conference of the African Association for the Study of Indigenous Knowledge Systems* (pp. 23-32).

Arcavi, A. (2003). The role of visual representations in the learning of Mathematics. *Education Studies in Mathematics, 52*, 215-241.

Asheela, E. N. (2017). An intervention on how using easily accessible resources to carry out hands-on practical activities in science influences science teachers' conceptual development and dispositions [Unpublished master's thesis]. Rhodes University.

Asheela, E., Ngcoza, K. M., & Sewry, J. (2021). The use of easily accessible resources during hands-on practical activities in rural under-resourced Namibian schools. In U. Ramnarain (Ed.), *School science practical work in Africa. Experiences and challenges* (pp. 14-31). Routledge.

Asogwa, I. S., Okoye, J., & Oni, K. (2017). Promotion of indigenous food preservation and processing knowledge and the challenge of food security in Africa. *Journal of Food Security, 5,* 75-87.

Atallah, F., Bryant, S. L., & Dada, R. (2010). Learners' and teachers' conception and dispositions of Mathematics from a Middle Eastern perspective. *US-China Education Review, 7*, 43-49.

Atar, H. Y. (2007). Investigating inquiry beliefs and nature of science (NoS): Conceptions of science teachers as revealed through online learning [Unpublished doctoral thesis]. Florida State University.

Bantwini, B. (2010). How teachers perceive the new curriculum reform. Lesson from a school district in the Eastern Cape Province, South Africa. *International Journal of Educational Development, 30,* 83-90.

Bertram, C., & Christiansen, I. (2015). *Understanding research: An introduction to reading research*. Van Schaik Publishers.

Bille, P. G. (2009). Science and technological development of Omashikwa; Namibian traditional fermented butter milk [Unpublished doctoral thesis]. University of Pretoria.

Blake, B., & Pope, T. (2008). Developmental psychology: Incorporating Piaget's and Vygotsky's theories in classrooms. *Journal of Cross-Disciplinary Perspectives in Education, 1,* 59-67.

Boblett, N. (2012). Scaffolding: Defining the metaphor. *Working Papers in TESOL and Applied Linguistics, 12*, 1-16.

Boisselle, L. N. (2016). Decolonizing science and science education in a postcolonial space. https://doi.org/10.1177/2158244016635257

Botha, R. L. (2010). Indigenous knowledge as culturally-centred education in South Africa. *African Education Review, 7*, 34-50.

Bourke, B. (2014). Positionality: Reflecting on the research process. *The Qualitative Report*, *19*, 1-9. https://nsuworks.nova.edu/tqr/vol19/iss33/3

Braund, M., & Reiss, M. (2006). Towards a more authentic science curriculum: The contribution of out- of- school learning, *International Journal of Science Education, 28*, 1373-1388, https://doi.org/10.1080/09500690500498419

Brodie, K. (2013). The power of professional learning communities. *Education as Change, 17*, 5-18.

Brodie, K. (2020). Teacher agency in professional learning communities. *Professional Development in Education, 47*, 560-573.

Brydon-Miller, M., & Maguire, P. (2009). Participatory action research: Contributions to the development of practitioner inquiry in education. *Educational Action Research*, *17*, 79-93.

Can, H. B (2021). Enacted pedagogical content knowledge profiles of Chemistry teachers. *Journal of Education, 7*, 565-583

Carlson, J., & Daehler, K. R. (2019). The refined consensus model of pedagogical content knowledge in science education. In A. C. Hume (Ed.), *Repositioning pedagogical content knowledge in teachers' knowledge for teaching science* (pp. 77-92). Springer.

Carter, L. (2007). *Sociocultural influences on science education: innovation for contemporary times* [Unpublished doctoral thesis]. Australian Catholic University.

Cetin-Dindar, A., & Geban, O. (2017). Conceptual understanding of acids and bases concepts and motivation to learn Chemistry. *The Journal of Educational Research, 110*, 85-97. https://doi.org/10.1080/00220671.2015.1039422

Chairam, S., Somsook, E & Coll, R. K. (2009). Enhancing Thai students' learning of chemical kinetics. *Research in Science & Technological Education, 27*, 95-115. https://doi.org/10.1080/02635140802658933.

Chang, S. (2020). Multicultural educators as cultural brokers and language mediators. *Multicultural Perspectives*, *22*, 146-152. https://doi.org/10.1080/15210960.2020.1792300

Chani, F., Ngcoza, K. M., Chikunda, C., & Sewry, J. (2018). Exploring the mediation of learning of chemical equilibrium to high-achieving students in a selected senior secondary school in Namibia. *African Journal of Research in Mathematics, Science and Technology Education, 22*, 287-296. https://doi.org/10.1080/18117295.2018.1528031

Chauraya, M., & Brodie, K. (2018). Conversations in a professional learning community: An analysis of teacher learning opportunities in Mathematics. *Pythagoras, 39*, 1-9.

Chen, M., Floridi, L., & Borgo, R. (2013). What is visualization really for? *The Philosophy of Information Quality. Springer Synthese Library*, *358*, 75-93. https://arxiv.org/ct?url=https%3A%2F%2Fdx.doi.org%2F10.1007%2F978-3-319-07121-3_5&v=fccbc932

Chikamori, K., Ono, Y., & Rogan, J. (2013). A lesson study approach to improving a biology lesson. *African Journal of Research in Mathematics, Science and Technology Education, 17*, 14-25.

Chikamori, K., Tanimura, C., & Ueno, M. (2019). Transformational model of education for sustainable development (TMESD) as a learning process of socialization. *Journal of Critical Realism*. https://doi.org/10.1080/14767430.2019.1667090

Chilisa, B. (2012). Indigenous research methodologies. Sage.

Chisholm, L., & Leyendecker, R. (2008). Curriculum reform in post-1990s sub-Saharan Africa. *International Journal of Educational Development*, *28*, 195-205.

Christmas, D., Kudzai, C., & Josiah, M. (2013). Vygotsky of proximal development theory: What are its implications for Mathematics teaching? *Greener Journal of Social Science, 3,* 371-377.

Cobern, W. W., & Loving, C. C. (2001). Defining "Science" in a multicultural world: Implications for science education*. Science Education, 85***,** 50-67.

Cochran, K. F., DeRuiter, J. A., & King, R. A. (1993). Pedagogical content knowledge: An integrative model for teacher preparation. *Journal of Teacher Education, 44*, 263-272.

Cochran, K. F., King, R. A., & DeRuiter, J. A. (1991). *Pedagogical knowledge content: A tentative model for teacher preparation*. Paper presented at the Annual Meeting of the American Educational Research Association, Chicaco, April, 1991.

Cocks, M. L., Alexander, J., & Dold, T. (2012). Inkcubeko nendalo: A bio-cultural diversity schools education project in South Africa and its implications for inclusive indigenous knowledge systems (IKS) sustainability. *Journal of Education for Sustainable Development, 6*, 241-252.

Coetzee, C., Rollnick, M., & Gaigher, E. (2020). Teaching electromagnetism for the first time: A case study of pre-service Science teachers'enacted pedagogical content knowledge. *Reserch in Science Education*. https://doi.org/10.1007/s11165-020-09948-4

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge.

Cook, A. (2015). Considering pre-service teacher disposition towards mathematics. *Mathematics Teacher Education and Development, 17*, 1-11

Cooper, C. R. (2014). Cultural brokers: How immigrant youth in multicultural societies navigate and negotiate their pathways to college identities: *Learning, Culture and Social Interaction, 3*, 170-176

Cooper, C. R., Denner, J., & Lopez, E. M. (1999). Cultural Brokers: Helping Latino children on pathways toward success. *The Future of Children, 9*, 51-57.

Creswell, J. W., Ebersohn L., Eloff, I., Ferreira, R., Ivankova, N.V., Jansen, J. D., Nieuwenhuis J., Pietersen, J., & Plano Clark, V. L. (2016). *First step in research.* Van Schaik.

Cronje, A., de Beer, J., & Ankiewicz, P. (2015). The development and use of an instrumental to investigate science teachers' views on indigenous knowledge. *African Journal of Research in Mathematics, Science and Technology Education, 19,* 319-332.

De Beer, J., & Mothwa, M. (2013). *Indigenous knowledge in the science classrooms: Science, Pseudoscience, or a missing link?* ISTE International Conference on Mathematics, Science and Technology Education, 21-24 October 2013. Mopani Camp in Kruger National Park, Limpopo, South Africa.

De Beer, J., & Mentz, E. (2016). *Self-directed learning: Lessons from indigenous knowledge holders for school science education.* https://uir.unisa.ac.za/bitstream/handle/10500/22868/Josef%20de%20Beer,%20Elsa%20Mentz.pdf?sequence=1

Denuga, D. D. (2018). An intervention on supporting teachers' understanding of and mediation of learning of stoichiometry in selected schools in the Zambezi Region [Unpublished doctoral dissertation]. Rhodes University.

Desimone, L. M. (2009). Improving Impact Studies of Teachers' Professional Development: Toward Better Conceptualizations and Measures. *Educational Researcher, 38*, 181-199.

Diwu, C. (2010). Effects of a dialogical argumentation instructional model on grade 10 learners' conception of fermentation. *PRAESA Occasional Papers, 36*. PRAESA.

Diwu, C. T., & Ogunniyi, M. B. (2012). Dialogical argumentation instruction as a catalytic agent for the integration of school science with Indigenous Knowledge Systems. *African Journal of Research in Mathematics, Science and Technology Education*, *16*, 333-347.

Dziva, D., Mpofu, V., & Kusure, L. P. (2011). Teachers' conception of indigenous knowledge in science curriculum in the context of Mberengwa district, Zimbabwe. *African Journal of Education and Technology, 1*, 88-102.

Embashu, W., & Nantanga, K. K. M. (2019) Pearl millet grain: A mini review of the milling, fermentation and brewing of *ontaku*, a non-alcoholic traditional beverage in Namibia. *Transactions of the Royal Society of South Africa, 74*, 276-282.

Embashu, W., Cheikhyoussef, A., & Kahaka, G. (2013). Oshikundu: A indigenous fermented beverage. In K. C. Chinsembu, A. Cheikhyoussef, D. Mumbengegwi, M. Kandawa-Schulz, C. D. Kasanda & L. Kazembe (Eds.). *Indigenous Knowledge of Namibia* (pp 187-203). University of Namibia Press.

Embashu, W., Cheikhyoussef, A., Kahaka, G., & Lendelvo, S. (2013). Processing methods of *Oshikundu*, a traditional bneverage from sub-tribes within *Aawambo* culture in the Northern Namibia. *Journal for Studies in Humanities and Social Sciences, 2*, 117-127.

Erinosho, S. Y. (2013). How do students perceive the difficulty of physics in secondary school? An exploratory study in Nigeria. *International Journal for Cross-Disciplinary Subjects in Education*, *3*, 1510-1515.

Eun, B. (2021). Teachers learning to teach: Professional development based on sociocultural theory for linguistically and culturally diverse classroom. *Professional Development in Education.* https://doi.org/10.1080/19415257.2021.1879224

February, F. (2016). Exploring the effect of a dialogical argumentation instructional model in enhancing grade two learners' understanding of the day and night cycle [Unpublished master's thesis]. University of the Western Cape.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods, 5,* 80-92.

Fernandez, C. (2014). Knowledge base for teaching and pedagogical content knowledge (PCK): Some useful models and implications for teachers' training. *Problems of Education in the 21st Century, 60*, 79-100.

Gana, A. K. (2009). Evaluation of the residual effect of cattle mature combinations with inorganic fertilizer and chemical weed control on the sustainability of chewing sugarcane production at Badeggi Southern Guinea Savanna of Nageria. *Middle-East Journal of Scientific Research, 4*, 282-287.

Gay, L. R., Mills, G. E., & Airasian, P. W. (2011). *Educational research: Competencies for analysis and application* (10th ed.). Pearson Education International.

Geddis, A. N., & Wood, E. (1997). Transforming subject matter and managing dilemmas: A case study in teacher education. *Teaching and Teacher Education, 13*, 611-626.

Goduka, N. (2005). Eziko: Sipheka sisophula: Nguni foundations for educating/researching for substainable development. *South African Journal of Higher Education*, *19*, 467-481.

Grossman, P. L. (1990). The making of a teacher: Teacher knowledge and teacher education. Teachers College Press.

Gwekwerere, Y. (2016). Schooling and the African child: Bridging African epistemology and Eurocentric physical sciences. In G. Emeagwali & E. Shizha (Eds.), *African indigenous knowledge and the sciences, journeys into the past and present* (pp. 33-46). Sense Publishers.

Hatcher, A., Bartler, C., Marshall, A., & Marshall, M. (2009). Two-eyed seeing in the classroom environment: Concepts, approaches, and challenges. *Canadian Journal of Science, Mathematics, and Technology Education, 9*(3), 141-153. https://doi.org/ 10.1080/14926150903118342

Hammond, J., & Gibbons, P. (2005). What is scaffolding? In A. Burns & H. S Joyce (Eds.), *Teachers' voice 8: Explicitly support reading and writing in the classroom* (pp. 8-16). National Centre for English Language Teaching and Research.

Hart, M. A. (2010). Indigenous worldviews, knowledge, and research: the development of an indigenous research paradigm. *Journal of Indigenous Voices in Social Work, 1*, 1-15.

Hashondili. S. (2020). Exploring working with Grade 6 Elementary Agricultural Science teachers on how to integrate local knowledge in food preservation [Unpublished master's thesis]. Rhodes University.

Hauster, V., Howlett, C., & Matthews, C. (2009). The place of indigenous knowledge in tertiary science education: A case study of Canadian practices in indigenizing the curriculum. *The Australian Journal of Indigenous Education, 38*, 46-57.

Hays, J. (2009). *Learning indigenous knowledge systems*. www.hsrcpress.ac.za

Henning, E., van Rensburg, W., & Smit, B. (2007). *Finding your way in qualitative research.* Van Schaik.

Hewson, M. G., & Ogunniyi, M. B. (2011). Argumentation-teaching as a method to introduce indigenous knowledge into science classrooms: Opportunities and challenges. *Cultural Studies of Science Education*, *6*, 679-692.

Hodson, D. (1990). A critical look at practical work in school science. *School Science Review*, *70*, 33-40.

Hodson, D. (2009). Teaching and learning about science. Language, theories, methods, history, tradition and values. Potterdam/Boston/Taipei.

Holmes, A. G. D. (2020). Researcher positionality - A consideration of its influence and place in qualitative research - A new researcher guide. *Shanlax International Journal of Education*, *8*, 1-10.

Hord, S. (1997). *Professional learning communities: Communities of continuous inquiry and improvement*. Southwest Educational Development Laboratory. http://www.sedl.org/pubs/change34/2.html

Horsthemke, K., & Schafer, M. (2007). Does ‘African mathematics’ facilitate access to mathematics? Toward an ongoing critical analysis of ethno-mathematics in a South African context. *Pythagoras, 65*, 2-9.

Huizinga, T., Handelzalts, A., Nieveen, N., & Voogt, M. (2014). Teacher involvements in curriculum design: Need for support to enhance teachers’ design expertise. *Journal of Curriculum Studies, 46*, 33-57: https://doi.org/10.1080/00220272.2013.834077

Isaacs, S. (2019). Towards the recognition of a Soweto boy's play capabilities in the formal education system [Unpublished doctoral thesis]. University of Johannesburg.

Jacobs, N. (2015). Investigation quality in education through the use of an active learning framework: A case of an intervention in the Namibian environmental curriculum studies [Unpublished master's thesis]. Rhodes University.

Jansen, J. (2017). Decolonizing the university curriculum given a dysfunctional school system? *Journal of Education, 68*, 3-14.

Jegede, O. J. (1995). Collateral learning and eco-cultural paradigm in Science and Mathematics education in Africa. *Studies in Science Education*, *25*, 95-137.

John, M., Molepo, J. M., & Chirwa, M. (2017). Secondary school learners' contextualized knowledge about reflection and refraction: A case study from South Africa. *Research in Science & Technological Education.* https://doi.org/10.1080/02635143.2017.1395331

John-Steiner, V., & Mahn, H. (1996). Sociocultural approaches to learning and development: A Vygotsky framework. *Educational Psychology, 3,* 191-206.

Jones, M. E., & Hunter, J. (2003). Enshrining indigenous knowledge in the national science curriculum: Issues arising from the Maori case. Articulating development and strengthening local practices. *Indilinga: African Journal of Indigenous Knowledge Systems 3*(2), 103-111.

Kakambi, W. M. (2020). Using the indigenous technology of dyeing and weaving African baskets as a cultural tool to mediate learning of chemical and physical changes [Unpublished master's thesis]. Rhodes University.

Kambeyo, L. (2012). An investigation into how grade 9 Physical Science learners make meaning of the topic on acids and bases through exploring their prior everyday knowledge and experiences: A case study [Unpublished master's thesis]. Rhodes University.

Kaseke, D., & Nyamupangedengu, E. (2019). Using concept map construction as a professional development activity aimed at developing a teacher's content knowledge for teaching a Biology topic: A self-study. In *South African association for research in mathematics, science and technology education* (pp. 130-144). SAARMSTE.

Kaya, E. (2013). Argumentation practices in classroom: Pre-service teachers' conceptual understanding of chemical equilibrium. *International Journal of Science Education, 35*, 1139-1158. https://doi.org/10.1080/09500693.2013.770935

Keane, M. (2008). Science education and worldview. *Journal for Cultural Studies of Science Education, 3*, 587–621. https://doi.org/10.1007/s11422-007-9086-5

Keane, M., Khupe, C., & Muza, B. (2016). *It matters who you are: Indigenous knowledge research and researchers*. https://doi.org/10.17159/1947-9417/2016/913

Keane, M., Khupe, C., & Seehawer, M. (2017). Decolonising methodology: Who benefits from indigenous knowledge research? *Educational Research for Social Change (ERSC), 6*, 12-24.

Kennedy, M. (1998). Education reform and subject matter knowledge. *Journal of Research in Science Teaching, 35*, 249-263. https://doi.org/10.1002/(SICI)1098-2736

Khupe, C. (2014). *Indigenous knowledge and school science: Possibilities for integration* [Unpublished doctoral thesis]. University of the Witwatersrand.

Kibirige, I., & van Rooyen, H. (2006). Enriching science teaching through the inclusion of indigenous knowledge. In J. de Beers & H. van Rooyen (Eds.), *Teaching science in the OBE classroom*. Macmillan.

Kibirige, I., Osodo, J., & Mgiba, A. N. (2014). Exploring grade 7 science teachers' perceptions regarding practical work in Limpopo, South Africa. *Mediterranean Journal of Social Sciences*, *5*, 399.

Kidman, G. (2011). Australia at the crossroads: A review of school science practical work. *Eurasia Journal of Mathematics, Science and Technology Education, 8*(1), 35-47.

Klein, J. (2011). Indigenous knowledge and education- the case of the Nama people in Namibia. *Education as Change, 15,* 81-94.

Koelsch, L. E. (2013). Re-conceptualizing the member check interview. *International Journal of Qualitative Research, 12*, 168-179.

Korthagen, F. (2017). Inconvenient truths about teacher learning: towards professional development. *Teachers and Teaching, 23*, 387- 405, https://doi.org/10.1080/13540602.2016.1211523

Kota, L. S. (2006). Local food choices and nutrition: A case study of amarewu in the FET consumer studies curriculum [Unpublished master's thesis]. Rhodes University.

Kovach, M. (2010). Conversation method in indigenous research. *First Peoples Child & Family Review*, *5*, 40-48. https://doi.org/10.7202/1069060ar

Kovach, M. (2012). Indigenous methodologies. Characteristics, conversations, and contexts. University of Toronto Press.

Kreisler, A., & Semali, L. (2001).Towards indigenous literacy: Science teachers learn to use indigenous knowledge resources. *Pacific Curriculum Network, 10*, 9-13.

Kruse, S. D., Louis, K. S., & Bryk, A. S. (1995). An emerging framework for analysing school-based professional community. In K. S. Louis & S. D. Kruse (Eds.), *Professionalism and community: Perspectives on reforming urban schools* (pp. 2-–34). Corwin Press.

Kudumo, P. W. (2020). Motivation to learn science and make sense of the concept of malleability through the traditional blast furnace in a grade 9 Physical Science class [Unpublished master's thesis]. Rhodes University.

Kuhlane, Z. (2011). An investigation into the benefits of integrating learners' prior everyday knowledge and experiences during teaching and learning of acids and bases in Grade 7: A case study [Unpublished master's thesis]. Rhodes University.

Lantolf, J., Thorne, S. L., & Poehner, M. (2015). Sociocultural theory and second language development. In B. van Patten & J. Williams (Eds.), *Theories in Second Language Acquisition* (pp. 207-226). Routledge.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Le Grange, L. (2007). Integrating western and indigenous knowledge systems: The basis for effective science education in South Africa? *International Review of Education, 53*, 577–591.

Le Grange, L. (2014). Currere's active force and the Africanisation of the university curriculum. *South African Journal of Higher Education, 28*, 1283-1294.

Le Grange, L., du Preez, P., Ramrathan, L., & Blignaut, S. (2020). Decolonising the university curriculum or decolonialwashing? A multiple case study. *Journal of Education, 80,* 25-48

Lemke, J. L. (1990). Talking *science: Language, learning, and values*. Ablex Publishing Corporation.

Lin, C-L., Tsai, C-C., & Liang, J-C. (2012). An investigation of two profiles within conceptions of learners' science: An examination of confirmatory factor analysis. *European Journal of Psychology Education, 27*, 499-521.

Liveve, A. K. (2017). Exploring the possibility of integrating traditional music and dance into the design and delivery of lessons on the concepts of echo and waves in the grade 10 Physical Science sound topic [Unpublished master's thesis]. Rhodes University.

Liveve, A., K. (2022). Revitalisation and indigenisation of the science curriculum through drum making, drumming, music and dance [Unpublished master's thesis]. Rhodes University.

Louw, W. (2010). Africanisation: A rich environment for active learning on a global platform. *Progression, 32*, 42-54.

Luehmann, A. L. (2009). Students' perspectives of a science enrichment programme: Out- of-school inquiry as access. *International Journal of Science Education, 31*, 1831-1855. https://doi.org/10.1080/09500690802354195

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 95-132). Kluwer.

Mallet, M., & du Plessis, P. (2001). *Mahangu post-harvest systems: a summary of current knowledge about pearl millet post-harvest issues in Namibia*. Windhoek, Centre for Research, Information, Action in Africa-South African Development and Consulting (CRIAA SADC).

Mapara, J. (2009). *Indigenous knowledge systems in Zimbabwe juxtaposing postcolonial theory*. Department of African Languages and Literature, Great Zimbabwe University.

Matemba, Y. H., & Lilemba, J. M. (2015). Challenging the status quo: Reclaiming Indigenous Knowledge through Namibia's postcolonial Education System. *Diaspora, Indigenous, and Minirity Education, 9*, 159-174. https://doi.org/10.1080/15595692.2014.997382

Mateus, V., & Ngcoza, K. M. (2019). The making of clay pots and its relevance to school science: Reclaiming knowledge in the cultural practice of *Ovawambo* people in Namibia: *Indilinga African Journal of Indigenous Knowledge Systems*, *18*, 64-77.

Mavhunga, E., & Rollnick, M. (2013). Improving PCK of chemical equilibrium in pre-service teachers. *African Journal of Research in Mathematics, Science and Technology Education, 17*, 113-125.

Mavhunga, E., Ibrahim, B., Qhobela, M., & Rollnick, M. (2016). Student teachers' competence to transfer strategies for developing PCK for Electric Circuits to another Physical Science topic. *African Journal of research of Mathematics, Science and Technology Education*, *20*, 299-313. https://doi.org/10.1080/18117295.2016.1237000

Mavuru, L., & Dudu, W. T. (2020). Advances in inquiry-based science education in Zimbabwean schools. In *School science practical work in Africa* (pp. 32-49). Routledge.

Mavuru, L., & Ramnarain, U. (2017). Teachers' knowledge and views on the use of learners' socio-cultural background in teaching natural sciences in grade 9 township classes. *African Journal of Research in Mathematics, Science and Technology Education*, *21*, 176-186.

Mayoh, K., & Knutton, S. (1997). Using out- of- school experience in science lessons: reality or rhetoric? *International Journal of Science Education, 19*, 849-867. https://doi.org/10.1080/0950069970190708.

Mbembe, A. (2021). *Out of the dark: Essays on decolonization*. Columbia University Press.

Mensah, F. M. (2011). A case for culturally relevant teaching in science education and lesson learned for teacher education. *The Journal of Negro Education, 80*, 296-309.

Meyer, H. (2004). Novice and expert teachers' conceptions of learners' prior knowledge. *Wiley InterScience*. https://onlinelibrary.wiley.com/doi/pdf/10.1002/sce.20006

Meyer, M. (2010). The rise of the knowledge broker. *Science Communication, 32*, 118-127

Mhakure, D., & Mushaikwa, N. (2014). Science teachers' indigenous knowledge identities. *Mediterranean Journal of Social Science, 20*, 1554-1563.

Mhakure, D., & Otulaja, F. S. (2017). Culturally-responsive pedagogy in science education. In F. S. Otulaja & M. B. Ogunniyi (Eds.), *The world of science education. Cultural and historical perspectives on science education. Handbooks* (pp. 81-100). Sense Publishers.

Millar, R. (2009). *The role of practical work in the teaching and learning of science.* Paper prepared for the committee, high school science laboratories: Role and vision. National Academy of Science, Washington, DC.

Ministry of Basic Education and Culture (1999). *How learner centred are you?* NIED.

Ministry of Education (2018). The National Curriculum for Basic Education. NIED.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teacher College Records, 108*, 1017-1054.

