Mobilising indigenous technologies of making *oshikundu* and *uumboloto* to motivate and enable sense making of the topic carbon dioxide by grade 8 rural school learners

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By

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Declaration of Originality

I Fredinard Nandjedi (19N9534), hereby declare that this thesis is my own original work and has not been previously submitted in any form for assessment or for a degree in any other higher education institution. Where I have used work from other scholars, such ideas have been acknowledged by means of quotations and references according to Rhodes University Education Department Guidelines.

08 June 2022

Signature Date

Dedication

This thesis is dedicated to my late mother, Victoria Mhleni Kaula and my father Matheus Nadjedi for raising me and teaching me all the norms and values of my culture and for making me the person I am today. I further dedicate the thesis to my son Amen Nghiwilepo Nandjedi and my entire family for handling all family responsibilities that I was supposed to carry out during my master's course which I could not do due to my tight study schedule. Moreover, for giving me the moral support to do the best that I can in this course.

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Abstract

Poor performance in Science has been noted in most rural schools and this has become a concern to education planners and implementers. Part of the failure is said to be caused by inadequate school resources, under-preparedness of teachers to teach Science, poor command of the Language of Learning and Teaching, negative attitudes that are accompanied by lack of insights into the value of Science, low self-efficacy, and poor-quality environments for learning Science. In this regard, literature has revealed that many Science teachers in Namibia do not consider learners' local indigenous knowledge (IK) also known as indigenous technology to mediate learning. Yet, it is a requirement of the Namibian Science curriculum. I assume that this could be due in part to the fact that the Science curriculum is not explicit on how IK should be integrated into Science teaching. It is against this backdrop that this study sought to explore the opportunities IK integration into Science may offer in mediating learning and sense-making on the topic of carbon dioxide (CO_2). Learners' indigenous technological practices of making *oshikundu* and *uumboloto* were used as vehicles of learning.

This qualitative case study is underpinned by the interpretive and indigenous research paradigms. Within the indigenous research paradigm, I focused on the Ubuntu perspective. This study was conducted at a rural under-resourced school in the Ohangwena region in Namibia. Thirty Grade 8 learners, one science teacher and two expert community members were involved as participants. Data were gathered using focus group interviews (sharing circles), group activities, participatory observations, and journal reflections. Data interpretation and analysis were done using Vygotsky's sociocultural theory and Ogunniyi's contiguity argumentative theory. A thematic approach to data analysis was adopted. That is, an inductive approach was employed whereby sub-themes were identified, and thereafter common sub-themes were combined into themes.

The findings of this study revealed that the process of making *oshikundu* and *uumboloto* can be used to enable learners to make sense of the topic of CO_2 and other related concepts. Furthermore, the study revealed that hands-on practical activities done with easily accessible resources which are related to learners' indigenous technologies help learners learn Science easily. The study thus recommends that educators should use *oshikundu* and/or *uumboloto* to mediate learning of topics such as CO_2. Science teachers should always try to tap into learners' socio-cultural backgrounds in their lessons to enhance better understanding of Science concepts.

Keywords: Physical Science; scientific concepts; carbon dioxide; indigenous technology; *oshikundu* and homemade bread *(uumboloto)*; socio-cultural theory; contiguity argumentative theory