Mokiwa, H. O. (2014). Teachers' conceptions of teaching physical science in the medium of english: towards additive bilingualism? *Mediterranean Journal of Social Sciences, 5, 79-86.*

Morine-Dershimer, G., & Kent, T. (1999). The complex nature and sources of teachers' pedagogical knowledge. In *Examining pedagogical content knowledge* (pp. 21-50). Springer.

Moser, S. (2008). Personality: A new positionality? *Area, 40,* 383-392.

Mothwa, M. M. (2011). *Teachers' experiences of incorporating indigenous knowledge in Life Sciences* [Unpublished doctoral thesis]. University of Johannesburg.

Mudau, A., & Tabane, R. (2014). Practical works as it says practical is something student do by themselves. *Mediterranean Journal of Social Sciences, 5*, 446-453.

Mukwambo, M. (2017). Exploring and expanding situated cognition in teaching science concepts: The nexus of indigenous knowledge and Western modern science [Unpublished doctoral thesis]. Rhodes University.

Mukwambo, M., Ngcoza, K., & Chikunda, C. (2014). Africanisation, Ubuntu and IKS: A learner-centred approach. In C. I. O. Okeke, M. M. van Wyk & N. T. Phasha (Eds.), *Schooling, society and inclusive education: An African perspective* (pp 1-16). Oxford University Press.

Mushayikwa, E., & Ogunniyi, M. (2011, January). Modelling the integration of IKS into the teaching and learning of Science. In *Proceedings from the 19th conference of the Southern Association of Research in Science, Mathematics and Technology Education* (pp. 408-425).

Mutanho, C. (2021). Exploring indiginising the university's science curriculum through bottom-up decolonisation: Affordances and hindrances [Unpublished doctoral thesis]. Rhodes University.

Nakata, M. (2007). The cultural interface. *The Australian Journal of Indigenous Education*, *36*, 7-14.

Namibia. (2011). Population and housing census indicators. Windhoek.

Nangola, R. N. (2018). Exploring how Grade 11 Biology teachers mediate learning of osmosis when using easily accessible resources in the Oshikoto Region, Namibia [Unpublished master's thesis]. Rhodes University.

Ngcoza, K. M. (2007). Science teachers' transformative and continuous professional development: A journey towards capacity-building and reflexive practice [Unpublished doctoral thesis]. Rhodes University.

Ngcoza, K. M., & Southwood, S. (2015). Professional development networks: From transmission to co-construction. *Perspectives in Education, 33*, 4-14.

Ngcoza, K., & Southwood, S. (2019). Webs of development: Professional networks as spaces for learning. *Pythagoras, 40*, 1-7.

Nhase, Z. (2019). An exploration of how grade 3 foundation phase teachers develop basic scientific process skills using an inquiry-based approach in their classrooms [Unpublished doctoral thesis]. Rhodes University.

Nikodemus, K. S. (2017). Exploring how Grade 11 Physical Science learners make sense of the concept of rates of reactions through the inclusion of the indigenous practice of making Oshikundu [Unpublished master's thesis]. Rhodes University.

Nkhata, S. G., Ayua, E., Kamau, E. H., & Shingiro, J. B. (2018). Fermentation and germination improve nutritional value of cereals and legumes through activation of endogenous enzymes. *Food Science & Nutrition*, *6*, 2446-2458.

Nuntsu, S. N. (2020). Mobilising stories about cultural beliefs and practices on traditional foods to contextualise the topic on nutrition in a Grade 6 township class [Unpublished master's thesis]. Rhodes University.

Nyambe, J., & Wilmot, D. (2012). New pedagogy, old pedagogic structures: A fork-tongued discourse in Namibian teacher education reform. *Journal of Education, 55*, 55-82.

Nyambe, J., Kasanda, C., & Iipinge, S. (2016). A 'teacher-centred' approach to CPD: The case of Namibia's localized and decentralized model of teacher CPD. *Continuing Professional Teacher Development in Sub-Saharan Africa: Improving Teaching and Learning*, *41*.

Nyambe, K. J. (2008). Teacher educators' interpretation and practice of learner-centred pedagogy: A case study [Unpublished doctoral thesis]. Rhodes University.

Nyika, R. (2017). Views and experiences of Gweru Rural Primary schools teachers on integrating indigenous knowledge system in the teaching and learning of Environment Science in Zimbabwe. *Journal of Arts, Humanities and Social Sciences, 5*, 280-286.

O'Leary, Z. (2014). The essential guide to doing your research project (2nd ed.). Sage.

Ogunniyi, M. B. (2004). The challenge of preparing and equipping science teachers in higher education to integrate scientific and indigenous knowledge systems for learners. *South African Journal of Higher Education, 18*, 289-304.

Ogunniyi, M. B. (2007a). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum: Part 1. *International Journal of Science Education, 29*, 963-986.

Ogunniyi, M. B. (2007b). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum: Part 2 [Abstract]. *International Journal of Science Education, 29*, 1189-1207.

Ogunniyi, M. B. (2018). Indigenization of the curriculum: The prospects and the challenges. In L. M. Semali & A. Singambi (Eds.), *Proceedings of the 4th Annual Conference of the African Association for the Study of Indigenous Knowledge Systems* (pp. 2-16). AASIKS.

Ogunniyi, M. B., & Ogawa, M. (2008). The prospects and challenges of training South African and Japanese educator to enact an indigenized science curriculum. *South Africa Journal of Higher Education, 22*, 175-190.

Osman, D. J., & Warner, J. R. (2020). Measuring teachers' motivation: The missing link between professional development and practice. *Teaching and Teacher Education, 92*, 1-12.

Otera, F. K., & Nathan, M. J. (2008). Preservice Elementary Teachers' views of their students' prior knowledge of science: *Journal of Research in Science Teaching, 45*, 497-523.

Ottander, C., & Grelsson, G. (2006). Laboratory work: the teachers' perspective. *Journal of Biological Education, 40*, 113-118. https://doi.org/10.1080/00219266.2006.9656027

Òtúlàjà, F. S., Cameron, A., & Msimanga, A. (2011). Rethinking argumentation-teaching strategies and indigenous knowledge in South African science classrooms. *Culture Studies of Science Education, 6*, 693-703.

Onwu, G. O. M., & Charles Mufundirwa, C. (2020) A Two-Eyed Seeing Context based Approach for Incorporating Indigenous Knowledge into School Science Teaching, African *Journal of Research in Mathematics, Science and Technology Education, 24*, 229-240, DOI: 10.1080/18117295.2020.1816700

Owuor, J. A. (2007). Integrating African Indigenous knowledge in Kenya's Formal Education system: The potential for sustainable development. *Journal of Contemporary Issue in Education, 2*, 21-37.

Palincsar, S, A. (1998). Social constructivist perspectives on teaching and learning: *Annual Review Psychology, 49,* 345-375.

Pete, S. (2015). *100 ways to indigenize and decolonize academic programs and courses*. https://www.uregina.ca/president/assets/docs/president-docs/indigenization/indigenize-decolonize-university-courses.pdf

Pidgeon, M. (2019). Moving between theory and practice within an Indigenous research paradigm. *Qualitative Research, 19*, 418-436.

Pitjeng-Mosabala, P., & Rollnick, M. (2018). Exploring the development of novice unqualified graduate teachers' topic specific pck in teaching the particulate nature of matter in South African's classrooms. *International Journal of Science Education*, *40*(4), 1-29. http://dx.doi.org/10.1080/09500693.2018.1446569

Probyn, M. (2009). Making sense of science through two language: A South African case study. University of Gloucestershire.

Quinnell, R., Thompson, R., & LeBard, R. J. (2013) It is not Maths; it is science: Exploring thinking dispositions, learning thresholds and mindfulness in science learning. *International Journal of Mathematical Education in Science and Technology, 44*, 808-816, https://doi.org/10.1080/0020739X.2013.800598

Raju, C. K. (2001). *Three ways to decolonize science*. http://ckraju.net/papers/uct-panel-decolonising-science-ckr-summary.pdf

Ramorogo, G., & Ogunniyi, M. (2010). Exploring teachers' conceptions of the rainbow using an argumentation-based intervention. *African Journal of Research in Mathematics, Science and Technology Education*, *14*, 24-35.

Rennie, L. J., Feher, E., Dierking, L. D., & Falk, J. H. (2003). Toward an Agenda for Advancing Research on Science Learning in Out-of-School Settings: *Journal of Research in Science Teaching, 40*, 112-120.

Richardson, J. T. E. (2010). Approaches to studying, conceptions of learning and learning styles in higher education. *Learning and Individual Differences, 21*, 288-293.

Roller, M. R., & Lavrakas, P.J. (2015). Applied qualitative research design: A total quality framework approach. Guildford Press.

Rollnick, M., & Mavhunga, E. (2016). The place of subject matter knowledge in teacher education. In J. Loughran & M. Hamilton (Eds.), The international handbook on teacher education (pp. 423-452). Springer.

Rollnick, M., Bennett, J., Rhemtula, M., Dharsey, N., & Ndlovu, T. (2008). The place of subject matter knowledge in pedagogical content knowledge: A case study of South African teachers teaching the amount of substance and chemical equilibrium. *International Journal of Science Education, 30*, 1365-1387.

Roschelle, J. (1995). Learning in interactive environment: Prior knowledge and new experience. In J. H. Falk & L. D. Dierking (Eds.), Public institution for personal learning: Establishing a research agenda (pp. 1-26). American Association of Museum.

Rule, P., & John, V. (2011). *Your guide to case study research*. Van Schaik.

Ryan, J., & Gass, S. (2012). *Stimulated recall*. https://www.researchgate.net/publication/267573796

Sayed, Y., Motala, S., & Hoffman, N. (2017). Decolonizing initial teacher education in South Africa universities: More than an event. *Journal of Education, 68*, 59-92.

Sedlacek, K., & Sedova, M. (2017). How many are talking? The role of collectivity in dialogic teaching. *International Journal of Educational Research, 85*, 99-108.

Seehawer, M. (2018). Decolonising research in a Sub-Saharan African context: Exploring Ubuntu as a foundation for research methodology, ethics and agenda. *International Journal of Social Research Methodology*. https://doi.org/10.1080/13645579.2018.1432404

Seehawer, M. (2018). South African science teachers' strategies for integrating indigenous and western knowledge in their classes: Practical lessons in decolonisation. *Educational Research for Social Change (ERSC)*, 7, 91- 110. https://doi.org/10.17159/2221-4070/2018/v7i0a7

Seehawer, M., & Breidlid, A. (2021). Dialogue between epistemologies as quality education. Integrating knowledge in Sub-Sahara Africa classrooms to foster sustainability learning and contextually relevant education. *Social Science and Humanities Open, 4*, 1-8.

Shabani, K. (2016). Applications of Vygotsky's sociocultural approach for teachers' professional development. *Cogent Education*, *3*, 1-10.

Shabani, K., Khatib, M. & Ebadi, S. (2010). Vygotsky's zone of proximal development: Instructional Implications and teachers' professional development. *Canadian Center of Science and Education, English Language Teaching, 3,* 237-248.

Sharratt, M., & Usoro, A. (2003). Understanding knowledge-sharing in online communities of practice. *Electronic Journal on Knowledge Management, 1*, 187-196.

Shifafure, A. M. (2014). Understanding how grade 11 Physical Science teachers mediate learning of the topic distillation in the Kavango Region [Unpublished master's thesis]. Rhodes University.

Shinana, E. N. L. (2019). Mobilising the indigenous practice of making Oshikundu using an inquiry-based approach to support Grade 8 Life Science teachers in mediating learning of enzymes [Unpublished master's thesis]. Rhodes University.

Shinana, E., Ngcoza, K. M., & Mavhunga, E. (2021). Development of teachers' PCK for a scientific inquiry-based teaching approach in Namibia's rural schools. *African Journal of Research in Mathematics, Science and Technology Education.* https://doi.org/10.1080/18117295.2021.1913375

Shizha, E. (2007). Critical analysis of problems encountered in incorporating indigenous knowledge in science teaching by primary school teachers in Zimbabwe. *Alberta Journal of Educational Research, 53,* 302-319.

Shizha, E. (2016). African indigenous perspectives on technology. In G. Emeagwali & E. Shizha (Eds.), *African indigenous knowledge and the sciences, journeys into the past and present* (pp. 47-62). Sense Publishers.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Education Researcher, 15*, 4-14.

Shulman, L. S. (1987). Knowledge and teaching: foundations of a new reform. *Harvard Educational Review, 57* (1), 1-22.

Shulman, L. S. (2015). PCK: Its genesis and exodus. In A. Berry, P. Friedrichsen & J. Loughran (Eds.), *Re-examining pedagogical content knowledge in science education* (pp. 28-42). Routledge.

Sibanda, D. (2018). What sequence do we follow in teaching concepts in Chemistry? A study of high school Physical Science teachers' PCK. *African Journal of Research in Mathematics, Science and Technology Education, 22*, 196-208. https://doi.org/10.1080/18117295.2018.1484408

Simasiku, F. S. (2016). Exploring Grade 9 Physical science teachers' views and experiences on the inclusion of traditional or local knowledge (indigenous knowledge) in their lesson. A Namibian case study [Unpublished master's thesis]. Rhodes University.

Simonds, V. W., & Christopher, S. (2013). Adapting Western Research Methods to Indigenous Ways of Knowing. American Journal of Public Health, 103, 2185-2192

Singh, H., Luft, J. A., & Napier, J. B. (2021). The development of ePCK of newly hired in-field and out-of-field teachers during their first three years of teaching. *European Journal of Teacher Education.* https://doi.org/10.1080/02619768.2021.1943660

Siseho, C. S. (2013). The effect of an argumentation instructional model on pre-service teachers' ability to implement a science-IK curriculum [Unpublished doctoral thesis]. University of Western Cape.

Smith, T. M., & Desimone, L. M. (2003). Do changes in patterns of participation in teachers' professional development reflect the goals of standards-based reform? *Educational Horizons, 81*, 119-129.

Snively, G. J., & Williams, L. B. (2008). "Coming to know". Weaving Aboriginal and western science knowledge, language, and literacy into the science classroom. *Educational Studies in Language and Literature, 8,* 109-133.

Stott, D. (2016). Making sense of the ZPD: An organizing framework for Mathematics education research. *African Journal of Research in Mathematics, Science and Technology Education, 20*, 25-34.

Stracke, E. (2010). Undertaking the Journey Together: Peer Learning for a Successful and Enjoyable PhD Experience. *Journal of University Teaching & Learning Practice, 7*, 111-121. https://doi.org/10.53761/1.7.1.8

Supasorn, S., & Promarak, V. (2015). Implementation of 5E inquiry incorporated with analogy learning approach to enhance conceptual understanding of chemical reaction rate for grade 11 students. *Chemistry Education Research and Practice, 16*, 121-132.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of research in science teaching, 37*, 963-980.

Supovitz1, J. A & Turner, H. M (2000). The Effects of Professional Development on Science Teaching Practices and Classroom Culture. *Journal of Research in Science Teaching, 37*, 963-980.

Tam, A. C. F. (2015). The role of a professional learning community in teacher change: a perspective from beliefs and practices. *Teachers and Teaching, 2*, 22-43. https://doi.org/10.1080/13540602.2014.928122

Taylor, D. L., & Booth, S. (2015). Secondary physical science teachers' conceptions of science teaching in a context of change. *International Journal of Science Education, 37*, 1299-1320. https://doi.org/10.1080/09500693.2015.1035356

Taylor, D. L., & Cameron, A. (2016). Valuing IKS in successive South Africa physical science curricula. *African Journal of Research in Mathematics, Science and Technology Education, 20*, 35-44.

Thiong'o, Ngũgĩ wa. (2009). Foreword. In D. Caracciolo & A. M. Mungai (Eds.), *In the spirit of Ubuntu. Stories of teaching and research* (p. ix). Rotterdam: Sense Publishers.

Tibika, F. (2013). *Molecular consciousness: Why the universe is aware of our presence*. Park Street Press, Rochester, Vermont, Toronto. Canada.

Tosey, P. & Gregory, J. (1998). The Peer Learning Community in Higher Education: Reflections on Practice, Innovations in Education and Training International, 35:1, 74-81, DOI: 10.1080/1355800980350110

Tosey, P. (1999). The peer learning community: a contextual design for learning? *Management Decision, 37*, 403-410.

Tsai, C-C. (2004). Conceptions of learning science among high school students in Taiwan: a phenomenographic analysis. *International Journal of Science Education, 26*, 1733-1750. https://doi.org/10.1080/0950069042000230776

Tsai, C-C., & Kuo, P-C. (2008). Cram school students' conceptions of learning and learning science in Taiwan. *International Journal of Science Education, 30*, 353-375. https://doi.org/10.1080/09500690701191425

Turuk, M. C. (2008). The relevance and implications of Vygotsky's socio-cultural theory in the second language classroom. *ARECLS, 5*, 244-262.

UNICEF. (2011). Improving quality and equity in education in Namibia: A trend and gap analysis. UNICEF.

Utete, C., Ilukena, A., & Sindano, G. (2017). Exploring how modern science impede the development of indigenous knowledge (IK) [ethino-science and ethno-mathematics] in the Kavango East Region: A case study. *Journal for Studies in Humanities and Social Science, 6,* 68-88.

Uushona, I. T. K. (2013). An investigation into how grade 9 learners make sense of the fermentation and distillation processes through exploring the indigenous practice of making the traditional alcoholic beverage called Ombike: A case study [Unpublished master's thesis]. Rhodes University.

Vadeboncoeur, J. A & Collie, R. J. (2013). Locating Social and Emotional Learning in Schooled Environments: *A Vygotskian Perspective on Learning as Unified, Mind, Culture, and Activity, 20*, 201-225, DOI: 10.1080/10749039.2012.755205.

Vakalahi, H. F. O., & Taiapa, J. T. T. (2013). Getting grounded on Maori research. *Journal of Intercultural Studies,* 1-11.

Van Driel, J. H., Verloop, N., & de Vos, W. (1998). Developing science teachers pedagogical content knowledge. *Journal of Research in Science Teaching, 35*, 673-695.

Vollebregt, B. R., Gaigher, E., & Coetzee, C. (2021). Development of science teachers' PCK about waves through training in the use of the ripple tank apparatus. *African Journal of Research in Mathematics, Science and Technology Education, 25*, 12-26.

Vygotsky, L. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

Wahyuni, D. (2012). The research design maze: Understanding paradigms, cases, methods and methodologies. *Journal of Applied Management Accounting Research, 10,* 69-80.

Walker, D., & Myrick, F. (2006). Ground theory: An exploration of process and procedure. *Qualitative Health Research, 16*, 547-559.

Walter, M. (2009). Participatory action research. In A. Bryman (Ed.), *Social research methods* (pp. 151-158). The Falmer Press.

Warle, B., Riar, C., Gaikwad, S., & Mane, V. (2015). Effect of germination on nutritional quality of soybean (Glycine Max). *Red*, *1*(1.3).

Webb, P. (2013). Xhosa indigenous knowledge: Stakeholder awareness, value, and choice. *International Journal of Science and Mathematics Education, 11,* 89-110.

Wenger, E. (1998). Community of practice. Learning, meaning and identity. University of Cambridge Press.

Wenger, E., & Wenger-Trayner, B. (2015). *Communities of practice*: *A brief introduction*. https://wenger-trayner.com/introduction-to-communities-of-practice/

Wenger, E., McDermott, R., & Snyder, W. M. (2002). *Cultivating communities of practice*. Harvard Business School Press.

Williams, J. J., & Lombrozo, T. (2010). Explanation constrains learning and prior knowledge constrains explanation. University of California.

Wilson, S. (2001). What is indigenous research methodology? *Canadian Journal of Native Education, 25*, 175-179

Wilson, S. (2003). Progressing toward an indigenous research paradigm in Canada and Australia. *Canadian Journal of Native Education, 27*, 161-178.

Wisdom, G. O., Ndana, R. W., & Abdulrahim, Y. (2012). The comparative study of the effect of organic manure cow dung and inorganic fertilizer NPK on the growth rate of maize (Zea mays L.). *International Research Journal of Agricultural Science and Soil Science*, *2*, 516-519.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem-solving. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 17*, 89-100.

Woodley, E**.** (2009). Practical work in school science - Why is it important? *School Science Review*, 91, 49-51.

Wyatt, T. R., de Dousa, E. B. C., & Mendenhall, S. C. (2017). Professional Development as a Process of Cultural Brokering: Positioning Coaches as Cultural Brokers: *Journal of Educational Research and Practice*, 7, 95-110.

Yalçınkaya, E., Taştan-Kırık, Ö., Boz, Y., & Yıldıran, D. (2012). Is case-based learning an effective teaching strategy to challenge students' alternative conceptions regarding chemical kinetics? *Research in Science & Technological Education, 30*, 151-172. https://doi.org/10.1080/02635143.2012.698605

Yazan, B. (2015). Three approaches to case study methods in education: Yin, Merriam, and Stake. *The Qualitative Report on Teaching and Learning, 20*, 134-152.

Yeasmin, S., & Rahman, K. F. (2012). Triangulation research method as the tool of social science research. *Bangladesh University of Professionals Journal, 1*, 2219-4851.

Yoon, J., & Kim, J. (2019). A sociocultural theoretical approach to understanding mentor-mentee interactions during a teaching English as a second language practicum at the Masters' degree level. *Mentoring & Tutoring*: *Partnership in Learning, 27*, 88-108.

Zengeya-Makulu, V., Kushure, I., Zengeya, A., & Bhukuvhani, C. E. (2013). Secondary school teachers'conception of indigenous knowledge: A basis for its inclusion into curriculum. *International Journal of Innovative Research and Development, 2*, 446-452.

APPENDICES

Appendix A: Research Ethics clearance

RHODES UNIVERSITY
Where leaders learn

Prof K Ngcoza and Ms Z Nhase
Faculty of Education
Rhodes University

18 June 2020

Dear Prof Ngcoza and Ms Nhase,

Research Ethics Clearance for Mr Fredrick Simataa Simasiku (13S7222)

I hereby grant provisional research ethics approval for the PhD study provisionally titled "Working with Grade 10Chemistry teachers and in community on how to integrate local or indigenous in Chemistry lessons".

Approval is provisional, pending receipt of the permission letter from the following authorities:

Education Director (relevant region).

Approval is granted for one year. Aprogress report will be requested in order to renew approval at the end of 2020, if required. Please notify the Faculty of Education Ethics Committee should any substantive change(s) that deviate from this application, be made during the research process. Please also provide a brief report to the Committee on the completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, or if any problems arose that the Committee should be aware of. If the research results in the completion of a thesis lodged in the Rhodes University Library, please provide the Committee with the details of the submission as well.

The Provisional Ethics Clearance Number for this study is 2020-07/20.

We wish you every success with thisstudy.

Prof Eureta Rosenberg (E.Rosenberg@ru.ac.za)
Education Faculty Ethics Chair

Copied to:Dr GamuchiraiChakona; Mr Siyanda Manqele

Appendix B: Permission letter to the Director

RHODES UNIVERSITY
Where leaders learn

Rhodes University
Drosty Road,
Grahamstown,
6139

Office of the Director
Ohangwena Directorate of Education
Private Bag 88005
Eenhana

22 June 2020

Dear. Mr. Hamatwi

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

I am **Fredrick Simataa Simasiku**, student no: **13s7222** a second years student, am a registered PhD student in the Department of Education at the Rhodes University. My supervisor is **Prof Kenneth Mlungisi Ngcoza.** The proposed topic of my research is:

*Leveraging peer-learning community and expert community members in the integration of indigenous knowledge into the learning and teaching of Grade 10 Chemistry on the rate of reactions.*The objective of the study is: To mobilise the indigenous knowledge practice as an example on how to integrate local or indigenous knowledge to contextualise Chemistry lessons.

I am hereby seeking your consent to allow me to carry out the research in Ohangwena region specifically in Endola Circuit. Three secondary schools under the Ministry of Education, Arts & Culture will be involved. Six Grade 10 Chemistry teachers will take part in this study. The research will be divided into seven phases. I therefore, seek permission for three secondary schools and six Chemistry teachers to take part in the research after school between 14:00-16:00. To assist you in reaching a decision, I have attached to this letter:

(a) A copy of an ethical clearance certificate issued by the University

(b) A copy of the research instruments which I intend using in my research

(c) A copy of abstract and research process I will be following

Should you require any further information, please do not hesitate to contact me or my supervisor. Our contact details are as follows: I can be reached at +264813808989 and email (wadingha@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 University of Free State, email address (nhasez@ufs.ac.za), Cell: +27847868093
3. The Rhodes University Ethic Coordinator Research office is Mr. Siyanda Manqele, email address (s.manqele@ru.ac.za), Tell: +27466037727 and Fax: +27866167707

Upon completion of the study, I undertake to provide your office with the feedback.

Yours sincerely,

Fredrick Simataa Simasiku

Onepandaulo Combined School

Endola Circuit

Appendix C: Response from the office of the Director

REPUBLIC OF NAMIBIA
OHANGWENA REGIONAL COUNCIL
DIRECTORATE OF EDUCATION, ARTS AND CULTURE

Section: Office of the Director
Tel: (+264) 65 290200
Fax: (+264) 65 290224
Enquiries: Magano Gaoses
Our Ref: 12/3/10/1

Harelbecke Street, Greenwell Complex Building
Private Bag, 88005
Eenhana

26 June 2020

To: Mr. Fredrick Simataa Simasiku
Onepandaulo Combined School
Endola Circuit

SUBJECT: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

1. Receipt of your letter dated 22 June 2020 is hereby acknowledged.
2. The request has been evaluated and found to have merit.
3. Kindly be informed that permission to collect data from three secondary school in Endola circuit for research has been granted under the following conditions and requests.
   - The data to be collected only be used for the completion of your studies.
   - Kindly liaise with the concerned Principals so as to make prior arrangements before the date of the research.
   - No other data should be collected other than the data stated in the request.
   - You may share the final report of your study with the directorate.
4. It is trusted that you will find this arrangement in order while wishing you all the best with your studies.

Yours Sincerely,

26/06/2020

Ohangwena Regional Council
Directorate ... Culture
26 JUN 2020

Isak Hamatwi
Director

cc: Inspector of Education: Endola circuit

Appendix D: Permission letter to the Inspector office

Rhodes University

Drosty Road,
Grahamstown,
6139

Inspector of Education
Endola Circuit
P O Box 3668
Ongwediva

07 July 2020

Dear. Mr. Simon Vaeta

REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN ENDOLA CIRCUIT

I am **Fredrick Simataa Simasiku**, student no: **13s7222** a second years student, am a registered PhD student in the Department of Education at the Rhodes University. My supervisor is **Prof Kenneth Mlungisi Ngcoza**. The proposed topic of my research is: *Leveraging peer-learning community and expert community members in the integration of indigenous knowledge into the learning and teaching of Grade 10 Chemistry on the rate of reactions.*The objective of the study is: To mobilise the indigenous knowledge practice as an example on how to integrate local or indigenous knowledge to contextualise Chemistry lessons.

I am hereby seeking your consent to allow me to carry out the research in Endola Circuit. Six Grade 10 Chemistry teachers will take part in this study. The research will be divided into seven phases. I therefore, seek permission for three secondary schools **………………………**and six Chemistry teachers to take part in the research after school between 15:00-17:00. To assist you in reaching a decision, I have attached to this letter:

(a) A copy of an ethical clearance certificate issued by the University
(b) A copy of approved letter from the Director's office
(c) A copy of abstract and research process I will be following

Should you require any further information, please do not hesitate to contact me or my supervisor. Our contact details are as follows: I can be reached at +264813808989 and email (wadingha@gmail.com)

NB: For any further inquiries the following can be contacted:

4. My supervisor: Prof K. M. Ngcoza at Rhodes University, email address (k.ngcoza@ru.ac.za), Cell: +27788852143

5. My co-supervisor: Dr. Zukiswa Nhase at University of Free State, email address (nhasez@ufs.ac.za), Cell: +27847868093
6. The Rhodes University Ethic Coordinator Research office is Mr. Siyanda Manqele, email address (s.manqele@ru.ac.za), Tell: +27466037727 and Fax: +27866167707

Upon completion of the study, I undertake to provide you with the feedback

Yours sincerely,

Fredrick Simataa Simasiku

Onepandaulo Combined School

Endola Circuit

Appendix E: Response from the Inspector office

REPUBLIC OF NAMIBIA
OHANGWENA REGIONAL COUNCIL
DIRECTORATE OF EDUCATION, ARTS AND CULTURE

Section Inspectorate
Tel: (+264) 65 265810
Fax: (+264) 65 268826
Enquiries: Mr. Simon Vaeta
Email Address: vaetasimon@gmail.com
Our Ref: 01

ENDOLA CIRCUIT

P O Box 3668
Ongwediva
10th July, 2020

To: Fredrick Simataa Simasiku

Onepandaulo Combined School

Endola Circuit, Ohangwena Region

Dear Mr. Simasiku,

RE: A REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN ENDOLA CIRCUIT

This letter serves to inform you that your request in a letter dated 7th **July, 2020** to conduct a research in three secondary schools namely Eengedjo SS; Omungwelume SSS and Shituwa SSS and six Chemistry teachers has been granted under the following terms and references:

- The data to be collected should only to be used for the completion of your studies.
- You are only collecting the data that for which you have requested.
- Your collection of data should not in any way disturb school activities.

Kindly liaise with the concerned School Principals so as to make prior arrangements before the date of the research.

It is wished and hoped that you would find this arrangement in order while wishing you all the best with your studies.

I thank you.

Yours in quality education.

10.07.2020

16 -07- 2020

Mr. Simon Vaeta

Inspector of Education, Endola Circuit

Appendix F: Permission letter to the school Principal

Rhodes University

Drosty Road,
Grahamstown,
6139

Dear: Principal
…………………. Secondary School
P O Box ………
Oshakati

20 July 2020

REQUEST FOR PERMISSION TO BE A PARTICIPANT IN MY RESEARCH

I am **Fredrick Simataa Simasiku**, student no: **13s7222** a second years student, am a registered PhD student in the Department of Education at the Rhodes University. My supervisor is **Prof Kenneth Mlungisi Ngcoza.** The proposed topic of my research is: *Leveraging peer-learning community and expert community members in the integration of indigenous knowledge into the learning and teaching of Grade 10 Chemistry on the rate of reactions.* The objective of the study is: To mobilise the indigenous knowledge practice as an example on how to integrate local or indigenous knowledge to contextualise Chemistry lessons.

I am hereby seeking your consent to take part as a participant in my research as Grade 10 Chemistry teachers at school **…………**. The research will be divided into seven phases. I therefore, seek permission for you (Chemistry teacher) to take part in the research after school between 14:00-17:00. **…………** also will be part of the research process and contribute knowledge in the field of science and integrating of indigenous knowledge in Chemistry.

I will assure you that the data generated in this study will not be used for any other purposes outside its intended purpose. The identity of the participants will be treated as confidential. The data collected (hard and soft copies) will be kept in the places that a lockable for 24/7 at least a period of five years. The data collected will be used for reporting in my thesis and publications. Confidentiality of information and anonymity of participants is guaranteed. To assist you in reaching a decision, I have attached to this letter:

(a) A copy of an ethical clearance certificate issued by the University
(b) A copy of the research instruments which I intend using in my research
(c) A copy of abstract and research process I will be following
(d) A copy of approved letter from the Director's office, Inspector's office and School Principal

Should you require any further information, please do not hesitate to contact me or my supervisor. Our contact details are as follows: I can be reached at +264813808989 and email (wadingha@gmail.com)

NB: For any further inquiries the following can be contacted:

My supervisor: Prof K. M. Ngcoza at Rhodes University, email address (k.ngcoza@ru.ac.za), Cell: +27788852143. My co-supervisor: Ms Zukiswa Nhase at University of Free State, email address (nhasez@ufs.ac.za), Cell: +27847868093. The Rhodes University Ethic Coordinator Research office is Mr. Siyanda Manqele, email address (s.manqele@ru.ac.za), Tell: +27466037727 and Fax: +27866167707
Upon completion of the study, I undertake to provide you with the feedback on request.

NB: Transport to the research venue will be provided and lunch.

Yours sincerely,

Fredrick Simataa Simasiku

Onepandaulo Combined School

Endola Circuit

Appendix G: Semi-structured interviews and purpose

What are Grade 10 Chemistry teachers' experiences, and pedagogical insights on the use of IK in Chemistry learning and teaching before they were engaged in a peer-learning community and with the ECMs?

Main Question	**Purpose**
Could you please tell me about your experiences of teaching Chemistry using learners' prior everyday knowledge?	To find out about their experiences of teaching Chemistry starting from learners' prior everyday knowledge.
Could you please tell me what challenges have you been experiencing when teaching Chemistry?	To find out the challenges teachers are encountering when teaching the topic with a view to establish whether they are away of alternative ways of teaching.
Could you please tell me what are your views on the integration of local knowledge in Chemistry lessons?	To find out if teachers are away of using local knowledge in their lessons.
Could you please me how you use to present the topic/s in Chemistry using local knowledge?	To find out how the teachers use to teach the topic/s in Chemistry with the help of local knowledge.
Could you please give me examples of any topic/s in Chemistry in which you think you can integrate local knowledge?	To find out if teachers have understanding of the topic in which they integrate local knowledge.
Could you please tell me what advantages of integrating local knowledge in Chemistry lessons?	To find out if teachers understand the values of integrating local knowledge in Chemistry lessons.
Could you please tell me what disadvantages of integrating local knowledge in Chemistry lessons?	To find out if the teachers understand the challenges of integrating local knowledge in Chemistry lessons.

Appendix H: Chemistry teachers' conceptions and dispositions

Conceptions	
C1	Describing what they think the subject is—their ideas or thoughts about preserving of *Mahangu*, making *Mahangu* flour and making *Oshikundu*
C2	Describing what they believe is required to teach the subject (to study it)
C3	Describing what they believe is required to teach the subject (to do the class activities and problems)
C5	Describing what they think is the purpose of integrating IK in Chemistry (why it must be integrated in the school curriculum, its usefulness in everyday life, …)
C6	Describing what they believe indicates that they have learnt science (how do they know that they have learnt)
Dispositions	
D1	Describing their ability in the teaching of Chemistry
D2	Describing their attitudes towards the subject (Chemistry)
D3	Describing the expectations about the integration of IK in Chemistry lessons (what helped them achieve that)
D4	Describing the perceived value of the Chemistry
D5	Describing the evidence that they would provide to others as a 'proof' that they have learnt how to integrate IK in Chemistry

Appendix I: Empty reflection journal

1. School location (tick one)

Urban	Rural	Semi-urban	Semi-Rural

2. Gender

Male	Female

3. Ethnicity (tick the correct one)

Kwanyama	Ndonga	Herero	Zambezian	Ngadjera	Others

4. Qualifications (tick the qualifications you have)

ECP	BETD	ACE/FDE/ MASTEP	HONS	MEd	PhD	Other

5. Teaching Experience in Chemistry and total teaching experience?

Teaching experience of Chemistry in Grade 10	Total teaching experience

6. Age group (Tick one box)

20 - 25 years	26 - 30	31 - 35	36 – 40	41 – 45	46 - 50	Above 50

PART B: Participating school's profile

Name of schools	School A	School B	School C
Gender of Principal			

No of HoDs			
No of Teachers			
Enrolments			
Participants Teacher Subject Taught			
Experiences And Grade Taught			

Journal for participants' reflection on PLC

Activity	**Tick only one**
Workshop	
Excursion to the house of ECM (making *Oshikundu)*	
Professional Leaning communities with other Chemistry teacher	

(a) What lessons can Grade 10 Chemistry teachers learn (or not) in their peer-learning community when co-analysing the Chemistry curriculum documents?
(b) How do Grade 10 Chemistry teachers interact, participate, and learn (or not) during the ECMs' practical demonstrations and explanations on the preservation and pounding of Mahangu flour and making of Oshikundu?
How does the peer-learning community enable and/or constrain Grade 10 Chemistry teachers in using the IK of the ECMs on the preservation and pounding of Mahangu and making of Oshikundu and other indigenous practices to co-develop exemplar Chemistry lessons?
How do the Grade 10 Chemistry teachers selected from the peer-learning community mediate learning of the co-developed exemplar lessons in their Chemistry classrooms?

Most salient knowledge gained during the workshops with community members, researcher and other teachers?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
………………………………………………………………
How did co-analyse of documents using topic-specific pedagogical content knowledge helped you: Chemistry curriculum

…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………
Chemistry Syllabus
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………

Chemistry Textbooks (3 textbooks)
T1……………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………
T2……………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………
T3……………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………
How do co-analyse Physical Science question papers & Examiners reports integrated IK or helped you to integrate IK.
2015……………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………
2016……………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………
2017……………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………
2018……………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………
2019……………………………………………………………………………………………
…………………………………………………………………………………………………

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………
What was the most useful aspect on the practical demonstrations/workshops with the expert community members?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………
How did you interact, participate and learn (or not) during community members' practical demonstration on making *Oshikundu* helped you to gain new knowledge?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………
How IK was integrated with scientific knowledge during practical demonstration with the expert community members?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………
How did the process of co-develop the exemplar lessons plan helped you to integrate IK in your Chemistry lessons:
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………
How teaching co-developed exemplar lesson plans did helped you to understand TSPCK and the integration of IK in Chemistry classrooms:
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………
What must be done to improve the integration of IK in Chemistry lessons?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
………………………………………………………………………………
Explain how did Professional learning communities helped you to integrate IK in Chemistry lessons?

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
………………………………………………………………
What other suggestions do you have for the researcher to improve in future?
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
………………………………………………

Appendix J: Empty classroom observation schedule form

Name of School: ____________________ Observation Date: ____________________

Name of Teacher: _______________________ Grade 10:________

Subject: Chemistry Number of Learners: __________________

Lesson Topic: __________________________ Observer: FS Simasiku

How do Grade 10 Chemistry teachers mediate learning of the co-developed model lessons in their classrooms?

Introduction
Learners prior knowledge: ____ ____ ____ ____ **The link between IK and WS:** ____ ____ ____ ____
Body/lesson presentation
Curricular Saliency: ____ ____ ____ ____ **Presentation:** ____ ____ ____ ____ ____ **What is difficult to Understand:** ____ ____ ____ ____ ____

Conceptual teaching strategies: ______________________________
Activities/ Tasks
IK integrated in the Activities/Tasks ______________________________
Assessment
Life Experiences: ______________________________

Observer's Name: _________________ Signature: __________ Date: __________________

Teacher's Name: __________________ Signature: __________ Date: __________________

Appendix K: Topic-Specific PCK translation device

COMPONENTS	**DESCRIPTION**	**LP^{--} (Weak)**	**LP^{-} (Moderate)**	**LP^{+} (Strong)**	**LP^{++} (Very Strong)**
Learner Prior Knowledge	Includes common learner misconceptions known in a topic	No identification or no acknowledgement or no consideration of learners' prior knowledge or misconceptions; no attempt to address the learners' misconceptions.	Identifies prior knowledge or misconceptions; provides standardized definition as a means to counteract the misconception; no evidence of drawing on other TSPCK.	Identifies prior knowledge or misconceptions; provides standardized knowledge as definition; expands and re-phrases explanations using one other component of TSPCK interactively.	Identifies prior knowledge or misconceptions; provides standardized knowledge as definition; expands and re-phrases explanation correctly; confronts misconceptions or confirms accurate understanding drawing on two or more other components of TSPCK interactively.
		CS^{--} (Weak)	**CS^{-} (Moderate)**	**CS^{+} (Strong)**	**CS^{++} (Very strong)**
Curriculum Saliency (CS)	Refers to the identification of the most important meaning of major concepts of a topic, without which understanding of the topic would be difficult for learners. It also includes the knowledge to logically sequence the learning and knowledge of pre-concepts needed prior to teaching a topic	Identified concepts are a mix of Big ideas and subordinate ideas; identified pre-concepts are far from topic; sequencing no value due to mixed concepts; reasons given are generic benefit of education.	Identifies at least 3 Big ideas; not all 3 Big ideas and subordinate ideas identified; identified pre-concepts are far from the current topic; suggested sequencing has one or two illogical placing of Big ideas; reasons exclude conceptual considerations and show no evidence of drawing on other TSPCK components.	Identifies at least 3 Big ideas; subordinate concepts correctly identified for all Big ideas; identifies pre-concepts relevant to the topic; provides logical sequence; reasons given for importance of the topic include reference to conceptual scaffolding/sequential development draws on other TSPCK components, e.g., what makes topic difficult.	Identifies at least 3 Big ideas; subordinate concepts correctly identified for all Big ideas with explanatory notes; identifies pre-concepts relevant to the topic and explanatory notes given; provides logical sequence of all Big ideas and with logical reasons; reasons given for importance of the topic include reference to conceptual scaffolding/sequential development draws on other TSPCK components, e.g., what makes topic difficult.

		WDU^{--} (Weak)	WDU^{-} (Moderate)	WDU^{+} (Strong)	WDU^{++} (Very strong)
What is Difficult to Understand (WDU)	Refers to gatekeeping concepts which are difficult to understand often because they cause conflict with previously established understanding	Identifies broad topics without reason and specifying the actual subordinate sub-concepts that are problematic.	Identifies specific concepts but provides broad generic reasons such as abstract concepts.	Identifies specific concepts leading to learner difficulty; reasons given relate to one other TSPCK component.	Identifies specific concepts with reasons linking to specific gatekeeping concepts and to TSPCK components such as prior knowledge and aspects of curricular saliency.
		RP^{--} (Weak)	**RP^{-} (Moderate)**	**RP^{+} (Strong)**	**RP^{++} (Very strong)**
Representations (RP)	Refers to a combination of representations at macro, symbol and sub-microscopic levels that may be employed to support an explanation	Limited to use of only macroscopic representation (analogies, demos etc.) with no explanation of specific links to the concepts represented.	Use of macroscopic representation (analogies, demos etc.) and use of scientific symbolic representation without explanatory notes to make the links to the aspects of the concept being explained.	Use of macroscopic representation (analogies, demos etc.) and use of scientific symbolic representation with explanatory notes linking the two representations to the aspect(s) of the concept being explained; use of above combination of representations with reference to one other TSPCK components, e.g., prior knowledge.	Use of macroscopic or symbolic representation with sub-microscopic representation to enforce a specific aspect; Explicit link with other components of TSPCK, e.g., emphasis on core aspect of CK demonstrated in the representations and learner prior knowledge.
		CST^{--} (Weak)	**CST^{-} (Moderate)**	**CST^{+} (Strong)**	**CST^{++} (Very strong)**
Conceptual Teaching Strategies (CST)	Refers to teaching strategies derived from the	No evidence of acknowledgement of learner prior knowledge and	Acknowledges learner misconceptions verbally with no corresponding	Considers confirmation/confrontation of learner prior knowledge	Considers learner prior knowledge and evidence of confrontation of misconceptions;

	considerations made from the other four components and excludes general teaching methodologies	misconceptions; lacks aspects of CS; use of representations limited to macroscopic or symbolic scientific symbolic representation.	confrontation strategy; lacks aspects of CS; use of macroscopic or symbolic representation with no linking explanatory notes.	and/or misconceptions; considers at least one aspect related to CS, e.g., sequencing or what not to discuss yet or emphasis of important aspects; uses at least two different levels of representation to enable understanding.	considers at least two aspect related to CS, e.g., sequencing or what not to discuss yet or emphasis of important aspects; uses either the macroscopic or symbolic representation with sub-microscopic representation to enable understanding.

Appendix L: Collated semi-structured interview Data

What are Grade 10 Chemistry teachers' perspectives, experiences and pedagogical insights on the use of local or IK in Chemistry lessons?

Collate interview from five participants

Questions	Michael	Sebron	Ndeshi	Shipefi 16	Tala
Could you please tell me about your experiences of teaching Chemistry using learners' prior everyday knowledge?	Ok, jaa as teacher always you have to plan, in planning you to consider all this aspects, what does they know, I mean what does learners knows before, what you know and what you are going to teach, so to answer your question, I have to plan, when am planning I have to consider learners prior knowledge, soo I have to ask them maybe asking them, what do they know from home, for instance maybe this things of aaa maybe atoms, what do they know from home, what is an atom from home or maybe …. How do they know small things maybe from home, just very very small things? Maybe I will consider when am planning actually, consider their knowledge from home… when they are doing, I mean coming up with something. Let me just be specific, a process in aaaaa, maybe rate of reaction, soo maybe I will ask, I will consider for myself, about how I do things considering the	Ok, I have been teaching Chemistry now for about 8 years, most of the knowledge that I equipped with learners, for instant when am teaching fermentation, I refer them to the way we prepare Ovambo liquor at home. We collect fruit from trees, and we put them in water and the ferment, then from there we prepare Ovambo liquor. Alcohol evaporate first and water remains and also when teaching the types of salts. I also refer them to the salts that we use at home and also we another salt that is used in hospital when someone is broken his leg	Right, aaaa Chemistry actually have never existed as a subject in our curriculum, it was last year when Physical Science was split into two subjects, Chemistry and Physics and for me having teaching Physical Science for quite sometimes now, I can really say I have a good experience in teaching Chemistry. That means I have been teaching Physical Science for 11 years now, which is quite some experience.	Since aaa this is my second year teaching this subjects uh, I came to see that they are quite a lot of things that are very much new to these learners. Due to this new curriculum and the prior knowledge that we mostly use in the more especially when it come too use of *Ombike* for example, when we are teaching this fractional distillation. Jaa most of the learners they really understand how steam change to liquid when you add water, you know that container (demonstrating showing by hand how the pot look like) where we insert a pipe, where	I have been teaching for 10 years now, aaa I use to include learners prior everyday knowledge by asking learners the examples that they know from home. Sometimes I ask them what they learnt from the other grades. At home they know about Ombike that they use to prepare with their parents.

	temperature maybe cooking porridge also, I know before I put flour in the pot, I will make sure that the temperature must be optimal and if it is too hot I know it will be rouning my porridge and maybe if too cold it will take time for me to cook that porridge. So considering all this aaa knowledge for learners…. I will consider them when am planning, their prior knowledge for learners.	or they used to be given this, (demonstrating by showing how the plaster used to be made), that how I teach them.		the steam has to pass through when, when you add water you cook steam to liquid. Just the same as we make when our granny mother are making their *Ombike* at home. Most of them they are recalling very well, yes those are some of the example that we use as learners prior veryday knowledge.	
Could you please tell me what challenges have you been experiencing when teaching Chemistry?	Obviously, materials, teaching materials is a challenge, am addicted to the word now, let say chemicals, some chemicals like in the school they might be expired if not available, soo those are the challenge that one can experience honestly. But with all the challenge we know we are facing, economic crisis, and the pandemic (COVID-19) off course, so we have to compromise, whatever is available we use it or maybe we use aaaa we use available materials. They can be environmental available maybe, we see things just around we can just use those, but they are many challenges.	yaa, I have experienced a lot of challenges, the first one is this learners don't really have better ground when it came to Chemistry and most of them don't take it serious especially when we are teaching reaction because we do not have enough equipment's (materials) in the lab to carry experiment or practical. They tend not to really understand the content because we use	Actually, Chemistry is talking about Chemical, Let me refer use back to you previous question, which I think I did not fully answer, the part of prior everyday knowledge of the learners. There came a certain challenge because when we talk about Chemical, the content in the book does not really give room for this learners put the content in the context of what they have at home and that has been	The most challenges that, more especially this year because it was quite difficult because this Chemistry need practical every time. But we luck that time of having all learners at one time or at one room where they can make their experiment. That is the problem we have experienced, we don't make time for practical. Some time now what we do most is the theory part, without	Chemistry is part of Physical Science since they are topics that cover Chemistry in Physical Science, Learners they don't like Physical Science and the intend to dislike it when the topic they are learning is difficult to them, the othe problem is lack of teaching and learning materials in our school. Our school does not have the lab to do practical

		to say you tell me I forget, and you show me I remember. They expect us to do a lot of practical but we don't have enough equipment's in the lab, learners are not interest in the Chemistry and that is the challenges I have experienced.	actually the challenge in the creating our everyday knowledge for the learners and what we are learning in the really content. So sometime when you try to explain a certain phenomenon learners might not really understand it simple because it's very far from what they experienced.	practicing things for the learners to really see yes, it is true what we are taught is true, when the practice it but only few few few like reaction of water and metal. Those one yes, we expose them to that but mostly jaa we are now four teachers now teaching Chemistry now, but we only arrange, even though we arrange this practical let put it. Time and the room like where we can put our learners and do the practical, we don't have enough space here, and even our lab is occupied now it is Grade 11A. So, we lack doing practical and we don't have enough textbooks and we only have living that is it. R: which mean that you have a shortage of a lab that is limiting you to do the practical activities, where the learners have to	activities or demonstration for the learners to understand.

				see, they have to touch? P; Exactly, we don't have the laboratories, it is here but the one that we have is more now as a classroom, sometimes I go there where we have the netball court (open space) but it is not safe to the learners to do practical there. Just to try at least some of the things that you know. Learners will not understand if we did not do that.	
Could you please tell me what are your views on the integration of local knowledge in Chemistry lessons?	no it helpful, sometime but the problem is maybe the translation from aaa maybe from local language to English, that could be also a challenge, thou you can explain it in our vernacular but when it come to the paper (Examinations), you can explain it very very well in the vernacular but obviously the question will come in English….. soo my views now is it possible, very possible and it helpful also (pause) some distubase from other teacher P: yaaa, my views on the integration local	yaa, I think that is a very good ideas because we always learn from known to unknown, and they also say science start from home. Most of the things we do in Chemistry that is exactly what we do at home. Say for instance we talk about proteins, proteins is made from carbon reacting with Oxygen and Hydrogen and most of the food that we	Based on the challenges that I came across, I suggest that we start exploring the necessary or the correct and actually the appropriate indigenous practices that goes hand and hand with science aaa science is everything we use in our everyday life. So, if we take some of those practices we do at home, we have aaaa let me refer to this example of fractional	Jaa, I they are quite a lot of things that we can integrate in this Chemistry lessons, they are quite a lot of things (Examples) that connect to science. Unfortunately in my case only few few few things that I have used as example but….. maybe we lack this thing of planning together then we discuss, everybody just plan on his own as maybe you	Yaa, you see integration of local knowledge sometime bring problems in the classroom when learners have different views about it, Local knowledge can help teacher to explain the concepts that is done at home using local examples from home, teachers need to know which local knowledge is

	knowledge, I said it possible we just need to put more effort so that we can bring all this (local knowledge) known or maybe prior knowledge, actually from both side teachers side and learners side. If you teach a learner the same terminology that he knows home, that learner can understand it very very well or just going to teach something that the learner hearing for the first time.soo we need to use this (IK) soo that we can link the knowledge that we learn from home and the one that you are learning in science classrooms.	use to eat at home is made from proteins but they don't know. And also as I have indicated that there are some place where we have some salts water and people are just drink salt water but if we say ok, for instance that salt water is water mixed with salt, if you boil the water, water will evaporate and salts will remain. If we try that then we will solve the problem that we have in our society. R: Ok that mean water evaporate first and salt will remain P: yes, but yet people are having problem of salt and that is what we do in Chemistry.	distillation, where we make Ombike, we have that one, it is a very good example to use when we teach this learners about fractional distillation. The whole process of Ombike, fermentation that process if can be documented in our on African book (Namibian books) then of course it will put content in the learners context. Which then makes it understandable because learning about this distillation plants, I can say the western way (western knowledge) yet we have our own indigenous practices that we do that are actually fit to be incorporated in our curriculum and fit in our context as Namibian, African. So my suggestion is that we should then explore more and documents our own indigenous knowledge so that we put Chemistry, not only Chemistry, I	are on the some pace, you are on the same topic but it was supposed to be like we come together and so that we search what can we use here for learners to relate this context into what we can give as an example. So, sometimes, jaa they are quite a lot of things but the time that we don't take so we come together and discuss so that we can improve the learners. R: it means there is lack of PLC, teachers they don't come together, sit together, plan together and then when you are going to teach you know that its almost the same what my colleagues is going to teach, example that am going to use is the same like the example that my colleagues is going to use. P: yes, exams is always the same, we have common test	good for which topics.

			can say we put all the sciences at a certain level.	but planning together when we are going to teach this part try to integrate this, try to put this, give example they will understand better, we don't do that. Everyone has his on way of teaching now, we don't have that common understanding like we we use same example to the learners.	
Could you please tell me how you use to present the topic/s in Chemistry using local knowledge?	yaa, ok…. My experience that I have used the local knowledge, aaa if my memory serves me correct… what did I use (short pause looking up trying to recall the topic), Me: maybe a topic on materials, topic on chemical reactions, topic on fractional distillation Michael: we were just started like for Grade 10, what is it, aaa scientific process, yaa scientific techniques, thereby there is involvement, but not involvement but where techniques are distillations, separation of mixture. Yaa for instance we have discussed about fractional distillation, whereby I have given the example of how our old kukus	Yaa, I have met one topic where I asked learners to bring salt, to bring sand, to bring the stones, then we put them in water to separate water from sand and also to separate water from salt, and also separate water from stones. I also told them to bring beans, and Mahangu and they mix them up…… and they will separate them that is under the topic separation of mixtures.	ooo, o right fractional distillation as I mentioned, we also have this separation of mixtures for example, how do you do that aaa in at home people brew for example Omalondu, Oshikundu and Omaongo. Especially Omaongo you have to do filtration there, to separate the liquid (Omaongo) from the other dirty substances, you have to filter and if then you are teaching that this is filtration, which is the process that we deal with of	jaa as I said it earlier on, the one that learners really understand and I know even in the exams they will never fail, maybe it is only this part where we have methods of separating mixture. Those one jaa more especially the one I stated earlier that, the making of Ombike at home. Mostly all learners understood well the container, everything, the whole process how it work it just the same and most of them (Learners) they are from house	Teaching Physical Science, the topic on acid and bases, I will use local fruits and also the use learners to bring those fruit at school for us to do practical in the class by testing them. There are a lot of examples like Omutoko, Epwaka, Omalundo and Omaongo. I give those aaa examples in the classroom when am teaching the topic on acid and bases.