Table of Contents

List of Tables

List of Figures

List of Abbreviations and/or Acronyms

BEd: Bachelor of Education

CAT: Contiguity Argumentation Theory

CO_2: Carbon Dioxide

CoP: Community of Practice

DBE: Department of Basic Education

ESD: Education for Sustainable Development

FGIs: Focus Group Interviews

GA: Group Activity

IEA: International Association for the Evaluation of Educational Achievement

IK: Indigenous Knowledge

IKS: Indigenous Knowledge System

LCE: Learner-Centered Education

MEAC: Ministry of Education, Arts, and Culture

MEd: Master of Education

MKO: More Knowledgeable Other

MoE: Ministry of Education

NCBE: National Curriculum for Basic Education

NSSC: Namibia Senior Secondary Certificate

PEEOE: Predict, Explain, Explore, Observe, Explain

PhD.: Doctor of Philosophy

SCT: Socio-Cultural Theory

SDGs: Sustainable Development Goals

STEM: Science Technology Engineering and Mathematics

TMESD: Transformational Model of Education for Sustainable Development

TIMSS: Trends in Mathematics and Science Study

WS: Western Science

ZPD: Zone of Proximal Development

CHAPTER ONE: SITUATING THE STUDY

1.1 Introduction

The main goal of this study was to tap into the indigenous technology (IT) also known as indigenous knowledge (IK) to motivate and foster the learning process of the specific scientific concept of carbon dioxide (CO_2) by rural school learners. The IT practices of making *oshikundu*[1] and homemade bread (*uumboloto*) were used as easily accessible resources to support Grade 8 Physical Science learners to carry out hands-on practical activities (Asheela et al., 2021). This was an attempt to improvise on resources in other to make the topic of CO_2 easily understandable for rural school learners – that is, to mobilise these two practices to mediate learning and sense-making on the topic of CO_2 in Grade 8 at a rural school in the Ohangwena region. This study was triggered by many factors.

Firstly, it hoped to help learners learn and acquire knowledge about CO_2 and its related concepts. Secondly, the fact that CO_2 has a crucial role in the ecosystem and is a powerful greenhouse gas called for this study. Indeed, CO_2 plays a role in the increase of the greenhouse effect which is a 21st-century concern that can lead to a rise in the temperature of the air near the earth's surface which may be devastating as it causes global warming that leads to climate changes (Jones et al., 2016). In my view, therefore, new studies around CO_2 should be made.

[1] Oshikundu is a non-alcoholic traditional beverage that is made from fermenting three flours, namely, *ongundo*, *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 essentially to prevent dehydration (Shinana, 2019).

Thirdly, my personal experience as a learner and currently as a Physical Science teacher has influenced this study. Similarly, poor performance in Chemistry at the Grade 11 level (Ministry of Education [NMoE], 2017–2021), lack of resources to carry out hands-on practical activities in rural schools (Asheela, 2017) and the silence in the literature that calls for contextualisation of school Science have also motivated the need for this study. This study like a few other studies previously carried out by Rhodes University students such as Asheela et al. (2021), Kakambi (2020) and Shinana et al. (2021) argue that the use of IK has the potential to provide opportunities for bridging African knowledge with westernised knowledge to reach the optimal level of science comprehension by learners. Hence, it promotes the contextualisation of Science (Gwekwerere, 2016), to make it more relevant and accessible to rural school learners who are generally disadvantaged when it comes to adequate materials or resources needed to learn Science.

In this chapter, I describe the background of the study by first discussing the international views on IK integration into Science. Secondly, I looked at the local context based on Namibia's Ministry of Education's National Curriculum for Basic Education (MoE, 2016). Thirdly, I discuss the statement of the problem, purpose and significance of this study, the research goal and research questions. Lastly, I present the theoretical and analytical frameworks and end with a chapter summary.

1.2 Background of the Study

In recent years, a few African countries have experienced some economic growth, but still struggle to meet the basic needs of their citizens. Education plays a vital role in the development of the human capital needed to ensure more sustainable economies. More importantly, the development of locally relevant scientific knowledge is needed for inventions of sustainable technologies that utilise locally available resources (Asheela et al., 2021; Gwekwerere, 2016; Mavuru & Dudu, 2021). Much of the debate on the nature of science and science learning is reflected in a body of literature that analyses the tensions between disparate (Western and non-Western) perspectives on science education. Post-colonialists, feminists, multiculturalists, sociologists of scientific knowledge and those who refer to themselves as indigenous researchers argue that science is not universal but locally and culturally produced. Universalists, on the other hand, argue that modern Western Science (WS) is superior to indigenous knowledge (IK) in the natural world because of the former's advanced predictive and explanatory powers (le Grange, 2007).

However, protagonists for IK (Aikenhead, 2006; Gwekwerere, 2016; Erinosho, 2013; Ogunniyi, 2007a) have accused the teaching and learning of science in other parts of the world other than in the West, to be biased. It is said to be biased because it is customarily done according to Western customs which involve the use of Western technology, methodology, materials and terminology usage in classrooms. These approaches to teaching and learning science are said to be alien to non-Western learners as they make learning science abstract, and generally do not align with the non-western learners' ways of living (Erinosho, 2013; Gwekwerere, 2016) – this consequently leads to non-Western learners' poor performance in science compared to their Western fellows.