	(grandmother) and memes (mother) use, I mean how the make Ombike from mixing things (ingredients), actually we have drawn the structure of fractional distillation, we were not using this baker, I mean baker and thing that we are using in the laboratories. But we using, I mean I have given example of the pot on the fire, on the pot, our memes and kukus, they connect like kind of a bucket structure (trough) in the there is a pipe, that is connected to the pot, but it is not the mixture, just up there but its closed again (pot), in that bucket (trough) kind of thing there is now water, I cannot just say cold water but room temperature water, soo by then aaa that how to make Ombike in Oshiwambo. That is whereby when our old mother and parents they use now, when the water is hot then the take some of the water out and the replace with the room temperature water again, so it obviously that condensation will happen and clear solution (Ombike) will come out at the end of the tube (pipe) that is connected to the pot, from the pot through that bucket of water (trough) and clear solution will come out.		course these learners will understand. If you are making Omalondu, Oshikundu the process of fermentation is there if you want to produce, the production of alcohol is through fermentation and these learners knows that there is fermentation that is involved here and then we take that and give it to our learners as an example when we are explaining the process of fermentation and all that, it quite a different. The other things when we also teaching gases of the Air for example. We talk about Oxygen, Oxygen is that gas that actually support combustion. What do you do when you make fire, this simple thing so if you are making fire you for example take aaa how do I say it, take for example Elilo (traditional plate made	where Ombike is being made. They understand it well. Some of the things, jaa I tried to make as an example but not all learners are exposed to that. But that one of Ombike, fractional Distillation that process they understood it very well.	

	Me: I can visualise that picture and now why do the taking out this warm water and replace it with room temperature water, what was the science behind there? Michael: yes, when the stem is coming out of the pot, obviously the pot on fire, then when the steam is coming it has to be condensed, to change from steam to liquid, when they replace the hot water with cold water, actually they are condensing the steam from the pot and that is science from home.		from palm leaves) then you have to provide more air (demonstration, by using Elilo to blow air to the fire, the way how Mapukuta is working) to the fire, what is happening, you are actually increasing the content of Oxygen there, because you know Oxygen is in the air right, when you are doing this (demonstrating how to blow air to the fire using Elilo), you are actually increasing the air in the some process you are increasing, you are exposing more Oxygen to the fire. And we make fire with fire woods every day and then the fire woods …. The burning of fire wood again on itself, there is another science behind, because when we talk about physical and chemical change, you can easily explain to this learners that when you burn the fire wood, what will happen, you get ash and		

			charcoal (Ash could be used to teach bases and Acidic), will you change those one to make fire wood again, No how do we call that process is it a physical or Chemical change. You this are the things that are happening in our everyday life and we interact with the in our everyday life and then of course if we try to incorporate them in science and of course Chemistry will be understandable. Me: thank you very much, I never knew that when our elderly use something to blow air in the fire they are increasing the level of Oxygen in the fire P: they are exposing more air, not really Oxygen in particular but more of which Oxygen is part of the air.		
Could you please give me examples of	To much movement; you said where I can	Yaa, as have indicated early that	I have mentioned, just to recall what I	Jaa, like on Electricity, I should think	Like I said ealier, Acid and bases and

any topic/s in Chemistry in which you think you can integrate local knowledge?	integrate local knowledge, yes for instance aaa the one that I have said earlier, rate of reactions and we have, yes in the rate of reaction again we have how to make Omalondu, Oshikundu, and whereby ok, for instance aaa in rate of reaction, there is how can I put it, there is flour from ……… (Mahangu) no the other one where we can make Oshikundu…it is not millet but Ilyavala (sorghum) that one is the kind of and it can be used as yeast to speed up the reaction in the process of the reaction for instance. When you put that one in Mahangu flour in boiled water, it obviously that solution, that mixture will be in the solution when there is no Ilyavala flour…. So that is the rate of reaction. The other thing again………pause Me: before you go to the next topic you talked about put Ilyabala in Oshikundu, now in case if they don't put that Ilyavala what will	experimental techniques, is one of the topic that can be integrated because it is talking about mixture, how to separate mixtures. Like in our environment some people drink water from lake, dirty water. There are insoluble substances that need to be separated. For instance talking about filtration over fractional distillation, but yet people are drinking dirty water. There many methods we can make that water safe to drink. Me: now you talked about fractional distillation, can you elaborate more, how can we integrate it in Chemistry lessons. Sebron: yaa, fractional distillation is when you have salt water, that water mixed with salt and you now want to have pure water from salt water. So you can just boil the water then	have mentioned nee, so that Ombike, Oshikundu, in term of the process of fermentation and this filtering ect, separation of mixtures and what else, the making of fire, yes my mind is leaving me now, my mind is betraying me now I actually has a lot of ideas but now I don't know what is happening. But of course yes there are there are topics that we can integrate.	there we have tooo, but then I don't know if this one is a local knowledge. Learners need to be exposed to this power station where we use to nuclear theeeee radiation nuclear, where it need to decay when it split and release the energy that warm or heat the water, to steam that turn the turbine to turn on the generator that produce now the electricity, so Ruacana station, maybe learners have to go there, but that one I know its not local Shipefi 16: that one we can refer that steaming of water, you can come back to them when they are cooking, what they use to do because they know that process that for the water to be like this what do we have to do. P; Boiling of water we have a lot thing that we talk about	….. what other topic in Physical Science…. Let me think about the other topics.

	happen to that Oshikundu : that will just remain like that (un fermented) yes it will not ferment…. It mean the other one could be for speeding up the process and it can be used as yeast …. Yes sometimes it cannot be used in the process (reaction) it will just help to speed the process of making Oshikundu.	when you boil the water, water will evaporate then salt will remain as crystal and that is what we call simple filtration. We also have fractional distillation where you want to prepare alcohol, you evaporate the water. I mean you heat the mixture then alcohol evaporate first because it has a low boiling point compare to water, then water remains then from there you get alcohol that you wanted.		when water changes or even when you have a little water in a container but if you put it on the fire you see water like it will expand, terms like expansion, we will make use of those examples.	
Could you please tell me what advantages of integrating local knowledge in Chemistry lessons?	Yes, learners understanding will be boosted, when you integrate what they know or maybe that they use to do at home with the western knowledge that we are learning from school, It will also be easier you as a teacher to teach learners that understand what you are saying. Make easy learning, enrich the understanding of learners, It also help learners answer questions (Test or Examination) accordingly, learners will be critical thinkers and think broad when	Yes, very good question. Aaa we are talking about meaningful education and quality education, so quality is the education that can solve problem that we have in our community and we cannot train people to be diverse in the country. We need to integrate these topic/s so that we can solve that problem	the advantages, you know there is this who said, I think a scholar who said, learners aaa remember very well after having seen something, they really remember very well. But now not only by seeing actually I want to comment on that but when you interact with thing in your everyday life, you are likely not to	yes, very much important because learners will familiarise with things that they know already and it will make them understand better, yes if they are to relate what they are learning to what they know, things that are happening in their community and in the environment	Yes, yes local knowledge help learners to remembers what they are taught, by linking what they use to do at home with what is done in the classroom, it improve the interaction in the classroom between the teachers and learners.

	the question ask him/her to explain something, he will use his own word based on the understanding (conceptual understanding and increase the vocabulary of learners) by using the knowledge from home and the one that is he/she get from the teacher.	that we have in our country. Problems like, we have people that are excel in business brewing, then can excel on that they have basics and we have the notions of people drinking dirty water, if you know how to make that water pure, that will also solve the problem that we have instead of government buying chemical too to treat the water, we can just do the basics we have gained Chemistry.	forget, meaning to say all these process I have mentioned all those practices I have mentioned, aaa if you happen to teach to include the indigenous practices in the grade in any content. The advantage is that these learners are likely to remember from what the practices. Learners do not have to learn by rote learning, the don't memories, but they write about things that they know, that they understand that they can explain. Even when someone is sleeping and you tell me what is the science behind when you are making Ombike, of course the learners will start imagining the whole process which actually makes it yes, very easy for this learners to remembers. I think there is more advantages than disadvantages in integrate IK	where they are in relate to content itself and they will learn the subject better and they like it even, because they will want to go back and see (explore/ investigate, discover) and come back to the content and familiarise things, they will link together. Which mean the will go and do more research, so that by the time they come back to the class they are well equipped and they can even explain to the other learners.	

			in Chemistry lessons.		
Could you please tell me what disadvantages of integrating local knowledge in Chemistry lessons?	Aaaa…yaa there is nothing without the disadvantages, for this one I can say maybe if there if a misconceptions between the two knowledge ….. western knowledge and local knowledge if there is a misunderstanding of course learners will be in confusing, we know this one from home but sir you are saying this and which one must I go for, that is misconceptions and again ……. Pause Me: what about in the examination, do they to include this knowledge or we can just teach it there then we remain there, it will not be tested in the examination Michael: it also depend if our examiners, we are in Namibia and our learners write the same exams, so for instance us from North we know this in our own language, that is what we know and we learnt something again and western knowledge again we compile this two and again and people from south or maybe east soooo they know also their own local knowledge (It is not universal). If this local knowledge in northern part is not crossponding with	Yaa, the disadvantages that we have is this, most of the terms (terminologies) that are used in Chemistry they cannot be translated in local language. For instance now you want to integrate a certain topic and then the words (terminologies) that are used or the materials that are used there are not readily available in our community. Most of the materials are very expensive…. Even though you want to integrate it will not be effective because the equipment's are not available and also very expensive. Me: which mean you cannot look around the community where you can get this equipment's that we can use in place of those one	Of course like I said, there are more advantage than disadvantages, there is nothing that comes with 100% without disadvantages, jaaa and in this case if we happen to teach this learners, you know aa let me say Namibia is a multicultural nation. We have so many tribes and we have so many culture, now the making of Omalondu and Ombike it only been practices in there Oshiwambo speaking community, what about the Herero, what is indigenous to Ovawambo, is not going to be indigenous or it is not going to be everyday practices for other tribes, that is actually one big disadvantage, so if you happen to but some topics looking at the certain tribe of course in a way we are disadvantaging	Jaa maybe the disadvantage when it comes to I don't know if they will try to react some Acid or because use mostly chemicals. Maybe they might want to practice some of the things like, they can even use that pounders in the battery and water in the battery that can even be dangerous. That is the only problem. I don't things there are more disadvantage only if they try to go and try the use of chemicals Shipefi 16: what about in the examination, do the examiners use to include IK or have you ever seen something like that Shipefi 16: jaa, not really but it connected to learners knowledge.	Local knowledge is not examined during examination.

	local knowledge at the southern part of Namibia or maybe in central, soo there will be many confusing and the markers must also consider those not markers but examiners.	which are very expensive. Like looking around easily available resources in the community. P: yaa, we can improvise but the most advantage part of it is the knowledge that we give to our learners that we don't give them enough practical because we don't have enough equipment's or equipped lab, from there they will have negative self-concepts towards Chemistry and you cannot able to integrate.	the rest of the group who do not belong to that tribe, that culture and again, if we only restrict our content to our indigenous practices as African now, the will be a time that we for example we want to go study abroad for example, around the globe but it is going to be difficult for us as or for the learners actually as they will not be able to connect what they have being doing to the rest of, I mean to what the rest of the world have been doing or is doing. So, I then suggest instead of only focusing on this indigenous or focusing on the western, there should be a balance, there should be a 50/50 situation. You must learn this content in in both context. If you are giving one example of this making Oshikundu, we must also at least have one example that we are		

			supposed to do in the lab. What I mean is we must try to bring this indigenous practices and have them as experiments just as models to represent what is in the books. So then we can make the situation as 50/50. R: meaning that we to teach western science and indigenous knowledge co-currently in the lessons, now when you bring this example then you bring this example to see if the process are just the same for learners to have a better understanding. P: Exactly….		
Conceptions					
What do you think Chemistry is?	yaa what do I think Chemistry is, Chemistry is learning of this sophisticated things, solutions it obviously when we talk about Chemistry, you also need to include substances, it is a learning on how to combined solutions to come up with a better thing. For instance I have …. Soil and	Chemistry is a very very interesting subject because Chemistry touches non-living things, and living things and Chemistry also touches Biology, because our body is	what I thing, (laughing), Chemistry is actually a way to understand the life processes, the way to understand where life begin because when we talk about a tiny particles an	Chemistry, I think this is more of Engineering and this thought of lab techniques, is more of someone has to go and work in the lab or in the mine, jaa is those thing of Engineering	Chemistry is the subjects where we learn about sofiscated thinks that are only known by western and use African we don't have any say on that. Is the subjects

	maybe water, what must I do to utilise this soil and water to make something useful for my life… It just a combination of things not substances to develop something useful.	Chemistry everything that we touches is Chemistry. For instance we have Physical Science which is combination of Chemistry, Chemistry has to do with how things reacts to form up a certain substances and again its very interesting subject because it covers almost all the science subjects that we have.	atoms and then you build on elements, then it come to materials, you know it just a starting point of learning other sciences because other sciences now will build on, on the materials and if you do not have the materials, the atoms then we could not have elements and we could not have materials. So, it is just where life begin.	and Geology, and it is a very nice subject anywhere. If learners happens to know more of this they will go for these courses in future. It is very nice and important in our life.	where we teach learners to think critically?
What do you believe is required to study Chemistry?	What I believe is required to study Chemistry, Mathematics is obviously because you have to calculate, how much you put and the outcome, the quantity, science lab it also required and you take this precautions something are more dangerous, hazard.	The first thing that is required is the interest, you need to have interest that is now our self and we also need to have enough practical…. Learners … we need to give more practical to the learners so that they will love and like the subject because if we are just teaching theory, without practical they cannot love the subject because they always, we always learn by doing. Jaa if we keep on teaching	To me there is no requirement for some to study, for as long as the person is willing to learn, there is no other specific requirement for that person to possess certain something so that the person could do Chemistry. Me:To be able to cope Ndeshi: for as long you are willing to learn.	Just the knowledge of science, if you are good in science then yes you can be capable of doing Chemistry. Me: there is no that things of I know when we were growing that this subject is for clever learners, this one is for the dull learners or anyone can do Shipeefi 16: it is more of those one yes, but not really done by clever learners only that if learners understand	For someone to study Chemistry must have Mathematics and be smart learners because you learn something that you don't see. With lack of practical it become even more challenging.

		they will not like the subject.		well science, they will do well in Chemistry as well. It is about exposing them to practical activities learners will have the love of the subject.	
What do you believe is required to teach Chemistry (to do the class activities and problems)	Aaaa, preparation, you need to prepare, you need to do …..yes maybe to do more practical because Chemistry is practical based subject… soo it preparation and preparation where its involves on how to conduct investigation or sooo.	Jaaa what I believe is required is to improvise not really to have equip lab but also to use what is available…. To use the materials that we can find in our community. And then those one we can just try how we can amalgamate (join together) everything from the we can teach very effectively.	Well like what I said already like Chemistry actually starting point of learning other sciences. I can refer back to the example of atoms I have given already. If you do not have any atoms, we could not have elements and then materials and other science related. So, we need to teach these one, we need to teach Chemistry so that we make other science or other science discipline meaningful to the learners because aaa, aaa I treat Chemistry as the starting point, iot is the engine of science. If the learners does not understand this, this the building blocks of matter, that person will not	You must have that content Chemistry at high institutions. If you have done Chemistry at high institution, then yes you can teach Chemistry but you just maybe did Physical Science, jaa but you will be struggling, but if you have done Chemistry like us in Zim (Zimbabwe) we have done Chemistry and Physics separate subjects. We have done a lot of practical now when, even if am trying to put up I know what am doing.	You must understand Chemistry and Mathematics for you to be able to understand the calculation that are done in Chemistry, Chemistry is the subject that use need to do practical.

			understand Biology, that person will not understand Physics, that person will not understand Geography, you see it actually the engine of science.		
Dispositions					
What is your ability in teaching Chemistry?	no as a professional as a teacher, teacher by profession of course I like teach Chemistry despite the subject and Chemistry is also my major, I have no complain of teaching my subject so …so I enjoy teaching Chemistry, for instance Chemistry is nice to to teach because you do more practical then learners get to be involved more. When learners are involved more the teacher enjoy more, teaching of course. Because you know you are giving something that learners get to value or maybe to use their hand, It was Vygotsky or Bruner the one that say doing by hand is butter than just studying the theory.	My ability is tooo… my ability that I have in Chemistry is to, I know I have together equipment and also I know how to come up with model that will make learners understand even we don't have really equipment that make them to understand like equipment that a stipulated in the the syllabus, I can improvise, I can motivate learners through rewards, through words, so I do all I can just to … to make sure that I have swallowed their thoughts toward Chemistry.	Exactly, like I said we have been teaching Physics and Chemistry as one subject Physical Science, now that Chemistry is a subjects on its own, Physics is the subject on its own. I feel since I mentioned that Chemistry is the engine of all the sciences. I have that energy of teaching Chemistry, making it thoroughly understood by these learners because I want to prepare them to understand other science subjects. The reason why I even opted to go for Chemistry it is because I really want this learners to have	oooo I understand now, like for me here at school I have 5 classes, mean 6 classes for Chemistry in my time table there is no any other subject only Chemistry. Unfortunately I don't have it here I could have shown you that only Chemistry in there. 5 grade 11 and 1 grade 10 but I always want to go and teach Chemistry, even if, they know even Maths teachers they always complain. No Nauyoma every time, as soon the bell ring he is already at the do. They know and my learners always	My ability, yaaa I enjoy teaching it and jaa, this subject sometimes requires you to think out of the box to explain the content.

			that spirit of learning Chemistry, of learning science. So, if they don't understand Chemistry it will make it, it will be difficult for them to get some interest in other science subjects. So the energy that I when I wake up just to come to work and teach Chemistry, it is very ……. It is at another level.	if I did not go to class that day maybe I have something to do, they will come and look for me, yes. They really want to learn, even the teacher who left (the one who was in the office) if we can call him now he will tell you, he teach Physics but he can even ask this good learners in Grade 11A, they will tell you no we understand Chemistry better than Physics. That is what is happening in the school now, here. Now am happy am not the one who is saying it but the learners that show that am doing well.	
What is your attitudes towards Chemistry?	Personally I don't have a problem with Chemistry as a subject, though they are also many implications, sooo we need to suffer so that we gain, train harder so that go fight easy. I really love teaching Chemistry.	My attitudes toward Chemistry is Positive, That is my subjects I love it so much and I know that is the only subject one can take when he/she want to do maybe to become a Doctor…	my dear friend, I am that person who is always willing to teach the subject, I am that person who is always to steal other teachers' lessons, you know, take advantage of other teachers' lesson when	Attitudes, I love it so much since I was at my tertiary institution, yes I like it. The tutor who taught us this, actually is not one they are more than three but there is Mr. ………… Who taught us	Personally I don't have a problem with the subject because I love teaching it and I enjoy teaching it very much.

		because it is dealing with medicine and other thing. I have positive attitudes toward it and I know the learner who will love that subject will excel in life and can have diversity when it became to study courses.	they are not at work. I am willing to at least aaa make these learners …. Am not forcing them as such, am not forcing the learners as such but always trying to motivate them at least through those small practical, when… you can only afford to have those one when you yourself as a teachers is interested, then you are not interested, the you don't do anything.	very well? If we say no we don't understand there, he can erase everything the whole, anything that was on which he explained and start. I like it soo much It's the love from my heart I like the subject. Me: it mean that love it was also influenced by someone? Shipefi 16: yes, like that teacher Mr ………. Oo aaye (a sign of really appreciating the tutor), he is very good up to now sometimes I speak like him and learners can laugh at me sometimes when I can speak like him some of the words, but I got them from him.	

Appendix M: Workshop data on Co-analysing national curriculum documents

Me: colleagues well come back, so as I have presented the outline of my research, now we have to look at the National Curriculum for Basic Education. To see if the is that space they had allowed us to integrated local/indigenous knowledge from known to unknown. Those five components of TSPCK so we have to look at that one. I hope all of us we are having the National Curriculum for Basic Education. Even though some of them are 2016 and 2018 but the content is almost the same. We cannot read it from page one up to the last page, so there are some component that we have to look at and try to see if they integrate local knowledge or allow us to integrate local knowledge. The first components is …. If we look at the goal and the aims that is on page 5. The goal of basic education and the aim of basic education for the society of the future. If we try to analyse that one, does this curriculum allow us to integrate local knowledge. Looking at the interest of my research.

Sebron: what was the question again sir

Me: when you look at the goal of the curriculum does it allow us to integrate local knowledge or prior everyday knowledge, that learners has from home into our lessons, because this is broad, everything that we are doing is coming from NCBE?

Ndeshi: if can say something on that, I can see two thing that are supporting the integration of local knowledge. The first thing is under goal, the second paragraph "*In the context of globalisation, 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"*. If we are talking about identity, has to come where you are coming from, what do you do at home, your culture, cultural practices and I think by mentioning the next one "*Knowledge encompasses indigenous knowledge, local and national culture"*. That is the key we have to focus by now. Which mean the curriculum actually emphases the integration of indigenous knowledge. That is what I have to say.

Sebron: I want to concur with what she said, in the first paragraph there *"The goal of basic education is to empower learners to actively participate in making Namibian society a knowledge-based society. A knowledge-based society is characterised by the effective and wise use of existing knowledge and the creation of new knowledge; the effective sharing and using of knowledge"*. This existing knowledge is the knowledge they gained from home and that knowledge is the knowledge that learners bring to the classroom. They usually say science start from home and that is the indigenous knowledge we are looking for and the creation of knew knowledge this is one learners will get from school. Which means when learners are coming from home are having existing knowledge and we have to create the new one from the textbooks.

Tala: I don't want to point on what they have pointed out "*Only with a strong cultural and individual identity and positive values is it possible to influence globalisation and not be overwhelmed by it*". The other one is "*The path to a knowledge-based society with a strong identity and culture is not achieved through formal basic education alone, but through lifelong learning. Lifelong learning starts in the home, continues throughout early childhood education and basic education, and beyond. It is developed through informal, non-formal and formal modes of learning. Because basic education reaches everyone in society, it has the greatest potential for laying the foundation for lifelong learning"*. This is the knowledge that learners gain from home and we cannot base our learning only in the classroom but the outside classroom also is needed.

Its emphases that lifelong learning, informal, non-formal and formal modes of learning is required. Informal and non-formal refer to the way we gain local knowledge from the local community and formal mode is when learners are taught in the classrooms and required to master certain basic competencies or to achieve them.

Me: now we are try to unpack the curriculum

Ndeshi: Just to add, actually in summary the whole ideas under 2.1 we have this as stimulation it actually support the inclusion of indigenous knowledge, even the third paragraph, lifelong learning start from home. Yes I see the curriculum is supporting our local knowledge, it will depend on how we put it in our Chemistry classrooms.

Me: Thank you very much, now we have seen that the curriculum support the inclusion of local knowledge in our lessons. We you look at those core skills, they are (counting them) in total they are 7 core skills. When we look at those core skills and we look at our Chemistry, which core skill is applicable in our subject or which one is allowing us to integrate local knowledge? Mentioning the core skills as: learning to learn, personal skills, social skills, cognitive skills, commination skills, numeracy skills and information and commination technology skills. On page 10 they are summarised. When you look at that table which one there is supporting the inclusion of indigenous knowledge. I can see we are try to synthase which one is applicable in Chemistry.