Such poor performance is evident in the Trends in Mathematics and Science Study (TIMSS). The TIMSS is a series of international examination assessments of students' achievement dedicated to improving teaching and learning in Mathematics and Science conducted by the International Association for the Evaluation of Educational Achievement (IEA). First conducted in 1995, TIMSS reports every four years on the achievement of fourth and eighth-grade learners. As a globally cooperative enterprise, TIMSS conducts comprehensive state-of-the-art assessments of learners' achievement supported by extensive data about country, school and classroom learning environments. There is enormous diversity among the TIMSS countries – in terms of economic development, geographical location and population size. Fundamental to IEA's vision is the notion that the diversity of educational philosophies, models and approaches that characterise the world's education systems constitute a natural laboratory in which each country can learn from the experiences of others. TIMSS participants share the conviction that comparing education systems in terms of their organisation, curricula and instructional practices concerning their corresponding learners' achievement provides information crucial for effective education policymaking.

The 2019 TIMSS shows countries' average achievement being led by the East Asian countries as top performers that have outperformed the other countries by substantial margins in Science in the fourth and eighth grades. Singapore was ranked first with an average of 608, followed by Chinese Taipei with 574, Japan with 570 Korea and a few other European countries such as the Russian Federation and Finland (Mullis & Martin, 2017). A large margin was also drawn between the United States and East Asians. The United States performed with an average of 522 which was poor but better compared to the rest of the African countries. South Africa, a neighbouring country to Namibia, is one of the few countries representing Africa in the TIMSS and performed quite poorly, ranked last with an average of 370 in the eighth grade in Science. Unfortunately, Namibia did not take part in the part in TIMSS and I assume that it did not meet the TIMSS requirements.

Commending on TIMSS' outcomes, Govender (2014) posits that part of the African learners' poor performance is exacerbated by the ways African learners learn science and their attitudes towards science (Manzini, 2000). They learn abstractly because science is taught without reference to their local or indigenous experiences. It is for these reasons that some scholars believe that IK should be seen as an alternative approach to assist in the teaching and learning of science (Klein, 2011; Opoku & James, 2021; Rosales & Sulaiman, 2016). Aikenhead and Jegede (1999) warn that learners find it difficult moving between the micro-culture of the family and the micro-culture of the school; as a result, it affects their success in science.

Notably, the call for the integration of IK into school curricula has now found momentum in many countries (Naidoo & Vithal, 2014; Ogunniyi & Hewson, 2008). Seehawer and Breidlid (2021) claim that there should be a dialogue between IK and westernised knowledge instead of fitting IK into westernised knowledge.

The South African Department of Education, for example, one of the general aims of its Curriculum and Assessment Policy Statement (Department of Basic Education [DBE], 2011) is to value indigenous knowledge systems (IKS) – acknowledging the rich history and heritage of that country as an important contributor to nurturing the values contained in its constitution. Similarly, the Namibian National Curriculum for Basic Education [NCBE] for both 2010 and 2016 call for knowledge that embraces IK. It thus suggests that teachers should select learning content and methods within the learners' immediate environment and community (Mavuru & Ramnarain, 2017).

1.3 Expectations of the Namibian Curriculum

Namibia, Tanzania, Zimbabwe, South Africa and a few other African countries support the integration of IK into science teaching and learning. For instance, in the NCBE an emphasis is made that the type of knowledge to be imparted to learners should be "knowledge that embraces indigenous knowledge (IK) and national culture as well as international and global culture" (Ministry of Education, Arts, and Culture, [MEAC], 2016, p. 5). Therefore, Namibia has responded to the call for the integration of IK into science teaching. This is intended to counteract Western methodologies and approaches used in Science classrooms to teach Science (Aikenhead, 2006; Taylor & Cameron, 2016) since it seems there is a bias in the use of Western approaches alone – in many cases such approaches benefit only a few learners since they are not accessible to all. To ameliorate this, the Namibian curriculum requires teachers to recognise learners' prior everyday knowledge (Kuhlane, 2011; Roschelle, 1995) and experiences from their homes and communities (MoEAC, 2016). For instance, in Grade 8, teachers are required to integrate learners' IK to teach the composition of air (nitrogen, oxygen, carbon dioxide, argon and others) and their characteristics.

Unfortunately, despite this being the case, it is worrisome that little has been done to support Science teachers on how they can go about integrating indigenous knowledge into their teaching. As a result, it is unclear *how*, *what, where, which* and *when* to use the IK or resources (Asheela, 2017). This suggests that there is a gap in how specific IK should be used (integrated) to teach specific science topics. In other words, there is an incoherence or contradiction – a gap in understanding between curriculum designers and implementers. This may be intensified by the fact that most Namibian teachers went through a Western education system and that most of them never considered the indigenous ways of knowing as a useful approach to mediate teaching and learning (Dziva et al., 2011).

For example, based on the past 11 years of my teaching experience, the topic 'Gases of air' has been a challenge to both learners and myself due to the inadequate resources needed to test for the different air components.

Albeit the curriculum calls for the use of easily accessible resources as learners' IK, professional development (CPD) workshops are rarely done in most regions. Where they are done, teachers are normally taught how to interpret basic competencies instead of teaching them how they use local resources at their disposal to achieve specific abstract basic competencies. In my view, I think it is vital that teachers should know what to use to teach specific concepts in case the school cannot provide the needed learning aids.

I should acknowledge that to a certain extent, this study carries a *two-in-one* nature, it is obvious that it serves both purposes (teaching and learning) to varying degrees. Though this study elaborates on teachers' knowledge around IK, it worked *with* learners intending to help them to do hands-on practical activities using IT tools to learn science (CO_2). However, I believe teachers' pedagogical content knowledge (PCK) plays a role in learners' learning. Equally, through mediating learning, teachers improve their PCK levels. I, therefore, believe that this study might be equally beneficial to both teaching (*teachers*) and learning (*learners*).

Of interest to this study are studies done by Nuntsu (2020), Mayana (2020), Kudumo (2020) and others who set good examples of how IK should be used in Science topics using indigenous interventions as illustrated in their studies. The findings in these studies revealed that learners were able to comprehend the Science concepts being taught with ease. It is for this reason that I intend to do likewise by mobilising the IK of making *oshikundu* and homemade bread (*uumboloto*)[2] to mediate learning and sense-making on the topic of CO_2 in my Grade 8 Physical Science learners in a rural school.

Indeed, this study is timely as I would like to relate this topic to learners' everyday lives so that they can appreciate the application of science to their real-life worlds (Gwekwerere, 2016). For instance, since learners are required to wear masks to prevent Covid-19 infections, asking them how Covid-19 may infect those who do not wear masks might enrich their sense of gases of air. In my view, the fact that learners are well aware that human beings breathe air in and out serves as their prior everyday knowledge. Similarly, asking them why there is a need to plant more trees may be part of their prior everyday knowledge concerning CO_2. Herein lies the importance of Education for Sustainable Development. I also assume that learners are aware of how *oshikundu* and *uumboloto* are made in their homes. It is recognised, however, that they might not be aware of the scientific concepts embedded in these IT practices (Shinana et al., 2021). In the sections below, I discuss the approach to teaching and learning of Physical Science in Namibia.

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[2] *Uumboloto* is an *Oshiwambo* traditional bread that is prepared almost like modern bread, mainly using, Bakpro white or all-purpose bread flour, Sugar and salt, instant dry yeast and warm water.

1.3.1 Approach to teaching and learning Physical Science

The NCBE (MoEAC, 2016) has placed Physical Science under Natural Sciences as an area of learning. The Natural Sciences learning area encompasses the following subjects: Environmental Learning (pre-primary), Environmental Studies (grades 1-3), Natural Science and Health Education (grades 4-7), Elementary Agriculture (grades 5-7), Life Science (grades 8-9), Physical Science (grades 8-9), Agricultural Science (grades 8-12), Biology (grades 10-12), Physics (grades 10-12) and Chemistry (grades 10-12) (MoEAC, 2016). Generally, all Natural Science subjects are interlinked in one way or other. The basic (lower) grades set the foundations for the higher grades.

Bearing in mind this sequential order, this study sought to improve learning of Physical Science in the junior secondary phase, that is, grades 8 and 9, particularly in Grade 8, and to set a good foundation for the senior phase (grades 10-12). Physical Science is a combination of Chemistry and Physics that are offered separately in grades 10-12. Hence, at the end of the junior secondary phase (Grade 9) learners have to choose either Chemistry or Physics. According to Stein et al. (2008) Chemistry, Physics and Physical Science are subjects that are regarded as difficult for both teachers and learners alike, because they include concepts that are too abstract to understand. Science teachers are, therefore, required to ensure that the abstract concepts are made relevant to the learners' lived experiences. It is against this background that the Namibian MoEAC (2016, p. 5) advises that:

> The starting point for teaching and learning is the fact that the learner brings to the school a wealth of knowledge and experience gained continually from the family, the community, and through interaction with the environment. Learning in school must involve, build on, extend and challenge the learners' prior knowledge and experiences.