Ndeshi: I feel the cognitive skills, this is because if you look at the competencies there *"exploring, investigating, enquiring, recognising, contextualising"* especially the word contextualising has to do (in my opinion) taking this science that we learn "westernised science" actually bring it in our own context, using our own example of the practices that we use at home to teach science.

Tala: I think that skill (using local cultural practices to teach science), I feel about it. For example when you are teaching about rate of reactions, don't talk about westernised knowledge, and use Oshikundu to enhance learners' conceptual understanding. We have to talk about Omalondu, Oshikundu and other to bring out that knowledge in the context of the learners.

Me: Thank you very much …. We have to contextualise…. Any other skills that we thing is support the inclusion of IK in science.

Tala: I think learning to learn, when we look at solving problems, maybe we can use our indigenous knowledge to solve problems, for example if you want to learn about rate of reactions. We can use Oshikundu to help us to understand the rate of reactions.

Shipefi 16: adding to that working independently and in group, learners knows the process that are involved when making or producing Oshikundu and Omalondu, asking them to explain the process or write it, it will shows that this learners are independently and can learn own their own if we build from what is locally done to science in the text. Also we can put learners in group to explain certain cultural identity and like us here we are learning in group. Other learners might be good in certain cultural practices than others… I think that one also.

Me: one of component of TSPCK is presentation and analogies. Analogies is when you bring the westernised knowledge and local knowledge and try to see if they match, the best example like using is making Ombike, if you take that picture in westernised book and the local artefacts. They match exactly.

Michael: Jaa yes they are the same, if we only teach about fractional distillation in the book and ignore the one they learners are familiar with, learners will not be able to analogise the two process or bring them together. Learners will not be able to go home and say this is what we are taught at school. Some of them they are even knowledgeable about making Ombike. They can explain from the first step to the last step.

Me: if we are done we have to look at the learning areas on the next page, especially on natural science. When we look at that natural science to be specific, what can we try to get from there that can help us to integrate indigenous knowledge?

Ndeshi: Am not show sure, the second statement "*The natural sciences area of learning contributes to the foundation of a knowledge-based society by empowering learners with the scientific knowledge, skills and attitudes"*. I actually want to underline the knowledge-based society, this has to do with local knowledge because when we talk about scientific knowledge, skills and attitudes we actually has some thought of science as African, the only problem we us is that our science is not documented, we do a lot of things, we have a lot of knowledge, scientific knowledge in our societies. That word knowledge-based society, there is nowhere the Kuku (Granny) can be happy if we use their knowledge but we don't appreciate them and allow them to explain that knowledge they have in science if we do not bring it up as teachers. Some of the topic that we teach can be well presented by community by inviting them in the lesson and as teachers we translate those terminologies to English. Learn will think and try to bring very cultural practices at home into science lessons. If we make the community to be aware of that their knowledge is useful in science they will be willing to support the school.

Me: moving forward on page 26 or 27 on junior secondary school and Senior Secondary school, they try to explain each subject.

Ndeshi: let me say something there, they are talking about real-life situations. For example "*Learners use methods and skills to increase variables in existing scientific models in order for models to reflect real-life situations and also they realise the value of the natural environment and factors affecting the environment, and have the skills and knowledge to maintain a safe and healthy lifestyle*". The value of natural environment, you know within a certain area or community, this has to do with cultural beliefs and things that are indigenous and specifically indigenous for that community. It mean through learning about this one. These learners are actually required to make use of the value of the environment. They can only realise the values of the natural environment if they understand the purpose of making references to it as they learn science. If they don't use it or make reference to their environment they might not understand science and the importance of having natural resources.

Me: any one to add to that before we move to the senior secondary?

Sebron: Am seeing this word "real-life situations" as the key because this will also help learners, like what she said, understand and know the reason why they are learning some of those things. Sometimes our learners get not interested in the topics because they do not know the reason why they are learning that. It is like "*you are training people to be divers but you do not have a sea".* That become useless, now if you teach them rate of reactions and you relate them to how Oshikundu is prepared, they will really understand why they are learning this rate of reactions. They will know that they are benefiting from learning it.

Me: Natural science senior secondary

Shipefi 16: there is this one which say *"They apply and generalise scientific knowledge to everyday situations, understand the value*". This one apply to indigenous knowledge that can also be integrated in science classrooms.

Me: when we talk about everyday situation, were are we going to focus, is it scientific knowledge that we are not doing every day or local knowledge that we do on a daily bases.

Tala: We normal do not question and related to what we teach in the classrooms;

Sebron: even when someone is making fire, there are so much science in that but we don't bring it out from there into scientific explanation.

Me: Thank you very much:

Appendix N: Visit to the expert community member house (Mee Mukwaluvala)

Omapekepeko kombinga yoshikundu nghee hashi dungwa nongeenge oto dulu tuu oku oingela omhepo oikudja moshikundu.

Oshikundu ohashi dungwa noufila, ongudu nonghundu, onghundu noufila ohai di moilya yomahangu. Omapekapeko aa okwa kwatela mo okupitifa ombuto, oku okulima, nokutuvikla oilya, Okutwa, okudunga Oshikundu noku ongela omhepo okudja moshikundu.

<u>Oku pitifa ombuto:</u>

Mee Mukwaluvala: Okwa longekida ombuto ei tula mo moshimbale shoshikunino, a tula mo oilya komaludi aeshe ngaashi hashi ngingwa pomufyuululwakalo wovawambo nge tava pitifa ombuto, ngaashi omahangu, oilyavala, omakunde, eefukwa omatanga noilyavala.

Mee Mukwaluvala: Ta ingida, “etango ola ya, Mukwamhanhi!”

Mee Mukwamhani: Woi! Mukwamhani ta itavele.

Mee Mukwaluvala: Onde mwiifana tuyeni melandulafano loilonga yetu,

Mee Mukwamhani: Ta pula, ombuto oye ya?

C1: Ta ningi eilikano lokupifa ombuto ngaashi tashi shikula apa:

Tuyeni koshipala shaye;

Omwene tate Kalunga ketu nomukulili wetu nomuyuki nomuyapuki. Omwene tate omunamutimanghenda tate omufilishisho tate Omukulili woiwana aishe tate omunamapangelo aeshe, heeno Omwene tate ohatu ku pandula eshi wauhala pamwe nafye omutenya aushe, Omwene wetu Omukulili wetu omuyuki nomupauki, ohatu ku pandula tate wefilonghenda nohole nomhepo iyapiki, Omwene tate omuyuki nomuyapiki ohatu kupandula eshi wa enda pamwe novaenda vetu ava veya kufye, eshi weva amena nowa kala navo, owaninga omufikifi wavo, weva amena nowa kala komesho noknima, Omukilili wetu omuyuki nomuyapuki, Omwene tate kala pamwe na vakwetu ava tava ende eendjila dile nodixupi, uva kale komesho nokonima ove u dule oku va fikifa oku tava kafika.

Omwene omuyuki nomuyapuki ohatu ku indile ngaha medina laJesus Kristus Omwene wetu:

Tate yetu u li meulu, Edina loye nali yapulwe, ouhamba woye nau uye, ehalo loye naili longwe kombada yedu ngaashi meulu, omungome wetu womafiku aeshe tupa yo nena, tu kufila po omatimba etu ngaashi hatu kufile po ovanamatimba nafye, ino twala momayeleko ndele tu xupifa mowii, osheshi ouhamba owoye neenghono odoye, nefimano oloye alushe fiyo alushe: Amen!

Mee Mukwamhani: Ta pula, omatemo owe a etelela ngaho? Pife ngaha ohatu yeni mepya tu kapitife ombuto, ohatu kalimeni poshinenga shetu apa, Tete manga ovanhu inava kuna ohava limi.

Ovakufimbinga momapekapeko tava limi nee oshinenga shoku pitifila ombuto.

Mee Mukwamhani: Iyaloo, paife ohatu kufeni ombuto yetu fyee tu kuneni.

Michael: Ombuto ohatu kufeni nomake?

Mee Mukwamhani: Heeno, heeno

Shipefi 16: Umwe e na ngoo okambale, (okakunino)

Mee Mukwamhani: Omukulunhu oha kunine ngaa noposhinyafa shaye, hatu kuneneni nee hatu fufilile mo oilya nawa.

Mee Mukwaluvala: Ina i kala kombada otai lika po keexuxwa nokoudila.

Mee Mukwamhani: Fufileni nawa oilya opo iha likemo koudila, iyaloo shili oshinenga oshapwa oku kuna ngaha.

Mee Mukwamhani: Ta fatulula moule konima yokulima nokukuna:

<u>Okuteya no kuxwa</u>

Mee Mukwaluvala: Odula yo otai twikile nee tai loko, opo oilya imene nawa, ndele oilya nge yamene yo tai kulu ngaho, ovanhu tava tameke oku teya, oilya okwa li hai teywa eshi yakukuta nawa opo ovanhu vateye noupu. Paife ohatu yeni mepya tuka teyeni shaashi oilya oya pya, ta u like oihati ta ti: ei oihati yoilya, oilya oko ngaho hai kala keexulo doihati oku, ohatu teya oilya hatu teya, hatu teya.

Shipefi 16: Ta pula nonghumwe, oo hamba osho hakutiwa ovanhu otava teya? Ndele itava tete otava teya?

Mee Mukwamhani: Tava yelifa nawa, heeno otava teya ndele itava tete, shaashi otava teya ashike neenyala, osho oshikulu shetu sho nale, oto teya ove totula moshimbale. (oshiteyelo)

Mee Mukwamhani: Ohatu teya hatu tula moshimbale.

Ndeshi: Mhhhh! Nonghumwe, ta shiti ovanhu ohava teya kwa li neenyala fye katu shishi.

Shipefi 16: Ta i mo hamba hatu udu ovanhu ta vati otava kateya mboli otava ka teya neenyala?

Tala: Ta i mo ta ti: sho osho mboli oilya hai teelelwa ikukute nhenhe, ta yelifa vali kutya opena omwi ei hai pweywa, hai pweywa ashike neenyala, omunhu ho kwata oshihati ove topweyele moshimbale, elalakano loku pweya omwi oku palula ovaneumbo shaashi mokaanda omwapwa. Ovanhu ve na nee okupweya omwi opo va konge ouvalelo.

Mee Mukwamhani: Iyaloo otwa teya nee oilya yetu twa mana paife ohatu itwala koshipale opo tuye tu ka xwe omahangu etu noilyavala. Ta twikile nokuyelifa nawa kutya apa opo nee poshipale apa. (Onhele apa hapa xwilwa)

Mee Mukwaluvala: Ta lombwele ovanhu kutya otai tulwa poshindada vakwetu, hamba oilya otai xuwa po paife? Yee ta pandula Kalunga ta ti: Iyaloo Kalunga ketu neudo okwe tupa omahangu, ohatu pandula unene.

Mee Mukwamhani: Ta yelifa nawa paife oilya oyeya poshipale ohatu kufeni nee omishi tuxweni ovanhu tava xu oilya yavo.

Mee Mukwaluvala and Mee Mukwamhani: Ova Tameka Okuxwa tava imbi oyiimbo yavo yoshiwambo, shaashi ovanhu nge tava xu ohava imbula oyiimbo yopamufyuululwakalo wavo tava ti: Hayoye, hayoye! Handi u ya u tale, ndi mu lombwele shonghuti, onghuti tai kanw' omeva, nena otamu talele hayoyeye! Vo tava kuwilile wilililili!

Tala: Ta pula, i nai kukuta nawa mbela?

Shipefi 16: Aye oitalala.

Mee Mukwaluvala: Naye tai mo vali ta ti: oi na oshimbade, italala, tuyeni ola toka omhemba nokuya poshini.

Mee Mukwamhani: Konima yukuxwa tai mo ta ti: Iyaloo ewi olapya ngaha, paife ohatu kaxwa vali oilyavala, ohatu xu manga opo tuyele nawa? Ohatu kayela etango ola toka, oilya oyapya.

Michael: Ta pula, noilyavala otai xuwa?

Mee Mukwaluvala and Mee Mukwamhani: Heeno

Tala: Hano novalumenhu ohava xu ngoo nee?

Mee Mukwaluvala and Mee Mukwamhani: Tava nyamukula nondjungu: Heeno, ovalumenhu havo nee hava ndjeluka poipale opo tava imbi.

Tala: Ta twikile nepulo: ame ondishi ashike oilonga yetu okudenga ashike ndee opuwo.

Shipefi 16. Oilyavala ohai xuwa ashike omunhu to ningi kashona tondjadjala ashike. Osho a popya eshi taxu oilyavala.

Ndeshi: Elalakano lokuxwa todingonoka oshindada ola shike?

Tala: Opo u ha tatule oilya shaashi eshi toxu ponhele imwaike, to tolitwikile, to lifola popo oilya otai tatauka, fye inatu hala nee oilya yatatuka.

Tala: Ta pula Shipefi 16: ta shiti kushi kutya ovanhu ohava xu tave linyenge?

Tala: Ta pula kombinga yomhepo kutya ngeenge omunhu wa hala Okuyela ndele ka kuna omhepo ohamu ningi ngahelipi? Ngeno oilya oya dengwa ile yaxuwa nee paife owa hala nee Okuyela oto ningi ngahelipi? Ta twikile nokupula, kutya ngeno itatu longifa oshipeleki shaashi oshipeleki opo she ya (oshinima sho shinanena) oto ningi ngahelipi?

Mee Mukwamhani: Ta nyamukula kepulo la Tala ta ti: Ovakulunhu eshi vetu lombwela ovati omhepo ohai pendulwa hai ifanwa taku ti mhepo penduka uta" omhepo ohai pendulwa tai tangumunwa ta ku ti ngaha:

Mee Mukwaluvala and Mee Mukwamhani: Mhepo, mhepo yaKalolo kaHamutenya penduka dja moihati, uye tuxwike ekishi, mhepo yaKalolo kaHamutenya aya nomano oluvanda ndele omushamane ta handuka,

Mee Mukwamhani: ta yelifa kutya omhepo oya penduka (konima eshi omhepo yapendululwa oye penduka shili) ohatu kufa nee oimbale tuyele, omhepo eshi yapenduka ohatu yele. Ohandi endelele manga omhepo ina i shuna. Ta twikile noku pendula omhepo ta ti: mhepo penduka, mhepo penduka, omhepo kai kwete ku ya, mhepo penduka mhepo dja moihati, penduka uxwike ekishi, osho a twikila noku tangumona eshi ta ifana omhepo, ye tayele.

Mee Mukwamhani: Ta lombwele ovapekapeki kutya otwa mana Okuyela ngaha, osho a popya konima yokuyela. Oilya ngeenge yayelwa mo metutu lotete opo tai tengulwa mudje omako yo ikale yayela nawa, tai tengulwa noimbale, ohatu tengula nee ngaha, osho a popya eshi ta tengula.

Mee Mukwaluvala: Ta i mo yo: kutya ohatu itengula i ye meumbo ikaye mokaanda, ei yayela nawa nawa, ohai litulilwa moshimnbale shayo. Osho ngaho natango hatu kayela oilyavala Mee Mukwamhani, tai mo kutya oinima ei yokombada ohai kufwa ko ta popi omako.

Ndeshi: Ta pula: opo ayelifilwe natango pokutangumuna ngeenge omunhu ta ifana omhepo,

Mee Mukwamhani: Ta yelifa kutya opena oshitya shimwe inatu shipopya opo.

Ndeshi: Teva lombwele kutya popyeni ashike oinima aishe.

Mee Mukwamhani: Ta ti nee mhepo ya Kalolo kaHamutenya penduka tuxwike ekishi ponufu; penduka dja moihati wuuye tuxwike ekishi ponufu, iyaloo mhepo yaKalolo kaHamutenya a ya nomano oluvanda, ndee omushamane ta handuka.

Ovakufimbinga tava yolo nee shaashi oshiyolifa shili.

Tala: Ta pula, Haiti Mee Mukwaluvala, nale nale okwa li ashike hamu ingida omhepo ile okwa li ngoo pena sha omukalo umwe ou hamu dulu vali okulongifa moku ifana omhepo?

Mee Mukwamhani: Ta nyamukula epulo; ngeenge owa li oku ifana omhepo ndele inai u ya ovakulunhu ohava fola omwiidi umwe hau ifanwa Oshoke, oyo hai kufwa eshi omunhu te ya koshipale ye tei homeke moilya ei yaxuwa ya taalela kouninginino nomhepo otai penduka.

Mee Mukwamhani. Ta weda po vali ta ti: omukalo umwe ou ha u longifwa oku pendula omhepo, omunhu ota tula etanga li li koshi yoilya ye ta tula ko ngoo eemwiidi, etanga li talala lomungongo, ohe li tula koshi yoilya opo lihakufwe po kounona eshi tava danauka.

Mee Mukwaluvala: Ta weda po vali kutya; omunhu umwe eshi te ya koshipale ota etelele ashike nande okamute/omutoko ndele ta undu kombada yoilya oko, ile eshi eya poshipale ota kufa etutu olo layelwa nale ndele te li xwameke, onghee ngaho omhepo tai penduka konima ngeenge okamundilo okaxulupo, opo nee omhepo tai ya.

Tala: Omikalo do ku ifana omhepo di li 3, okwiimba, etanga nomwiidi nokuxwameka olungu nomundilo.

Mee Mukwaluvala and Mee Mukwamhani: Tava popi kutya paife oilya eshi yaxuwa yo oyapwa okuyelwa otai imeumbo ndele tai kaya mokaanda.

Oilya tai katuvikilwa

Ndeshi: Ta pula: ohatu ka tumba ko onduda?

Tala: Heeno tuka tumbeni onduda.

Mee Mukwamhani: Oilya ohai twalwa nee meumbo, opo ika tuvikilwe mokaanda.

Mee Mukwaluvala: Oilya ohai di mokaanda opo iye koshini, ngeenge nda hala oku twa.

Mee Mukwaluvala: Ta ti: tu tumbeni Okaanda tu tuleimo oilya etango olatoka nee, tau dike kutya otaka yuka peni, natu tuleni opo.

Ndeshi: Ta pula: Ota ku tuulwa?

Shipefi 16: Ta yelifa ye, ohatu ningi ashike twafa hatu tile mo oilya

Mee Mukwaluvala: Aka Okaanda, ohatu tula mo oilya yetu ei, oh! Tai hepa! Ye ta yelifa vali kutya, oilya ihai i mumwe noilyavala, omahangu oha kala mokaanda kao, omanga oilyavala hai kala mokaanda ka kwao.

Mee Mukwamhani: Ta yelifa: Ngaha otwa tuvikila oilya mokaanda, ohatu ka ila mo imwe nge hatu i koshini.

Tala: Ta pula, omolwashike hatu tuvikileko?

Mee Mukwaluvala: Ta nyamukula: opo mu ha ye onuko, opo natango ilya iha tukwe.

Tala: Ta twikile oku pula, Omapomolo?

Mee Mukwaluvala: Heeno nomapomolo oo iha finana.

Tala: Ta pula, Omapomolo ohaa pitile peni eshi hai momaanda, nge oha kala katuvikwa?

Mee Mukwaluvala: Ta nyamukula, Aye katushi shi kutya ohaa pitile peni opo aye mo, shaashi eshi nga to ka tuulako omo ngoo to a ha nge.

Ndeshi: Ta wedako, Omapomolo ohaa i mo ashike nge kwa tuulwa ndele ino fikila wa tuvika ko, shaashi opena efimbo limwe wa filula ko ndee ino tuvika ko vali diva mboli.

Tala: Ta pula, omolwashike ihatu tuvikile oilya moikola?

Mee Mukwaluvala: Tava nyamukula, ka pena oshikola hashi kala shakula tamu dulu oku kwatelwa oilya.

Tala: Ta pula vali: Omolwashike Okaanda haka tulwa onduda?

Mee Mukwaluvala: Opo ilya iha lokwe shaashi ngeenge Okaanda oka kala kombada nena eshi odula tai loko Okaanda otaka tu tu ndele oilya tai menene mo, ndele oilya tai nyonauka.

Ndeshi: omolwashike ovanhu hava kolonga Okaanda meni va lumbakanifa edu netudi longobe?

Tala: omolwaashi oilya mokaanda ohai kala mo efimbo lile opo mu he uye onuko, shaashi nge mu na omatudi ongobe oupuka itava i mo noupu, ohashi dulu oku ningwa nakeshe osho tashi dulu oku kelela mu haye onuko.

Ndeshi: Ta i mo vali onda mona omafiku enya nda ka landele omaanda availi, ashike kamwe kombada komunghulo oka filwa natudi longobe, opo shike mbela? Na ku tunga Okaanda okwa dilaadila shike mbela?

Mee Mukwaluvala: Shimwe oupamene wokaanda.

Ndeshi: Ta yelifa, okwa li ngaho nde shi pula kutya omolwashike, ashike ka kwa li nda pewa etomelo lofaafa, shaashi okwa nyamukula ashike kutya Okaanda weka tunga ito dulu ashike oku kalandifa po ashike ngaho ino ka vaeka omatudi eengobe.

Tala: Ta pula, omolwashike Okaanda ita ka kala pedu?

Mee Mukwaluvala: Ta nyamukula, ota kalika po keehedi ngeenge oka kala pedu, ko ota ka nyanauka komeva.

Ndeshi: Ta weda po nokuyelifa ngaha, etomelo la kula, olo ku amena Okaanda komeva nokeehedi.

Pounding of Mahangu

Shipefi 16: Ta pula, ndishi itapa xutulwa noku tula oilya momeva, ile otashi ningwa mongula?

Mee Mukwaluvala: Naye ta yelifa, ile ohatu xutuleni paife? Oshini opo shili.

Shipefi 16: Natu ka tweni koshini.

Ndeshi: Ta pula, Natu tuleko ashike nande ina i fifwa? (shaashi oshili omu landu kutya omunhu tete manga ngeno ina tula oilya koshini oku na oku fifa oilya omadu).

Shipefi 16: Tu tweni opo ashike tumone Ongudo.

Tala: Ta pula, omolwashike moshikundu hamu tulilemo Ongudo?

Mee Mukwamhani: Ta nyanukula, opo ngaa Oshikundu shi kale shina omulyo nawa.

Tala: Ta twikile nepulo, Ongudo?

Mee Mukwamhani: Ta nyamukula, nongudo kumwe ngaa ngaho.

Tala: Omolwashike Oshikundu ngeenge inashi tulwa Ongudo ihashi kala shiwa?

Mee Mukwamhani: Ta nyamukula, Ongudo oyo hai pifa Oshikundu.

Mee Mukwaluvala: Ta weda ko vali, Ongudo oyo hai eta omulyo moshikundu, yo ohai pifa Oshikundu.

Tala: Ta weda ko kenyamukulo, omolwa oshuuka ei ili mongudo.

Mee Mukwamhani: Ashike nande kuna Ongudo oto dulu ashike oku kala watula mo Ongudo ihapu.

Tala: Ta imbi eshi tat u ta ti: Takatu taka ekele,

Ndeshi: Kafa kehe na oukesho, taka tu taka ekele taka twile ovamati.

Shipefi 16: Ta i mo yo, oya pwa,

Tala: Ta pula, ongalo?

Mee Mukwamhani: Ta pula, hano Oshikundu otashi ningwa nomeva mahapu?

Mee Mukwaluvala: Mboli hano ngeno otwa tulile po mokambiya kashona.

Me: Ta fatulula kutya, Oshikundu oshina oku kala shihapu.

Mee Mukwaluvala: Ta pula, shihapu?

Me: tanyamukula, heeno.

Ndeshi: Ta popi, ota ku fendununwa, ye ta wedako eteni ongalo.

Me: Ongudo nayo ohai dulu oku telekifwa oifima?

Ndeshi: Tanyamukula kepulo, Heeno, otai dulu oku wedwa mo.

Tala: Opena nale Ongudo?

Mee Mukwaluvala: Ta nyamukula: heeno ope na.

Tala: Ta yelifa kombinga yokunengeka oilya oto tula mo natango omeva ashona.

Ndeshi: Ta nyamukula, heeno tula mo.

Tala: Ta pula a hala oku yelelwa nawa nawa kombinga yokunengeka oilya, omolwashike oilya hai tulwa pomutenya nge yanengekwa?

Ndeshi: Ongeenge ngaho wa hala indjene po yo ipye komutenya kashona, ngeenge kuna efimbo oto nengeke ashike inai yula shaashi kuna efimbo.

Tala: Ta pula kutya, ava hava nengeke tava tula meenailona? (Ina linyamukulwa)

Michael: Ame ondi hole okutwifa omushi u na ondjudo ihapu.

Tala: Ta yelifa, shima omushi u na Ongudo ihapu ota u tatutla diva oilya ngaho.

Ndeshi: Ta lombwele omupekapeki eshi tava tu ta ti: ou wete paife otai tameke okutoka ngaho, osho apopya eshi oilya tai pi koshini.

Ndeshi: Ta yolo, hehehehe!

Tala: Twa tofende ko manga, (opo oilya ipye nawa nge tai tuwa tai fendwa)

Ndeshi: Ta fatulula eyooloko pokati kongudo noufila, ta lombwele omupekapeki: Ouwete ngaho eyooloko pokati konima ei ivali?

Me: ei otai longifwa shike, Ongudo.

Tala: Ta yelifa kutya Ongudo otai longifwa moshikundu pamwe noufila, ashike tete oto tameke noufila opo nee ngeenge shapwa totula mo Ongudo.

Mee Mukwaluvala: Ta pula kutya: omwa pumbwa yoo okupekapeka kombinga yongudo?

Ndeshi: Ta i mo: Ongudo oi na nee ondjila ile shaashi oya pumbwa okumena tete.

Mee Mukwaluvala: Ta popi kutya, opena imwe inai findikwa natango, kwa li ndi na oku itula edu ndele inandi itula vali edu onda teelela muuye, oyadja nale momeva.

Ndeshi: Ta pula, oilyavala ei momeva oya ninga mo omafiku angapi?

Mee Mukwaluvala: Oya ninga mo omafiku anhe, atano kefiku lonena, ashike ina i pya natango noku twa, opo tai ka tulwa edu.

Mee Mukwaluvala and Mee Mukwamhani: Tava u likile omupekapeki Ongudo ei ei ya tuwa nale kutya, ohadi moilyavala, yafindikwa omo nee hamu di Ongudo ei omo.

Me: omolwashike Ongudo ina okumena tete manga inai tuwa?

Ndeshi: Ta twikile kepulo, omolwashike ina okume na?

Mee Mukwaluvala: Ta nyamukula, omino odo hadi eta omulyo mongudo,

Mee Mukwamhani: Ta weda ko okokutya, nge oya mene ohai kala iwa, nge oyamene ndele tai tilyana opo hai ningi oufila u kale utilyana nge inai mena oufila itau tilyana filufilu.

Tala: Ta pula, eshi ta ti, handi ya ndi pule, tete oilya ohamu itulwa momeva?

Mee mukwamhani: Heeno

Tala: Ohai ningi mo omafiku angapi?

Mee Mukwaluvala: Avali

Tala: Ta pula vali: omolwashike ta mu itulile momeva?

Mee Mukwamhani: Ta nyamukula, opo itute nawa, yo idule okumena diva yo ininge omino ngaha.

Tala: Nye tamu kei tula medu?

Mee Mukwaluvala and Mee Mukwamhani: Heeno, oto dulu oku kala ino itula medu toi tula ashike moshiyaha, to tuvike kononailona, to kala nee ho shashako oumeva kombada yonailona, otai ningi ashike omino ndele tai fiki nawa nawa ndele oufila tau kala utilyana muwa muwa.

Tala: Ngeenge tamu tula ko edu omolwashike hamu tulile ko eheke? Ihamu kufa ashike edu keshe pamwe?

Mee Mukwaluvala: Te i tula edu, ta findike, Tala: ta pula natango otai ya ngaho i findikwe?

Tala: Ta pula omolwashike ihamu longifa edu keshe ngaashi e li twa lyata kulo eli?

Mee Mukwaluvala: Aye olo oli na ondwi ihapu

Sebron: Ta pula, kombinga yedu lokufindika, edu olo ota li kadjako ngahelipi?

Mee Mukwaluvala: Ota li kadjako ashike ngaha, osho a ulika eshi takaulula ko edu kombada yoilyavala.

Ndeshi: Ta weda po ei yokombada ohai fifwa.

Michael: Ta weda po kutya eshi omunhu wafindika ngaha owafa omunhu ameneka mepya.

Sebron: Ovanhu ohava longifa nawa eheke opo omeva afike nawa koshi.

Mee Mukwaluvala: Ta yelifa kutya eheke oha li tulilwa ko opo oilyavala iha kukute, nongeenge kombada yeheke okwa kukuta natango otaku shashwa omeva, opo ifike nawa pefiku layo lokutwa ili nawa.

Sebron: Ongudo ohai tuwa nonghundu nge oya yula oto tula ko Ongudo ikukutu koshini, nge oya keshangala oto tula ko, Ongudo ya tuta koshini, nge oya keshangala oto tula Ongudo yakukuta.

Mee Mukwamhani: Nge owa tula ko Ongudo, Ongudo ohaipi nawa koshini, nale okwa li ashike tai lihane unene.

Ndeshi: Ongudo ihai fifwa yapepuka lela, omu na ngoo oku fyaala oumuma vamwe vamwe.

Tala: Ta pula, manga etumo lovasoomi ina li uya ovanhu okwa li hava ilikana ngahelipi?

Mee Mukwamhani: Ta nyamukula: okwa li hatu ilikana eilikano oko la kala ihomono omunhu aninga okanhenga kashona Shona ponhu? Okanhenga oko, oko ku pitifa ombuto, ovanhu tava ilikana ashike nande ove li vavali.

Sebron: Ta wedako kutya, opena vali oshiima shimwe ombuto nge tai kakunwa ohai indililwa, nongeenge tai kaliwa natango ohai indililwa.

Mee Mukwamhani: Ndele eshi tamu indile oinima aishe ei toka kuna opo ina oku kala ngaashi omakunde, eenhanga, eefukwa,omahangu noilyavala.

Sebron: Ta pula, paife otu na oufila womahangu nongudo, paife ohatu kadunga Oshikundu.

OSHIKUNDU

Tala: Omeva Oshikundu oshike ha andjene?

Mee Mukwaluvala: Opo Oshikundu shi ha toke, sho otashi ningi ashike Olumbololo, tashi ningi etepi itashi ikwata.

Ndeshi: Ta fatulula paife otu na oufila womahangu, nongudo paife ohatu dungu nee Oshikundu.

Omupekapeki okwa pula, kutya ovakainhu ashike veshi oku fifa nongalo? Ovakufimbinga tava yolo shaashi ovalumenhu okwa li tava kendabala Okufifa nongalo, sho oshiyolifa.

Tala: Ta pula, owafaneka nge, osho a pula eshi kwa li tafifi,

Omupekapeki ta nyamukula, ahowe inandi kufaneka.

Ndeshi: Paife ohatu dungeni nee Oshikundu, ashike omeva a Shona.

Mee Mukwaluvala: Omeva ashona? Okwa pwiinina mo vali mbela.

Ndeshi: Omeva ashona.

Mee Mukwaluvala: Na muwedwe hano divadiva.

Ndeshi: Iyaa oe li nawa ngaho.

Mee Mukwaluvala: Okwa li apwiinina mo okwa fuluka nale efimbo lile.

Shipefi 16: Ta pula; Hano oshike kwa li handi udu kutya eendunga dipe ohadi topa ngee dai pediko?

Mee Mukwaluvala: Heeno ohadi topa.

Ndeshi: Odo kadipe?

Mee Mukwaluvala: Ta nyamukula, aye odi kulu.

Ndeshi: Ta pula Mee Mukwaluvala, oshike to pepele omundilo ngaho mee?

Mee Mukwaluvala: Pediko ota pai omhepo eshi handi pepele, oyo tai fudile po.

Sebron: Ta pula, omhepo oyo tai i pediko omhepo ei hatu fudile mo, shaashi ohaku tiwa omhepo ei hatu fudile mo ohai yambidida omutemo.

Ndeshi: Ta nyamukula; heeno elumbakano lomhepo ei hatu fuda nai hatu fudile mo.

Sebron: Oshike tashi eta omundilo uteme?

Ndeshi: Ta nyamukula omolwa omhepo ei hatu fuda.

Ovakufimbinga, okwa li tave liyelifile nawa kombinga yeemhepo omaludi nghee hadi dulu oku hangana mokutema.

Tala: Ta pula kutya: Oshike kombinga imwe yediko kwa idilwa?

Ovakufimbinga tave liyelifile, kutya okwa idilwa shaashi opo omundilo udingonoke Ombiya, nomundilo uha pepelweshi komhepo yo Ombiya idule okupya diva, shaashi omundilo aushe owayuka kombiya.

Shipefi 16: Ta lombwele omupekapeki: tate R Oshikundu osho otu na okushinwa po filufilu.

Omupekapeki ta nyamukula, heeno otashi nuwa po mongula shaashi oshapya.

Tala: Ta pula; ohatu dungu Oshikundu sha yooloka, ile ohatu dungu Oshikundu shimwe?

Me: ohatu dungu ashike shimwe fyee hatu ka dila momakende ayooloka, shaashi Oshikundu shimwe otashi i Ongudo ndele itashi i ehete, omanga shimwe otashi i ehete, nongudo, omanga shikwao itashi i sha nande nande.

Tala: Hano Ongudo ei italala ohai longifwa ngaho?

Ndeshi: Ta nyamukula, Heeno.

Tala: Ta lombwele ovakufimbinga kutya ope na oufila umwe hau dulu oku ningifwa Oshikundu woilyavala, Oshikundu hashi ifanwa Oshikundu shekoko, oilyavala itoka hai ifanwa ekoko oyo hai dulu oku ningifwa oufila woshifima nomingome noshikundu.

Ndeshi: Omeva okwa fuluka

Sebron: Tetete omeva oe na okufuluka.

Michael: Ta i mo yo, ope na omukalo umwe ha u longifwa ngeenge omunhu in a hala omeva afuluka ohaku fa oufila ndele teu tula koluko lili kombada yombiya, ta teelele fiyo oufila otaupi washendja oluvala koshimhuke nena ngaho otashi ulike kutya omeva oo e li mombiya nande ina afuluka otaa dulu oku dunga Oshikundu ndele itshi ningi etepi.

Mee Mukwamhani: Ta yelifa yo kombinga yokaufila, aka haka tulwa koluko ngeenge ino hala omeva a fuluka, andjena. Ashike Oshikundu osho hashi kala shiwa.

Ndeshi: Ondi wete kutya okaufila oko shama weka tula ko ndele okaninga kafa oshifima ngaho otashi ti omeva oo ota adulu oku longifwa Oshikundu (osho a yelifa)

Shipefi 16: Naye ta yelifa yo, iho tula mombiya oho teneke ashike oluko kombada yombiya, shima she likwata otashi u like kutya omeva otaa dulu oku dunga Oshikundu itashi ningi etepi.

Ndeshi: Ta pula, oufila owaya mo?

Ovakufimbinga aveshe tava nyamukula? Heeno.

Ovakufimbinga tave lipe omayele kombinga yokudunga Oshikundu sho osho wuudite keshe umwe ota yandje omayele (omalyuudo) aye ngeenge Oshikundu otashi dungilwa mumwe sho shi ka tukulwe nale ile otashi dungwa sha tukaulwa petameko.

Ndeshi: Ta i mo oshafuluka unene.

Shipefi 16: Ta nyamukula, aye oshili nawa ngaho,

Ndeshi: Ohashi polopo manga kashona, ouwete kutya omolwashike hatu teelele shipolepo kashona, omolwashi, ngeenge Oitungifi oya i moupyu muhapu itai ka longa nawa.

Ovakufimbinga tava popi vo tava yolo eshi Tala, a pula epulo liyolifa.

Ndeshi: Ta twikile oku popya kutya Oitungifi nge oya i moupyu muhapu Oshikundu itashi kala vali shi na omulyo nawa, otu na oku pilula mo ndele hatu ka pilula mo vali.

Omupekapeki ta pula, kutya ngeenge otwa longifa omeva a talala?

Mee Mukwaluvala, Tala, tava yelifa kepulo osho hashi ningwa petameko manga oufila ina u ya momeva.

Mee Mukwaluvala: Ta nyamukula yo otashi ningi etepi, otashi ningi ashike Olumbololo otashi toka ashike toto, itashi kala ngaha ngaashi eshi.

Ndeshi: Ta fatulula kutya ngaho omahangu okwa telekwa etata.

Sebron: Ta pula, paife ngaho otomono ngahelipi kutya kashishi etepi?

Ovapekapeki, tava nyamukula shaashi kashitoka.

Mee Mukwamhani: Ta yelifa, nge owatula oumeva omu ndele totula mo oufila otapa kala eyooloko pokati kaashi naashi.

Shipefi 16: Ta koleke; Tutuleimo ashike omeva omo.

Mee Mukwaluvala: Eshi itashi li kwata ku wete itashi faafana naashi, eshi oshitoka.

Shipefi 16: Tula mo Ongudo osho a popya.

Ovakufimbinga vakwao tava i mo yo kutya aye natu shitukuleni manga moikwatelwa ivali, okavela aka oko natu kufeni aka:

Shipefi 16: I kale i li ivali?

Sebron: Ta imo mh! Shayela kutya otai kala ivali, ota pa kala shimwe oshi na Ongudo naashi shihe na Ongudo.

Ndeshi: Ta dimbulukifa Ongudo inatu itulamo.

Mee Mukwaluvala: Ta nyamukula mongudo onda tula mo Ongudo nde i pilulila mo eshi ndei kwanghula.

Mee Mukwamhanu: Oshikundu shimwe ohashi dulu okutulwa Ongudo ihapu ngee kuna Ongudo.

Mee Mukwamhani: Shimwe itashi i Ongudo?

Mee Mukwamhani: Ta nyamukula; ee shimwe itashi sha.

Shipefi 16: Mwaashi sha kula omo namuye Ongudo omu.

Omupekapeki ta lombwele Mee Mukwaluvala, meme tula mo natango inandi kufaneka.

Shipefi 16: Tala paife otashi yululuka. (konima eshi mwaya Ongudo)

Mee Mukwaluvala: Ta nyamukula; omolwaashi Ongudo eshi yatenda ngahenya itai pame vali, nande ngeno oto lungu Oshikundu sho ifima oho dulu oku itula mo ove to nyanyaula oifima, to pilula ashike fiyo tashi ningi embobo, ino tula mo nande omeva.

Shipefi 16: Ta i mo; ngaho otashi shendje sha yuka komeva.

Mee Mukwaluvala: Pamwe novakufimbinga tava nyamukula epulo oshita, heeno, ye C1 tayelifa omolwa Ongudo ei yaya mo.

Tala: Ame Ongudo ohai nye ngenge, mongudo omu na shike?

Mee Mukwaluvala: Mongudo omu na omulyo muhapu.

Sebron: Ooo omulyo oo oo hau etifa ounyenye moshikundu?

Mee Mukwamhani: Heeno shaashi ngeenge ongava oya kala inai tenda ile inai pya nawa itashi kala shiwa.

Shipefi 16: Opo ngaho handi uya ndi shinwe, ondi na okushinwa ashike, osho a popya eshi ta dili Oshikundu meomakende.

Tala: Ta i mo onda hala oshipififo, ehete.

Mee Mukwaluvala: Ehete? Omwafa ngaho mu na.

Tala: Omu ohatu tula mo Oshikundu nehete ndele itatu tula mo Ongudo ashike itatu tula mo Ongudo.

Ovakufimbinga tava nyamukula, otashipi.

Mee Mukwaluvala: Ndishi otashi dilwa momakende?

Sebron: Oshike mbela nge otwa tale ashike kongudo pehena sha ehete nande nande.

Sebron: Omu ota mu i?

Shipefi 16: Omu itamu isha omu, ohatu tutula mo ashike Oshikundu inamu ya sha ehete.

Tala: Hano omu na oinima i li ivali? Ame ondi shi ngeno ohatu kala tu na oinima ili itatu, shimwe ocontrolla, omu inamu yasha Ongudo. Mumwe omwaya Ongudo ndele ina muya ehete, mumwe otamu kala mwaya oinima aishe.

Tala: Nge ou na oinima i li itatu oto kala nee u li awa.

Ovakufimbinga tave lipe omayele, ngeno omu otamu dishimwe hatu shi weda mwaaashi, Tala: omu ota mu i omeva, oto ti osho ashike osho? Shinya oshihapu nai shii!

Tala: Eshi osho ashike hatu longifa, omu na muye natango omeva omu osho a lombwela vakwao.

Shipefi 16: Opuwo aye natango tula mo. Naamu omwa pumbwa okuya omu eli olapama natango namuye omeva natango.

Ndeshi: Ahowe ehete ota li i ashike mumwe amuke.

Mee Mukwaluvala: Hamba inamu tya shimwe otashi i Ongudo shimwe itashi i, shimwe itashi isha nande nande Ongudo ile ehete.

Sebron: Fye hatu tale nee kutya, eshi shina Ongudo nehete naashi shihe na ehete ndele oshi na Ongudo, naashi he na sha nande nande shili pi tashi pi tete?

Mee Mukwamhani: Ta pula, eshi inashi ya Ongudo oshili nawa?

Ndeshi: Ta nyamukula heeno osho oshapwa osho ngaho.

Me: osho oshapwa paife ohatu kufa mo ndele hatu tula vali mekende omu, kwaalo ohatu tuvike ko ashike nebaroona.

Shipefi 16: Noplastica? osho a pula.

Me: Aye onebaroona, opo tu ongeleni omhepo, sho tashi tu u likile kutya ekende li lipi ta li reactor meendelelo.

Sebron: To look the amount of gas produced by comparing the baroon.

Michael: Ashike omakende na a kale e na omalutun efike pamwe.

Sebron: Omu omo tamu kaya ehete omu osho a popya eshi ta di li ekende etivali.

Mee Mukwamhani: Oluko nande ola dimo.

Tala: Shono pilula mo omu, omu na ehete lihapu.

Tala: Ta pula, owa hala li kale liyadi ndoo ndoo?

Me: heeno opo omhepo yo Carbon Dioxide, iha mone omito yoku kala mo.

Me: Ta twikile noku pula, otamu i ehete? Ehete na li uye nee.

Ndeshi: Ndishi itatu hange ebaroona latopa nande? Ngaashi osho shina ehete otashi topa.

Me: ebaroona ota li nanunuka.

Tala na Shipefi 16: Olo ehete nee, Oshikundu tunwe mo nokuli.

Mee Mukwaluvala: Mboli ngeno onda etele ashike okavela.

Mee Mukwaluvala: Tula omu, tula omu.

Ndeshi: Oli hapu unene, otashi lulu diva.

Shipefi 16: Aye ola wana.

Tala: Ina mu hala shalula?

Ndeshi: Oushii ngaho kutya ohatu uya efimbo peni?

Shipefi 16: Itashi lulu shaashi okwa talala.Tate Chakapaya, ame ohandi uya po 12h00, ndinwe ndele ame handi

shuna kofikola vali manga, osho Tala a popya vo ovanhu tava yolo po manga.

Me: Paife ohatu didilikeni nee, e li losprite, ohatu tula ko ebaroon lishunga, ekende e li lolemona Twist ohatu tula

ko epink, likwao ohatu tula ko ebaroona litoka, (Coke nothing).

Me: ino longifa osho otashi twaalele mo oinima aishe mwii. Osho a popya eshi ta kelele oluko li ha pilulifwe

moshikundu shikwao ina li koshwa).

Tala: Ewa onda pumbwa oku likosha tuu? Ohandi kosho ko.

Sebron: Openi pena ombapila, ndi didilike.

Shipefi 16: Inda mohauto yange, (omu na omambo) opo tu hangwangwane mongula eshi hatu uya.

Tala: Iyaloo, osho a popya eshi vafika pexulilo.

Me: tai mo ovakufimbinga vatatu otava dulu oku a kufa po opo ndiva faneke.

Appendix O: Lesson One at School B with Shipefi 16: Chemistry lesson 1

Shipefi 16: Mr. Chakapaya is with us to day, he is the Principal of Onepandaulo CS, it is a nearby school. He is doing his PhD with Rhodes University and am one of his participants. He asked me to observe my lesson today where we are going to talk about experimental techniques, looking at methods of purifying, where we are going to talk about filtration and crystallisation. Right. Am only going to define two words, which is distillation and crystallisation. But before that I would like to ask learners to tell me how do you purify water at home? Let say you just took water from Ondombe, then you want to make it more pure for drinking purposes, how do you do that?

L3: Boiling

Shipefi 16: we boil them using what? We want the apparatus we are using at home, we just boil and from there we wait for the water to cool down so that you can drink. Am requesting you rise up your hands in case you want to say something. How do we make water to become pure ready for drinking purposes? Yes

L7: we boil water then after we add ash

Shipefi 16: that is *Omutoko* in Oshiwambo nee, after that?

L7: then we let the ash to settle down at the bottom

Shipefi 16: then the water will be clear or is there any other process, any one to add on that

L10: filter with the clothes

Shipefi 16: Jafet said you can either filter with the clothes at home so that the ash will remain and the other water becomes ready for drinking. Then today we are going to look at this two. Distillation the process of separating miscible liquid and crystallisation where we are separating what? Who can define for us what crystallisation is? To separate soluble content from the solution or soluble solid from the solvent or a solution and that is what we are going to do today. In the first place I would like to ask Namindo Regina to take her poster and come explain to us of simple distillation works.

L1: we are going to learn simple distillation. But before how do we get the pure solvent from the solution? This is a solution right, in this solution we have a solvent. How do we get a pure solvent from this solution? You people you don't understand the process of distillation or what? We just get the pure solvent from the solution by using simple distillation. The process of getting a pure solvent by simple distillation….. this is heat, this is distillation flask, here we have our solution, the solution which is in here is salt water solution. Now here we have the heat and this solution now is boiling. What happens here? Here it change from liquid to gas/vapour/steam/. This boiling flask is covered, what is the reason guy? One person at a time please.

L10: to prevent steam from escaping out

L1: yes to prevent steam from getting out, the main ideas is to get the pure solvent. If you let the steam to evaporate to the atmosphere will you get the solvent?

Learners: No

L1: we cannot collect solvent from the atmosphere, so you have to cover this thing with the cover/stopper. This one is called a condenser. Since this one is covered with the stopper this steam will just come this way this side. This is what we call a condenser now, what is the reason of having a condenser?

L12: to change the steam into liquid

L1: yes to condense, condenser is just from the word condensation. Do you know where the gas is coming from? From evaporation nee. Evaporation come from liquid to gas, now this gas will be condensed in the condenser. The function of the condenser is just to condense the gas/steam to liquid. This is condensation and it is cooling steam to liquid by let cold water in and warm water out. Cold water will get in here to cool steam this side, do you understand?

Learners: yes

L1: we always cool this thing to liquid and this liquid is what we call a distillate, the pure solvent now …. It like you guy are confused?

Learners: No

L1: do you guy understand?

Learners: yes

L1: so now we have obtained our pure solvent. This is?

Learners: heat

L1: here

Learners: mute

L1: condensation people (angry)

Learners: Evaporation

L1: when you heat solution it will evaporate, I want you guy to say evaporation

Learners: evaporation (loud)

L1: we have the stopper here so that the steam should not go anywhere so that it will just go to the condenser. For this thing to condense what do we need?

Learners: cooling

L1: How do we obtain cooling?

L13: by allowing cold water in

L1: Ok you guys you understand now, any question

Shipefi 16: clap hand for Regina, thank you very much. How do we call the liquid collected?

Learners: distillate

Shipefi 16: Distilled water nee, thank you and now…. This one is simple distillation when you want to collect the solvent, right. Right now we are moving to crystallisation, where we are only going to use an evaporating dish to get the salt from the water-salt solution. This one is going to be presented by Elizabeth and ……… right: come and do your presentation. Here Mr. Chakapaya is where we want to do the process itself, I don't know if we can make experiment… maybe you can just explain then we go and heat outside later. You can draw it on the chalkboard and explain.

L2: Afternoon class

Learners: Afternoon sir

L2: How are you?

Learners: fine and how are you sir

L2: Am fine, am going to demonstrate the experiment of crystallisation. Crystallisation is the process where we heat the solution, for example I can say salt solution to obtain salt crystals. We want to obtain the salt crystals from the solution of saltwater. Here is salt, can you see, here is water, water is a solvent. This is evaporation dish (Etiti), traditional evaporation dish. We don't have fire wood here, I want all of you to look on the chalkboard. This is the Bunsen burner, traditionally we use fire wood to produce heat. This is the evaporation dish it contain a solution of saltwater. We take the Bunsen burner and heat solution, you know different liquid has different boiling point?

Learners: yes

L2: water boiling point is 100 ^{0}C, if the temperature reaches 100 ^{0}C water will start to evaporate in to the air, leaving salt crystals here. When water evaporate completely, then you take out your evaporation dish to take you salt crystals. It is another simple way of collecting or obtaining the solute crystals from the solution.

Shipefi 16: Maybe Elizabeth want to add something

L5: Let me some up the process explained by ….. this process is known as crystallisation whereby we have to separate a soluble solid, which is a solvent separated from soluble solvent by heating the saturated solution whereby we heat the saturated solution to evaporate the solvent. The solid which come out from there is collected as crystals.

L2: We are going to illustrate this physical, this is evaporation dish is *Etiti*… traditional evaporation dish, am sorry that we don't have fire wood here. This is salt crystals. I will pour it in the evaporation dish, our solvent here is water you then take a stirring rod. You have to stir until salt dissolves completely in water. Let assume there is a Bunsen burner or fire wood under here. Heat, the evaporation dish will be then heated by the Bunsen burner and water will evaporate from the evaporating dish leaving salt crystals.

Shipefi 16: right we can go and do the demonstration, outside where we use to get out fatty cake, right. There is traditional *Omafiya*, we are still going to use this we will just try to make up the fire. We want to see if we salt crystals will be formed in the *Etiti*.

Learners: observed the process of crystallisation that took place outside the classroom.

L15: sir can this salt still be used?

Shipefi 16: yes it is salt you can use it

Shipefi 16: We can all confirm that crystals has been form

Learners: yes

Shipefi 16: Take *Etiti*, let go to the class

Shipefi 16: Can we see crystals are formed

Learners: yes

Shipefi 16: we only used *Etiti* because we don't have evaporating dish. Our next topic is distillation, where Rauna will demonstrate us how *Ombike* is made at home and the process of Distillation. Rauna u may come forth and demonstrate how *Ombike* is made.

L13: we have such interesting lesson, Good morning Mr. Chakapaya

L13: you can feel free to use either the local language, in case the term in English is not available, you can say it in Oshiwambo, for example *Ombiya*.

L13: Good afternoon Mr. Principal, Mr. Chakapaya, Good afternoon Mr. Nauyoma and Good Afternoon my classmate.

Learners: Good afternoon Rauna

L13: Let go ahead with our lesson, a simple distillation process can also be used to produce some of the brewed such as Whisky, by distillation in this case *Ombike*. I have a poster so that I can show you guy. This is the process, firstly we ferment, and fermentation is done. We make Ombike using fruit like *Eembe* (Jackal berry/ wild berry), *Eenyandi* (African Ebony), *Eengekete* (Buffalo

Thorn) and grapes. Let talk about *Eendunga* now, they are pilled off, the small pieces that are pilled off are fermented in a drum with water. They remain in that drum for about two weeks.

Learners: No maybe five days

L13: It depend, for you to know that now the fermented is ready for *Ombike* to be distilled out, you taste it, it will taste sour or it will have alcoholic taste. Before distillation, sugar is added to the solution in the drum so that it will provide sour taste when added to the mixture. Ok, it then cooked, after the solution produced an alcoholic taste. It is put in the clay pot which is covered with clay soil on top. Do you have ideas why it is covered?

Learners: yes

L13: so that the alcoholic steam will not evaporate out moos, it just the same like other distillation we talk off. We have *Okatemba*, inside is a metal pipe from the clay pot and it pass through the *Okatemba*. Ok here is the pipe we are talk off and it pass through *Okatemba* and out. In *Okatemba* we put cold water so that it will condense the steam we are get from the pot that is boiling. The steam is condense by cold water that we pour in this *Okatemba*. When the water in this *Okatemba* get warm, we replace it with cold water, so when the steam is condense it gets out through this pipe, the cylinder is put here so that the water (*Ombike*) will be dripped into this empty bottle through the small string that is put here. This pipe is wrapped in cloth soaked in cold water and cool water is also put in here. When the water get warm we pour out, you put back cold water so that the things coming out from this pipe is condense so that it drip out from the pipe. Then you collect the Whisky. Any question…..

Shipefi 16: Rise up you hand and speak out

L20: How do we get *Omachacha*?

Shipefi 16: That question I can answer it. Mr. Chakapaya she is asking how we get *Omachacha*. *Omachacha* is when *Ombike* which is not that strong, it come in when maybe in the process, when the person who is preparing *Ombike*, she went to greet someone in the house, then she forgot to replace the hot/warm water. You end up receive *Ombike* which is not stronger as the one that come first. Sometimes at the end of the process the fermented which are in the clay pot are getting finished, you end up have thing that don't have that quality you are looking for, that is *Omachacha*.

Shipefi 16: Learners you need to know apparatus that you have to use, either at home in case you find yourself without apparatus that you can make use off. Like in our case we found that we don't have apparatus in the lab, we can come up with any traditional apparatus that we can use instead of lab apparatus. That why we have used *Etiti* as example of evaporating Dish. What we need is to know the materials, local available materials that we can use in our science classroom. What were we doing out side?

Learners: Experiment

Shipefi 16: we were carrying out experiment, the apparatus might not be available, so might try to come up with something on our own. We must not just depend on those bought lab materials/apparatus

Shipefi 16: is there another question or someone who want to ask something before we call it a day. Is it very thing clear or someone what to ask a question. Mr. Chakapaya that was all about our lesson for today, we thank you for your time and our learners to know you, yes Mr. Chakapaya the Principal of Onepandaulo Combine school. Mr. Chakapaya will be visiting us again.

Appendix P: Collated reflections from participants

	Names for participants				
Participants questions	**Michael**	**Sebron**	**Ndeshi**	**Shipefi 16**	**Tala**
Most salient knowledge gained during the workshops with community members, researcher and other teachers?	I have learnt that IK is being supported by the Namibian National Curriculum and there many indigenous knowledge in our community that we use to do but we do not really noticed it if there is science involved. I have learnt /gained that team work is really important. I have gained that most western knowledge that we learn from school are pre-existing in our communities. From the community members again I have gained that Christianity have been there since because before we went for	I learnt the procedures of preparing *Mahangu* and how they are harvested. Indeed I learnt how Oshikundu is prepared with *Ongudo* and hot water. Furthermore I have come to know that the gas released from *Oshikundu* is Carbon dioxide this was proven when the gas was bubbled in the limewater and turned milky.	I learnt that there is so much that our local knowledge can offer as far as teaching and learning is concern. Several topics have some common practices in the community that can be used as examples to the learners e.g. making of *Oshikundu*. I learnt that there is so much in Oshiwambo culture that is more scientific, the concepts of making *Oshikundu* has aspects that are pure Chemistry. Topics such as rate of reactions where the one we dealt with. As	I have acquired the knowledge on the series of steps on how to prepare Mahangu and how they are harvested in the communities. I have also learnt and perfected the art of preparing *Oshikundu* with *Ongudo* and boiled water. To add to that I got to learn that the gas released from *Oshikundu* during fermentation is Carbon Dioxide. This was proven when the gas formed was bubbled in the limewater and turned milky.	The outstanding for me, was the way the community members narrated to us (teaches) how the plantation of *Mahangu* and sorghum take places. The community experts noted before we embark up on sowing we first pray for the seeds before sowing and this has been a common practices passed on us by our forefather and it is a practices within Namibia particularly an Oshiwambo speaking people.

	sowing they have prayed for the seeds and again for the rain and thereafter for the good harvest.		Chemistry teacher, I will start using this knowledge of *Ongudo, Oufila* (flour) and why hot water was used and many more.		
How did co-analyse of documents using topic specific pedagogical content knowledge helped you:					
Chemistry curriculum	It help to guide me on what to teach and learn as a teacher in Chemistry. For example, rate of reaction it personal helped me to understand and compare the knowledge from both angles, be it from home or the curriculum itself in school specifically in Chemistry classroom.	Chemistry curriculum has indicated that the content should reflect on real-life situations to boast the already existing knowledge. The topic under research can be more appropriate to use learners' knowledge on how to make *Oshikundu* as most of the learners already have the knowledge.	I came to understand that the national curriculum does not oppose the inclusion of IK and lies in hand of the teacher to pick correct teaching pedagogies as to include IK.	The Chemistry curriculum clearly started that the content to be learnt should reflect or be based on real-life situation in order to apply to the already existing knowledge. The topic under research can be more fitting to use learners' knowledge on how to prepare Oshikundu because most of the learners already have the existing or prior knowledge on how to	The curriculum has indicated that teachers should build on the pre-knowledge of the learners and their experience from the community. The curriculum further explained that teachers should integrate local with scientific knowledge to enhance the teaching and learning of science.

				prepare Oshikundu.	
Chemistry Syllabus	It helped me on lesson preparation based on the competencies to be taught and what are teaching aids and materials to be used. For example, on the topic of scientific process, I have been helped on how to use making *Ombike* set up to as the apparatus use our old meme to filter	The Chemistry syllabus has requested learners to know factors affecting the rate of reactions e.g. warming water to increase the rate of reactions and pounding *Mahangu* to increase the surface area	The Chemistry curriculum does also support the inclusion of IK as it does not specify which examples should be specifically given to the learners	Chemistry syllabus put in plea that learners know factors affecting the rate of reactions e.g boiling water to increase the rate of reactions and pounding *Mahangu* to increase the surface area	The syllabus shows that teachers should teach learners starting with their pre-knowledge as this will help learners learn better and relate IK with scientific knowledge
Chemistry Textbooks (3 textbooks)					
Chemistry Made clear.	From Chemistry made clear under rate of reactions, on surface area of particles in this book, they have Calcium Carbonate and Hydrochloric acid, they use powder $CaCO_3$ and marble chips, but powder $CaCO_3$ reaction is fast than chips $CaCO_3$. This help me to integrate the indigenous knowledge of	Chemistry made clear is clear explained the rate of reaction between calcium carbonate and hydrochloric acid producing CO_2 which looked into surface area of Calcium Carbonate (particle size). It was found that small sizes give a higher reaction rate	The effect of temperature: I learnt that I can use Oshikundu to demonstrate how temperature affect the rate of reaction. Putting it on the sun and the other one in the shade so that learners observe the changes.	Chemistry made clear state it clearly on the rate of reaction between Calcium Carbonate and Hydrochloric acid to form Carbon dioxide and water which looked into surface area of Calcium Carbonate (size particle). It was found that by decreasing the size of	The textbook explained what is the rate of reaction and the catalyst of increasing the rate of reaction (fermentation) which are applicable in the making of Oshikundu which shows that the local knowledge and scientific knowledge can be integrated. In conclusion is that all the three text books are

	why we pound *Mahangu* grains to make flour for production of *Oshikundu* instead of using *Mahangu* grains.	which is compared to *Mahangu* and *Mahangu* meals.		reactant, we are increasing its surface area, the smaller the particle size the faster the reaction which is compound to Mahangu and Mahangu flour.	speaking one thing.
Solid foundation Chemistry.	From Solid foundation under scientific process and apparatus. In this book they have talked about fractional distillation whereby there are involvement of the following apparatus, burner, beakers, thermometer, condenser, and etcetera. This process is exactly similar to the process of making *Ombike*. Culturally instead of introducing the topic with the western apparatus I would just talk about the making of Ombike then all my learners will apply it to school science.	Solid foundation Chemistry also use an example of calcium carbonate with Hydrochloric acid with the particle size, but however, temperature was also used as one factor affecting the rate of reaction. This is compared to hot water used during *Oshikundu* preparation where hot water is needed.	The book has some IK integration in it for instance: there is an example of wood ash as a base which locally available and accessible to all learners. An example of traditional beverage was used as an example of filtration. This has indeed helped me to expand my pedagogical knowledge.	Chemistry solid foundation also give an example of Calcium Carbonate with Hydrochloric acid when it comes to particles size and temperature in relation to the rate of reactions. Temperature is used as one of the factor affecting the rate of reaction by focusing on hot water used during *Oshikundu* preparation. At high temperature particles can collide more often and with more energy, which makes the reactions more quickly.	

Living Chemistry		This book also is discussing about particles size of calcium carbonate and hydrochloric acid, temperature, as well as catalyst. For catalyst this was portrayed in the use of *Ehete* to speed up the rate of reaction in *Oshikundu* and remained unchanged at the end of the reaction.	This book did not talk much about IK but there are some example used such as (firewood) which is locally available	This book discussed about particle size when it comes to the reaction between Calcium Carbonate and Hydrochloric acid and temperature and catalyst. This was portrayed in the use of Ehete to speed up the rate of reaction in *Oshikundu* and remained unchanged or balanced out at the end of a reaction.	
How do co-analyse Physical Science question papers & Examiners reports integrated IK or helped you to integrate IK.					
2015		Paper 3 question 1 for 2015 has addressed separation of mixture of ethanol and water, where learners were required to describe how the apparatus provided used to separate the mixture of alcohol and water. This question real		Paper 3 question 1 for 2015 has properly addressed on the separation of ethanol and water mixture, where the learners are asked to describe how the apparatus provided is used to separate the mixture of	

		required learners to use the knowledge of how Ombike is prepared at home and learner with know how about *Ombike* could do well in this questions. The teacher is therefore need to involve learners in this topic.		alcohol and water. This question requires learners to apply their real-life experiences when it came to preparation *Ombike* at home. Learners who have an idea on how preparation of *Ombike* will be able to answer this question very well. Therefore the teachers needs to include the learners in this topic beforehand.	
2016	Paper 3, learners were not able to understand and distinguish between convection and conduction, hence the question was answered fairly. But it was nice to integrate this concept with home knowledge of boiling water in the pot that bubbles come from the bottom to the top all in all that is convection	Question 8 paper 2 of 2016 is about how the eye works to allow light entering not to damage the retina. Learners know that too much light makes them uncomfortable and sometimes cover their faces when it is too sunny and by this reason they will real understand that too much light damages the retina. The		Question 8 paper 2 of 2016 is based on how the eye works to allow the light entering in order not to damage the retina. Learners are already aware that too much light causes your eyes to squint due to discomfort which leads to the eyes reflexes to kick in when there is too much light. Learners will understand	The question papers do not integrate IK. The examiners reports shows that learners performed poorly on the questions of rate of reaction, this could because IK was not integrated in learners teaching and setting up of question papers to make easier for learners. I have learnt that integration of IK can enhance learning of

	involved not conduction of heat. Since hot water is less dense than cold water thus at the bottom of the pot is hotter than the top because is where the source of heat is or concentrated most.	light sensitive cells found at the back of the eyes (Rods and cones)		that too much light causes eyes delimitation or abnormal growth which can lead to partial or blindness due to damages of light sensitive cells at the back of the eyes.	science concepts.
2017		The question 6 of paper 2 of 2017 has addressed about water waves and how water move from the deep surface to the shallow surface, that when water moves from the shallow to deep the speed increases. This is also apply in the real-life situation that learners know how water move at different surface in Oshana and also soil surfaces especially during flood.		The question 6 of paper 2 addressed on water waves and how water waves from deep surface to a shallow surface. Learners will understand that when it comes to speed when dealing with water waves, when water travelling from a shallow to deep surface the speed increases due to steepness but when it comes from deep to shallow the speed decreases that the learners will apply. This life situation as they are aware of how water travels	Learners performed again poorly on the topic that they could do better if IK was integrated during lesson presentation and setting up of question papers. This could be seen on topics such as separation of mixture (fractional distillation). Learners could not identify a condenser and a flask but this are the things they know from home. I have learnt that this is our duty to integrate IK in our teaching and learning as well as in our settings of examination questions papers

				e.g. In *Oshana* when they see water waves on high speed there is a deeper concentration of water.	
2018		Question 4 (d) of 2018 is asking about filtration of unreacted Copper (II) oxide from the solution of Copper (II) sulphate. Learners know that when preparing *Omalodu* at home filtration also used when separating *Omalodu* from *Ehete*, learners who know how to prepare *Omalodu* will not have a problem with this questions so real-life knowledge has also considered.		Question 4(d) of 2018 asked about the filtration of unreacted copper (II) oxide from the solution of Copper (II) Sulphate, learners are aware that when preparing *Omalodu* at home, filtration is also used when separating *Omalodu* from Ehete, learners who knows how prepare *Omalodu* would be able to answer this question well.	
2019					
2020					
What was the most useful aspect on the practical demonstrations/workshops	From the community members told us how to make	The most useful aspect was how water temperature	Respect the knowledge demonstrated by the community	The most useful aspect demonstrated by community	I have learnt that to make *Oshikundu* one should increase surface area of

with the expert community members?	*Oshikundu*, so soon by adding *Ehete* for the readiness of it (Catalyst). Ancient people when they were harvesting *Mahangu* and sorghum they do not cut but they only broke the head, so it *Okuteya* from breaking.	are controlled during preparing of *Oshikundu* and how *Ongudo* is fermented and gives out sweet taste afterward. Moreover praying for the seed before sowing impressed me, this show that Christianity real play a huge role in our tradition.	members. They are the custodian of IK. Preparing Mahangu flour, crushing to increase the surface area food storage, rates of reactions. Making fire using fire wood and blowing some air on it so it light up. Putting sorghum as a catalyst in *Oshikundu.*	members is how *ombuto* (sowing) is prepared by the owner of the home and how *Ongudo* make Oshikundu to be fermented to give out a sweet taste afterward. In other hand we come to understand why the temperature of water needs to be controlled during *Oshikundu* preparation to prevent it from spoiled and became *Etepi*.	*Mahangu* and sorghum by pounding them until their particles are small in order to speed up the rate reaction (fermentation). I also learnt that *Ehete* is the catalyst that is needed in *Oshikundu*. Furthermore, I have learnt that *Oshikundu* can be used to teach a rate of reaction to the learners.
How did you interact, participate and learn (or not) during community members' practical demonstration on making *Oshikundu* helped you to gain new knowledge?	During the separation of grains and the rest of the chaff or left over, they do it with the help of the wind, since the grains are heavy go with wind but if there is no wind that day and they want to separate their grains they sing or set up a fire the wind from the chaff to come and use the wind for separation.	My interaction with community members helped me to understand the science behind preparing of *Oshikundu* and really helped me to know that engaging parents experience in our science education will real help them to understand the concepts better than just using knowledge	Asking questions for further explanation. I also did some of the work like *Okutwa* (pounding), *Okufifa* (seiving), and *Mahangu* during the preparation of the flour. During this practical, I also took part in the making preparation of *Mahangu* flour that is pounding. I learnt a lot	During the interaction with the community member helped me to understand that there are steps to follow when preparing *Oshikundu* and it real tell us that adults in our communities engage in science education that make us understand better the reactions involved in Oshikundu	The interaction was great, the community members was confident and knowledgeable in making *Oshikundu*. I have learnt that it is a mystery to the community members as to why people use warm water to make *Oshikundu* even though they have explained why. The community members also narrated that *Oshikundu* is normally

		from the textbook (western knowledge). I also learnt that real science starts from home and that learners are born with knowledge they just need to be boasted.	through asking question as to why a certain aspect is to be done and how. Taking part in this activity enriched me as a Chemistry teacher because I will simply apply this knowledge and integrate it to my lessons.	making, rather than using western knowledge from the textbooks. This tell us that science start from home and it is very important for teachers to make learners aware of using this knowledge from real-life experiences that have from home.	towards sunsets because it will be served in the morning to school going kids and house members that will remain at home doing house work.
How IK was integrated with scientific knowledge during practical demonstration with the expert community members?	Making *Ongudo* there are many science process involved like letting the sorghum grains to germinate before it being pound into *Ongudo* but it remain unclear why the sorghum grains have to germinate. They questions is what is in the roots or in the early leaves of sorghum? That help to make *Ongudo* the way it is and how it does!	It was integrated with scientific knowledge during warming of water when preparing *Oshikundu*. High temperature is needed to speed up the rate of chemical reaction during preparing of *Oshikundu* and this what the syllabus stipulates. *Ehete* represents a catalyst was the most impressing factor in preparing *Oshikundu* and scientific definition of a	This was an interesting discoveries. I never thought of *Oshikundu* process before. The concepts of using *Ongudo* for the fermentation process to take place. The rate of the reaction when the *Oshikundu* bottles were put on the sun, the CO_2 collected and tested. This was a great adventure. This was a beautiful experience. I never knew that there is	It was integrated during the preparation of *Oshikundu*, high temperature is required, thus boiling of water to speed up the rate of reaction during the presentation of *Oshikundu* and is stated in Chemistry syllabus. Ehete that used during the preparation of *Oshikundu* act as a catalyst. A catalyst is any form of substance that increases the rate of reaction without itself	It is very clear that IK and scientific knowledge can co-exist because they have among other aspects in common. The notable one is when surface area of sorghum and *Mahangu* was increased through pounding. This is the same with Calcium Carbonate $CaCO_3$ which is used to prepare lime water. This shows that if sorghum, *Mahangu* and $CaCO_3$ increased the rate of reaction when in powder form than when

		catalyst say it speeds up the reaction and remains unchanged of which was the some case with *Ehete* in *Oshikundu*.	so much science in our everyday *Oshiwambo* practices. The pounding of Mahangu replaced the use of a mortar and pestle in the lab. Those are locally available and easily accessible to most *Ovawambo* people including myself. I normally do those practices but I never thought of linking them to the science I teach. I wish more of such practical could be carried out so as to integrate our local knowledge to every topic in Chemistry.	being consumed. *Ehete* used to speed up the reaction in *Oshikundu* making process.	big particles are used.
How did the process of co-develop the model lessons plan helped you to integrate IK in your Chemistry lessons:		It helped me to integrate IK because we have different approach in teaching, so through co-planning we have exchanged knowledge on		It really helped me a lot on using different teaching methods and mostly the good ideas shared as it helped us to discuss how best IK can be	Co-planning helped me to realise the importance of team work. It also allow me and other participants to share ideas and come up with teaching aids which are

		how to integrate IK.		integrated in Chemistry lessons. I understand how to transform western knowledge into real-life situation more especially on the rate of reactions e.g. making *Oshikundu* using *Ehete* and *Ongudo* and the process of making *Ombike* on fractional distillation.	relevant and useful in arousing learners' interest on the lessons.
How did teaching of co-developed model lesson plans helped you to understand TSPCK and the integration of IK in Chemistry classrooms:		It helped me to understand topic specific methods because learners real have knowledge on the topic from home and helped me to know that science real start from home.		I started by asking learners their prior knowledge that is what they know from their surrounding like in this case I asked them to explain how they purify water at home before I introduce a new concepts and explain the process of crystallisation outside the classroom and learners learnt a lot that even if they use sea	

				water they will get salt.	
What must be done to improve the integration of IK in Chemistry lessons?		Learners need to ask their parents on some of the concepts taught in the class as some of those topics and a reflection of what they do at home e.g. preparing *Ombike* that translated to fractional distillation.	I wish for more research to be done on how each topic can be linked to the IK in all the Namibian cultures not only in the Oshiwambo culture. This could be helpful as learners would learn from things that they process, it may arouse the learners interested to do science. There is so much science in our communities.	We need to involve community members more especially when teaching topics that requires learners to use their prior knowledge on this integration of IK. For example, making *Ombike* using fractional distillation and it really attract learners mind to think and relate all the process at home. The use of cold water in and hot water out and why fermentation has to take place first. It will help learners to relate Chemistry lessons to real-life situation.	
Explain how did Professional learning communities helped you to integrate IK in Chemistry lessons?		It helped me because I gained some knowledge on how *Oshikundu* is prepared and	As I mentioned already, this is an experience to me. I never thought of	During the workshop we analysed the syllabus looking at different competencies	

		that there some factors affecting the rate at which *Oshikundu* can be ready to be consumed. This also helped me to integrate this knowledge in my lessons.	using things like Oshikundu making to my learners from this activity. I went back to my learners and re-teach the topic on rate of reactions using the ideas that I have learnt from the community members' presentation.	that helped us on how we can integrate IK in Chemistry lessons. We also looked at the new curriculum as well as textbooks used on how best we can integrate IK in our lesson and it really helped us to relate prior knowledge to westernised knowledge and this was very helpful to make us understand the concepts better and use the local knowledge to IK.	
What other suggestions do you have for the researcher to improve in future?		The researcher needed to investigate again more on those factors and also to use laboratory experiment and compare it to IK, so that at the end of the day he can real see the relationship. For example Calcium carbonated powder compared to *Mahangu* flour and see	My suggestion is that the research process to starts at the beginning of the rain season as the *Mahangu* planting starts so that we explore other scientific concepts that may be involved.	The researcher need to give feedback after classroom visit so that teachers can improve where it is necessary or where they did not do well, just comments on the lesson taught.	The research was great and only need to improve on time management as most of us knock off late, may be to schedule the meetings in the weekends as this will help participants enough time to travel to and from the community.

		the relationship.			
Final reflections on the research process					
What was the salient about research process?	Knowledge, searching and collection. Identifying proper and appropriate teaching methods and aids for Grade 10 Chemistry subjects. Integration of different knowledge to teaching and learning process.	It is very important because it set as an eye opener to understand that science starts from home and that most of the topic we teach learners already have knowledge from home we just need to help learners to discover their knowledge.	The research process was an experience to me. I learnt working with other people especially the community members.	All the process of processing *Mahangu*, the excursion on *Oshikundu* making, the workshop that was very interesting even on the interpretation of the syllabus and most of all the integration of IK into Chemistry lessons.	I was impressed by the researcher professionalism throughout our meetings. He demonstrated calmness patience and the ability to assist where possible. I was also impressed by the community members and my co-participants eagerness to participate in the study and discuss.
What new knowledge did you gained during research process?	In fewer words I have learnt a lot, especially about the process involved in coming *Mahangu* flour including *Ongudo*. I have gained multiple of concepts and general team work and cooperation among ourselves.	I gained that most of the topic taught in Chemistry are related to what is done at home, that means most of the things we do at home is mostly science.	I never knew *Oshikundu* making has so much science in it, I learnt how to integrate our local knowledge in my Chemistry lessons.	The process of making *Oshikundu*, there are catalyst Enzymes, the gas produced during the fermentation process that is CO_2 since we tested it and the preparations of limewater and the word IK, or the abbreviation of IK that was new to me.	I have learnt that as a teacher I should use easily accessible resources to demonstrate and explain new ideas. I have also learnt that a community member can be a good teacher that can be used to explain topics to learners and can explain the importance of IK in science.

What was insightful about the research or not?	How the research is arranged it really showing commitment of the researcher and how knowledgeable he is from introduction and through the 7 phases including the workshops.	The way we investigated how *Oshikundu* is prepared from the start up to the end was real interesting as some of us had chances to physically participate in the process.	Indigenous knowledge has so much science in it. I learnt that researching does not only benefit the researcher but gives an opportunity to the participants to expand their horizons.	I really enjoyed it very much since I gained new knowledge when we shared ideas with colleagues on different topics more especially on the workshop and the knowledge that I gained from the community members.	The most insightful was when we collected gas produced by *Oshikundu*, we tested the gas and realised that it was Carbon dioxide because it turned lime water milky. I have also learnt that *Oshikund*u is acid because it turn the blue litmus paper red.
What need to be done different?	The number of participants need to be increased to get more different views.	We could have/ what is need to be done again is engaging parents/ indigenous people in our education as they can help in IK and this can make learners understand the concepts better.	I suggest that researcher gives more time/ starts the research process right at the beginning of the growing *Mahangu* season. There might be also other scientific concepts to be discovered.	We need to have more Chemistry teachers to know the good part of the research so that it attract them to join Rhodes University like I do and to know the use of IK.	Nothing to be done differently. I am convinced that his (presentation) projects was the best I ever involved.
What was your PK shift after the workshops?	At the next level of course, I have learnt a lot from the workshops.	I can refer most of the topic to what is happening at home so that learners will have abroad understanding on the topic taught.	Integrating the local knowledge in teaching Chemistry. I now know the *Oshikundu* part and opened up my mind to think about other local	It taught me a lot on how I can teach Chemistry using different locally examples that can make learners understand	I have learnt that local knowledge should be used to introduce concepts before we embark upon the scientific knowledge (western knowledge) as this will help

			practices that may be suitable for Chemistry.	the concepts better.	learners to see the importance and value of the knowledge used by our forefather. It also the duty of every teacher to consider pre-knowledge of the learners before introducing new concepts and ideas.
The use of TSPCK to plan model lessons and co-analyse the documents?	Integration of different approach is really helpful in presentation of the lesson	Helped me to know and understand the expectation of the subject on the learners and the skill required by the teacher to successfully give a quality lesson	This helped me to think and start analysing documents too. I also learnt that preparing lessons together may help finding the best teaching methods	Co-planning helped a lot for us to always start with what the learners knows from home before we start with a new concepts and analysing of document helped me to always think of what comes into our mind and how best we can tackle basic competencies	It is of great importance for teachers to plan lesson together as this will help them to prepare quality lesson plan with learning materials that are stimulating. It is also important to analyse the national documents before we start teaching. This will help us teachers to integrate what is indicated in the documents
The feeling about the involvement in the research process?	I feel really blessed to be part of this amazing process it is really improving my knowledge plus the way of presenting lessons.	I felt very happy as this research process helped me to gain more knowledge and how to integrate IK in the lesson that will enable learners to understand	I had a very great excitement as I learnt a lot through this process. I benefited soo much as a Chemistry teacher and as a researcher. It aroused my	I feel very proud to be part of the research and I am very happy that from the beginning of next year I will be a different teacher from who I am	It is a great feeling to be part of this research process, because it helped me in understanding the rate of reactions in our everyday life and how teachers can

		and love the lesson.	interest of studying until PhD too.	now, and it also taught me how research are being done in case I get admitted at Rhodes University one day.	use easily accessible learning materials to explain concepts and new ideas to learners and for learners to value indigenous knowledge that our forefather practised.
How do you describe yourself to the researcher?	I am a curious person thus I always want to know the world around me that why I did not think it twice when he called to partake in the research.	I am keen to learn and understanding and wants to be engaged in PD as to help in gaining new knowledge and information that will help you to grow.	I would describe myself as a researcher that would always want to find out more, probe for more information from the participants in order to get what the participants say.	I am very flexible and always want to learn new things and gain or enrich my knowledge to next level.	I am a good person who is reliable and ready to help when the need arises.

Appendix Q: Table 1: Summary for the five components of TSCPK

Components of TSCPK	The focus of the research
Learners' prior knowledge	How Chemistry teachers involved learners experience in the lessons. How the curriculum documents and textbooks address the issue of learners prior everyday knowledge.
Curricular saliency	The sequence of knowledge from prior everyday knowledge of learners to westernised science in the classrooms. The curriculum documents and textbooks presented the topics on the rate of reactions and others from known to unknown.
What is difficult to understand	How the teachers explain the difficult part of the lessons for learners to understand using locally available resources and the gatekeeping concepts from IK. How the curriculum documents and textbooks direct teachers to teach difficult concepts.
Presentation and analogies	How the curriculum and textbooks present the topics by using pictures and IK artefacts. How teachers presented the lessons with the help of the curriculum documents, textbooks and cultural artefacts.
Conceptual teaching strategies	What strategies do teachers apply to make learners understand the concepts to be taught? Apart from the above what else did the teachers use to make learners interested or attracted to the lessons and the topics?

Table 2: Evidence from the curriculum that reflects TSPCK

TSPCK components	Evidence from the NCBE (2018)
Prior everyday knowledge	Learning in school must constantly relate to, involve, and extend the learners' prior knowledge and experience, and this must be complemented and challenged by the knowledge that the school provides beyond the immediate sphere of the learners.
Curricular saliency	If they are taught in a way which builds on what they already know and have experienced, and relate new knowledge to the reality around them, they will learn that learning in school can be meaningful.
What is difficult to understand	Teaching which does not build on that experience and learning will limit the learners' thinking, and the learners will not see the connection between the world outside school and what is taught and learnt in school. Teaching should always begin with helping the learners realise what they might already know about something, and by eliciting ideas or questions they might have about it, and relating what they are learning to the environment within and around the school.
Presentation and analogies	Learner-centred education does not mean that the teacher no longer has any responsibility for seeing that learning takes place; it means that the teacher has to take on a wider repertoire of classroom roles. Whatever is presented and how it is presented will be common experiences from which each learner will select what to learn, and at the same time learn about learning.
Conceptual teaching strategies	Flexibility in their teaching methods will enable teachers to use the local environment and the community as extensions of the classroom, both as fields to be researched and as resources to obtain information and knowledge from and stimulate investigation, enquiry and creativity.

Appendix R: Lessons plan from School A and B

Teacher's Name: **Micheal**

Grade: 10D **Subject: Chemistry**

Date: 08/ 10/ 2020 **Time: 40 minutes**

Day: Thursday

Theme: ***Scientific Processes***

Topic: ***Experimental Techniques***

Teaching Methods: ***Demonstration, Learner-centred approach***

Teaching Aids: ***Flipchart***

General Objectives: Learners should be able to:

Understand the principles of experimental techniques.

Specific Objectives: Learners should be able to:

Describe methods of purification by the use of distillation (including the use of fractional distillation column. Refer to the fractional distillation of crude oil).

Presentation of the lesson: Monitoring of Homework:

No homework was given

Appropriate introduction:

The teacher will explain the reason of separation mixture solutions etcetera. The teacher will make a simple comparison of separation of mixture and that of solutions. The teacher will mention the specific objective and highlight the learners' expectations.

Lesson Structure

Teacher's Activities	**Learners' Activities**
Will explain in detail how the method of purification works specifically the fractional distillation by using local examples	Will be expected to pay attention in the class and respond to the questions and explain how separate mixtures

The teacher will ask the apparatus involved in this method of separation	Will be expected to ask questions and seek for further clarity
The teacher will ask learners to draw the structure illustrating the fractional distillation and the teacher will also integrate this concepts with how *Ombike* is made from home including the components of *Ombike* making process	Learners will be asked to draw the components of *Ombike* making process and further questions will be asked based on the observation of the two set up and comparison will be done. Learners will be allowed to explain the process using their drawing

Consolidation

More emphasis will be done by the teacher at the end of the presentation and class activities will be also be conducted and feedback will be done afterwards

Home work:

Homework will be given

Reflection:

…………………………………………………………………………………………………

Signed by:

Subject teacher: ……………………………………….. Date: ……../……./2020

Researcher: …………………………………………….. Date: ……../……./2020

Teacher's Name: **Micheal**

Grade: 10 **Subject: Chemistry**

Date: 20/10/ 2020 **Time: 40 minutes**

Day: Tuesday

Theme: **Chemical reactions**

Topic: **Rate of Reactions**

Teaching Methods: Learner-centred approach

Teaching Aids: Practical home examples

General Objectives: Learners should be able to:

Know the factors affecting rate of reactions

Specific Objectives: Learners should be able to:

Describe in terms of collision theory, the effects of concentration, pressure, particles size (surface area), catalyst (including inorganic or organic) and temperature and light on the rate of reactions

Presentation of the lesson: Monitoring of Homework:

No homework was given during the previous lessons

An Appropriate introduction:

The teacher will introduce the lesson by mention the specific objectives to the learners and use appropriate example of reactions and why the rate of reaction is important and why it is needed to be fastened

Lesson Structure

Teacher's Activities	**Learners' Activities**
The teacher will ask learners to recall the meaning of rate of reaction and catalyst?	Learners are expected to answer questions asked to them
The teacher will describe with practical example the effect of rate of reactions based on the concentration of the substances, pressure level, particle size of reactants, catalyst in the reactions, temperature and light by using *Oshikundu* making as exampler	Learners are expected to pay attention in the class and ask question related to the topic of discussion of the day
The teacher will ask learners to visualise how would it be if we use *Mahangu* grains to prepare porridge	Learners are expected to answer questions

Consolidation

Restating the specific objectives to the learners and put more emphasis on the key points and resolutions of misconceptions if there is one encountered

Home work:

Home work will be given based on the content learnt

Reflection:

………………………………………………………………………………………………………

Signed by:

Subject teacher: ……………………………………….. Date: ……../……./2020

Researcher: …………………………………………….. Date: ……../……./2020

Teacher's Name: **Shipefi 16**

Grade: 10A **Subject: Chemistry**

Date: 13/10/ 2020 **Time: 40 minutes**

Day: Tuesday

Theme: **Experimental Techniques**

Topic: **Methods of purifying: Distillation**

Teaching Methods: *Whole class discussion, Demonstration & Crystallisation*

Teaching Aids: ***Etiti, Water & Salt***

General Objectives: Learners should be able to:

Understand the principles of the experimental techniques

Specific Objectives: Learners should be able to:

Describe methods of purification by the use of suitable solvent filtration, crystallisation and distillation

Presentation of the lesson: Monitoring of Homework:

No homework was given

An Appropriate introduction:

The teacher ask learner to describe how they separate water from mud/ purifying drinking water at home by mentioning the apparatus they use and the procedure they follow

Lesson Structure

Teacher's Activities	**Learners' Activities**
Based on the learners responses on the introduction. The teacher weaves in the term distillation and crystallisation	Learners demonstrate the discussion by answering & asking questions
Demonstrates how to separate salt from salt solution by using *Etiti* as an evaporation dish	Take up the lead on the demonstration. For example making the fire, putting water & salt in *Etiti* and observe the crystallisation
Show how salt crystals forms and how water evaporate	Learners will observe the process outside the classroom
Also explain the *Ombike* process as distillation	Learners explain the process of making *Ombike* as distillation

Consolidation

Learners should know the local apparatus to use in the lab instead of purchasing lab apparatus. E.g. the use of clay pots

Home work:

No homework given

Reflection:

………………………………………………………………………………………………………

Signed by:

Subject teacher: ……………………………………….. Date: ……../……./2020

Researcher: ………………………………………….. Date: ……../……./2020

Teacher's Name: Shipefi 16

Grade: 10 Subject: **Chemistry**

Date: 22/10/ 2020 Time: 40 minutes

Day: Thursday

Theme: **Chemical reactions**

Topic: **Rate of reactions**

Teaching Methods: ***Teacher-learners discussion***

Teaching Aids: ***Sorghum grain, Mahangu grain, Ehete and Ongudo***

General Objectives: Learners should be able to:

Know the factors affecting rate of reaction

Specific Objectives: Learners should be able to:

Describe in terms of collision theory, the rate effects of concentration, pressure, particles sizes (surface area), catalyst, temperature and light on the rate of reactions.

Presentation of the lesson: Monitoring of Homework:

No home work was given

An Appropriate introduction:

The teacher ask learners to describe in terms of collision theory the effect of concentration, surface area, catalyst, temperature, and light on the rate of reactions and how they relate it to what they know from home i.e. when preparing Oshikundu etc.

Lesson Structure

Teacher's Activities	**Learners' Activities**
Teacher defines the term rate of reaction and describe the effect of concentration, pressure, surface area, catalyst, temperature and light on the rate of reactions	Learners highly participate by answering questions on the factors affecting the rate of reactions

Teacher to give a task so that learners can answer on the catalyst how they speed up the rate of reactions and why solid particles has to be pounded into powdered from to increase the surface area	Learners to takes up the lead in giving examples on the factor affecting the rate of reactions using their knowledge on the locally practice when it comes to concentration, surface area, catalyst, light etc.
Learners will be given the topic task	Learners to complete the task given

Consolidation

Learners should know the local knowledge on the rate of reaction based on what they do at home. E.g. Making of Oshikundu, Omalondu traditional beer and Ombike at the home, instead of western knowledge.

Home work:

Learners to find local available inhibitors (substances) that reduces or stop the rate of reactions

Reflection:

……………………………………………………………………………………………………..

Signed by:

Subject teacher: ……………………………………….. Date: ……../……./2020

Researcher: …………………………………………….. Date: ……../……./2020

Appendix S: Temperature

Table 1: Temperature of learners at School A and B

School A			School B			
Code of learners	**Day 1 08/10/2020**	**Day 2 21/10/2020**	**Day 1**	**13/10/2020**	**Day 2**	**22/10/2020**
			Code of learners	**Temperature**	**Code of learners**	**Temperature**
L1	36.7	36.8	L1L1	36.9	L2L1	36.7
L2	37.4	37.4	L1L2	36.8	L2L2	36.6
L3	37.4	37.4	L1L3	36.2	L2L3	36.6
L4	37.4	37.2	L1L4	36.4	L2L4	36.4
L5	37.2	37.1	L1L5	36.3	L2L5	36.2
L6	37.4	37.0	L1L6	36.3	L2L6	36.4
L7	36.9	36.9	L1L7	36.3	L2L7	36.6
L8	37.9	Absent	L1L8	36.4	L2L8	36.8
L9	37.0	36.6	L1L9	36.6	L2L9	36.5
L10	37.0	36.7	L1L10	36.5	L2L10	36.6
L11	36.8	36.6	L1L11	36.2	L2L11	36.9
L12	38.8	37.0	L1L12	36.2	L2L12	36.8

L13	36.7	Absent	L1L13	36.4	L2L13	36.4
L14	37.4	Absent	L1L14	36.9	L2L14	36.6
L15	36.9	37.2	L1L15	36.3	L2L15	36.7
L16	36.9	36.9	L1L16	36.4	L2L16	36.2
L17	37.3	36.8	L1L17	36.2	L2L17	36.5
L18	36.9	36.5	L1L18	36.3	L2L18	36.8
L19	37.6	36.8	L1L19	36.4	L2L19	36.8
L20	36.0	37.0	L1L20	36.4	L2L20	36.5
L21	37.2	37.5	L1L21	36.4	L2L21	35.9
L22	36.9	36.4	L1L22	36.3	L2L22	36.7
L23	36.6	36.9	L1L23	36.6		
L24	Absent	36.5	L1L24	36.6		
L25	Absent	37.0	L1L25	36.4		
L26	Absent	37.2	L1L26	36.6		
L27	Absent	36.2	L1L27	36.4		
Micheal	36.8	36.9	L1L28	36.3		
Sebron	35.6	36.9	Shipefi 16	36.6		37.1

			Ndeshi	35.8		36.7
Researcher	36.9	37.1		36.8		36.7

Table 2: Show the temperature record of the participants during practical demonstration workshops

Codes	**PDW 1**	**PDW2**
Mee Mukwaluvala	36.7	35.6
Mee Mukwamhani	35.9	36.0
C1	35.6	36.4
Me	36.3	35.7
Michael	35.4	34.5
Sebron	34.8	36.4
Ndeshi	36.3	35.5
Shipefi 16	35.4	36.0
Tala	36.3	35.8
Researcher assistant A	35.7	36.2

Table 2: Shows the temperature record of the participants during the workshops.

Teachers code	**Orientation workshops**	**W1**	**W2**	**W3**
Me	35.7	36.7	36.0	36.4
Michael	36.8	36.4	36.2	35.7

Sebron	36.3	35.4	36.5	35.8
Ndeshi	36.2	34.5	35.7	36.0
Shipefi 16	35.8	36.8	36.1	36.1
Tala	36.4	35.7	35.6	35.8

Appendix T: Demographic information for participants and Analytical frameworks

Table 1: Demographic information of the participants

Demographic information	**Teachers' names**	**Frequency**
School location		
Rural school	Ndeshi, Shipefi 16 & Tala	3
Semi-urban school	Michael and Sebron	2
Gender		
Male	Michael, Sebron, Shipefi 16 & Tala	4
Female	Ndeshi	1
Tribes		
Kwanyama	Michael, Sebron, Ndeshi & Shipefi 16	5
Others	Tala	1
Qualifications		
ACE/FDE/MASTEP	Shipefi 16 and Tala	2
HONS	Michael, Sebron & Ndeshi	3
Teachers experiences		
1-5	Michael	1

6-10	Sebron & Tala	2
11-15	Shipefi 16 & Ndeshi	2
Ages		
26-30	Michael	1
31-35	Sebron, Ndeshi & Tala	3
36-40	Shipefi 16	1

Table 2: Sub-themes and themes that emerged from semi-structured interviews (Chapter Five)

Themes	**Research Questions**	**Data Sources and Theory/Literatures**
Views and experiences of Chemistry teachers on integrating local knowledge in Chemistry lessons	1	Semi-structured interviews
Views, experiences, planning, available resources, local examples		Michael, Sebron, Ndeshi, Shipefi 16 & Tala, Vygotsky, 1978 (Sociocultural theory); Roschelle, 1995; Kibirige and Van Rooyen, 2006; Shizha, 2007; Ogunniyi and Ogawa, 2008; Mapara; 2009; Mukwambo, Ngcoza, and Chikunda, 2014
5.2.2 Indigenous knowledge enhance pedagogical understanding	1	Semi-structured interviews
Availability of local materials, learners understanding, prior everyday knowledge, artefacts, Sociocultural interaction, language		Michael, Sebron, Ndeshi, Shipefi 16 & Tala, Vygotsky, 1978 (Sociocultural theory); Roschelle, 1995 Kibirige & Van Rooyen, 2006; Ogunniyi & Ogawa, 2009; Kambeyo,

		2012; Mukwambo, 2017; Uushona, 2013; Shifafure, 2014; Mhakure & Mushaikwa, 2014
Factors that influence Chemistry teachers to integrate or and not integrate IK in their lessons.	1	Semi-structured interviews
Challenges, textbooks, laboratories, practical work and benefits to the learners		Michael, Sebron, Ndeshi, Shipefi 16 & Tala, Vygotsky, 1978 (Sociocultural theory); Aikenhead & Jegede, 1999; Ogunniyi, 2004, 2007a, 2007b; Nakata, 2007; Shizha, 2007; Hewson & Ogunniyi, 2011; Mushayikwa & Ogunniyi, 2011; Simasiku, 2016
Knowledge level of Chemistry teachers on integrating IK	1	Semi-structure interviews
Asking learners, learners prior everyday knowledge, Electricity, not local knowledge		Michael, Sebron, Ndeshi, Shipefi 16 & Tala, Meyer (2004); Aikenhead & Jegede, 1999; Wyatt et al., 2017; Gwekwerere, 2016.

Table 3: Sub-themes and themes that emerged from co-analysing curriculum documents (Chapter Six)

Sub-themes	**Themes**	**Research questions**	**Data source**
Existing knowledge, Cognitive skill, Local artefacts, everyday life, Oshikundu	**Co-analysing curriculum documents helped Chemistry**	2	NCBE(MoE, 2018), Chemistry textbooks and Chemistry syllabus), Reflection of participants, workshop presentation & discussions.

	teachers to understand IK integration		
Life experiences, *Oshikundu, Ongudo, Ehete,* Temperature, catalyst and enzymes	**Chemistry teachers understanding of concepts**	2	Co-analyse curriculum documents (National Curriculum for Basic Education, Chemistry textbooks and Chemistry syllabus), Reflection of participants, workshop presentation & discussions Michael, Sebron, Ndeshi, Shipefi 16 & Tala, Owour, 2017; Le Grange, 2014; Mukwambo, 2017; Webb, 2013; Simasiku & Ngcoza, 2019, Vygotsky (1978) SCT.
Learning, participation, local language, rate of reaction, teacher curiosity,	**Active engagement of participants**	2	Co-analyse curriculum documents (National Curriculum for Basic Education, Chemistry textbooks and Chemistry syllabus), Reflection of participants, workshop presentation & discussions Michael, Sebron, Ndeshi, Shipefi 16 & Tala; Shifafure, 2014; Chauraya & Brodie, 2018; Ogunniyi & Ogawa, 2008; Vygotsky, (1978) SCT.

Table 4: Sub-themes and themes that emerged from practical demonstration and participatory observation (Chapter Seven)

Sub-themes	**Themes**	**Data sources**	**Theories/literature**
Okuxwa, Okuyela, pounding, *Okufifwa*, Acid, Bases, CO_2, boiled water, cold water, stirring of *Oshikundu, Ongudo, Ehete*	**Explorations of Indigenous knowledge in Chemistry teaching**	Mee Mukwaluvala, Mee Mukwamhani, Michael, Sebron, Ndeshi, Shipefi 16 & Tala	Vygotsky, 1978; Liveve, 2017 & 2022; Simasiku & Ngcoza, 2019; Mishra & Koehler, 2006

Harvesting of *Mahangu*, threshing and separation of *Mahangu* from chaff, pounding *Mahangu* and making *Oshikundu*	**Social engagement with expert community members enhance teachers' understanding**	Mee Mukwaluvala, Mee Mukwamhani, Michael, Sebron, Ndeshi, Shipefi 16 & Tala	Vygotsky, 1978; Mavhunga & Kibirige, 2018; Naidoo & Vithal, 2014; Mavhunga & Rollnick, 2013
Cultural practices, beliefs, norms and status quo,	**Hand-on practical activities influences learning**	Mee Mukwaluvala, Mee Mukwamhani, Michael, Sebron, Ndeshi, Shipefi 16 & Tala	Vygotsky, 1978; Shinana, Ngcoza, & Mavhunga, 2021; Akbar, 2012; Arcavi, 2003
Practical demonstration of *Oshikundu*, Testing of CO_2, *Oshikundu*, social engagement	**Language use as a tool for mediation learning**	Mee Mukwaluvala, Mee Mukwamhani, Michael, Sebron, Ndeshi, Shipefi 16 & Tala	Vygotsky, 1978; Ma, 2008; Sedlacek & Sedova, 2017; Dziva, Mpofu & Kusure 2011; Simasiku & Ngcoza 2019.

Table 5. Sub-themes and themes that emerged from co-develop exemplar lessons plan, lesson observation and SRI (Chapter Eight)

Sub-themes	Themes	Research questions	Data source
Mediation, Learners participation, active engagement, learners talk, Indigenous knowledge, learners prior everyday knowledge	**Local knowledge bring about active engagement of learners**	3 & 4	Workshop presentation and discussion, co-develop of model lesson, Reflections of participants, lesson observation, SRI. L1SA, L2SA, L1SB, L2SB and SRIL1SA, SRIL2SA, SRIL1SB, SRIL2SB and learners

			Vygotsky (1978) SCT and Shulman (1986) PCK Le Grange (2007); Cronje, de Beer & Ankiewicz (2015); Dziva, Mpofu & Kusure (2011); Kaya (2013); and Abah, Mashebe & Denuga (2015)
Lesson activities, learners presentation of lesson, learning from co-learners, participation, usage of local language	**Indigenous knowledge improve learners conceptual understanding**	3 & 4	Workshop presentation and discussion, co-develop of model lesson, Reflections of participants, lesson observation, SRI. L1SA, L2SA, L1SB, L2SB and SRIL1SA, SRIL2SA, SRIL1SB, SRIL2SB and learners Vygotsky (1978) SCT and Shulman (1986) PCK

Table 6. Sub-themes and themes that emerged during reflective space workshop (Chapter Nine)

Sub-themes	**Themes**	**Data sources**	**Literatures**
Catalyst, *Ehete, Ongudo, Omhindo*, Acid, Litmus paper,	**Mind maps and concept map enhance conceptual understanding of Chemistry teachers**	Michael, Sebron, Ndeshi, Shipefi 16 & Tala	Vygotsky (1978), SCT; Asheela, 2017; Shinana, 2019
I gained, new knowledge, I learnt, multiple concepts	**Chemistry teachers gained new PCK**	Michael, Sebron, Ndeshi, Shipefi 16 & Tala	Shulman (1986), PCK

Appendix U: Summary of questions and data analysis processes

Types of data analysis	**Mode of interpretation**	**Research question answered**

Semi-structured interviews	Inductive-deductive data analysis, SCT and TSPCK as analytical tool and Atallah, Bryant & Dada (2010) teachers' conceptions and dispositions (Chapter 5)	*What are Grade 10 Chemistry teachers' experiences, and pedagogical insights on the use of IK in Chemistry learning and teaching before they were engaged in a peer-learning community and with the ECMs?*
Co-analyse curriculum documents, Workshop presentation and discussion & Reflection of participants	Sociocultural theory, PCK and TSPCK and TSCPK translation device (Chapter 6)	*(a) What lessons can Grade 10 Chemistry teachers learn (or not) in their peer-learning community when co-analysing the Chemistry curriculum documents?*
Reflections of participants and participatory observation	Sociocultural theory and the tenets (Chapter 7)	*(b) How do Grade 10 Chemistry teachers interact, participate, and learn (or not) during the ECMs' practical demonstrations and explanations on the preservation and pounding of Mahangu flour and making of Oshikundu?*
Workshop presentation and discussion, stimulated recall interview and reflections of participants, Lesson Observation notes, videotaped, reflections and stimulated recall interviews	Inductive-deductive data analysis, Sociocultural theory and PCK (Chapter 8)	*How does the peer-learning community enable and/or constrain Grade 10 Chemistry teachers in using the IK of the ECMs on the preservation and pounding of Mahangu and making of Oshikundu and other indigenous practices to co-develop exemplar Chemistry lessons?* *How do the Grade 10 Chemistry teachers selected from the peer-learning community mediate learning of the co-developed exemplar lessons in their Chemistry classrooms?*

Reflection, discussion, concept and mind map	Sociocultural theory (tenets), PCK, (Chapter 9)	*How do discussions and group reflections in the peer-learning community influence (or not) Grade 10 Chemistry teachers' understanding of integrating IK from the ECMs?*
Research questions responding to the study, conclusion, implications and recommendations	Summarised finding based on the research questions (Chapter 10)	Overviews of the study, findings of the study, recommendation and conclusion

Appendix V: Objectives and specific objectives

Table 1: Shows objectives and specific objectives extracted from the syllabus

Topic	**GENERAL OBJECTIVES** ***Learners will:***	**SPECIFIC OBJECTIVES** ***Learners should be able to:***
Experimental techniques	Understand the principles of experimental technique	describe methods of purification by the use of a suitable solvent, filtration, crystallisation, re-crystallisation, paper chromatography of coloured substances and distillation (including use of a fractionating column). (Refer to the fractional distillation of crude oil in Section 10.2.1 and products of fermentation in Section 10.5) (my emphasis) suggest suitable purification techniques, given information about the substances involved suggest suitable apparatus, given relevant information, for a variety of simple experiments, including collection of gases and measurements of rates of reaction

Table 2: Shows objectives and specific objectives extracted from the syllabus

Topic	**GENERAL OBJECTIVES** ***Learners will:***	**SPECIFIC OBJECTIVES** ***Learners should be able to:***
10.2.1 Fractional distillation of petroleum	know the names and uses of fractional distillation	name the fuels coal, natural gas and petroleum (crude oil) name methane as the main constituent of natural gas describe petroleum as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation (my emphasis).