Moreover, Nyika (2017), Ogunniyi (2007a) and Roschelle (1995) support that teaching approaches that build on learners' prior knowledge and experiences from everyday socio-cultural interactions are crucial to the learners' successive learning. Hence the call for teachers to employ teaching strategies that induce and challenge learners to use their socio-cultural background experiences and cultural worldviews in class to make sense of science concepts and to fully explore opportunities embedded in IK – enhancing learning with understanding (Erinosho, 2013; Mavuru & Ramnarain, 2020; Vygotsky, 1978). Based on these scholars' views and that of the NCBE, it seems teachers need to be skilful in eliciting and refining learners' prior knowledge to accommodate new information. Hence, a need for an intervention that mobilised learners' IK to enable science learning. Therefore, as a response to this call and to mitigate this gap, I used the process of making *oshikundu* and *uumboloto* to mediate learning and sense-making on the topic of CO_2 in Grade 8. In the section that follows, I discuss conducting hands-on practical activities – another aspect central to the teaching of Physical Science in Namibia.

1.3.2 The role of hands-on practical activities in science teaching and learning

Namibia's Natural Science Subject Policy Guide for grades 5-12 expects Physical Science teachers and learners to conduct hands-on practical activities (MEC, 2008). Thus, part of the assessment done in the junior secondary phase in Physical Science is hands-on practical activities. The continuous assessment (CA) tasks include practical investigations which are intended to assess learners' practical skills. To provide enough time for hands-on practical activities or experiments, each science subject is allocated a double lesson period on the timetable in a seven-day circle. As a minimum requirement at the end of each topic, the syllabus suggests several hands-on practical activities and commands that all learners should be exposed to. This is aimed at preparing and equipping learners with the practical skills and knowledge required, especially for the senior secondary practical examination papers.

Although hands-on practical activities and investigations are a must in Science teaching and learning in Namibia, it remains a challenge for many schools to conduct them. Several scholars have revealed that most Namibian secondary schools have inadequate resources available in their Science laboratories to carry out hands-on practical activities (Asheela et al., 2021; Liswaniso, 2019; Nikodemus, 2017). Further, Liswaniso (2019) alludes that a lack of hands-on practical activities leads to poor performance by the learners in the practical examinations. In my view, and as evidenced in Shinana et al.'s (2021) study, IT practices could offer alternative resources at little to no cost for conducting hands-on practical activities as required in the Physical Science curriculum. The benefits of IT practices are noted in many studies conducted both in Namibia and South Africa. For instance, Mayana (2020) explored affordances and hindrances when IK is integrated into the topic of waves and sound in a Grade 10 Physical Sciences; Asheela (2017) explored using easily accessible resources (using *oshikundu*) and another scholar, Nikodemus (2017) also used *oshikundu* – but this time to mediate learning of the concept of rates of reactions.

In my view, teachers fail to integrate IK in their teaching due to their lack of awareness of IK integration into science, especially the ability to make the connections between IK and the school Science concepts. Also, it seems most teachers are not aware of some indigenous practices that may be used to carry out specific hands-on practical activities or investigations in the absence of the scientific apparatus or reagents. Similarly, the curriculum itself seems to be too general and not explicit on this issue, since it does not give any specification of what, how and when learners' prior knowledge can be used side by side with school Science. In addition, I think part of the reason why the Namibian curriculum is not explicit on which IK is to be integrated into Science could be due partly to the fact that Namibia is a multi-cultural nation with a diversity of cultural practices and there cannot be a common cultural way of doing things. That is a common denominator for all the indigenous people of Namibia. Even so, I still believe that on a unitary base, different indigenous people may make use of whatever is appropriate in their cultures as indigenous practices to localise (contextualise) science.

Despite the above-mentioned ideas, the agenda of IK integration into Science seems to be at the infant stage in Namibia. Though several studies have been conducted in Namibia on IK integration into science teaching and learning, what is worrisome is that many of these studies are done through international universities and few through Namibian universities – I believe this could be one reason why the issue of IK integration into science is moving at a snail's pace. I hope this study will contribute to reforming the Namibian Science curriculum, as it mobilises the IK of making *oshikundu* and *uumboloto* to support learning the topic of CO_2 and its related concepts, which most teachers may ultimately use to contextualise Science in their classrooms.

1.4 My Personal Experience

Born and growing up in a typical *Oshiwambo*[3] cultural lifestyle, I learnt most of the *Oshiwambo's* cultural practices such as hunting, herding cattle, cooking, making *oshikundu*, extracting Marula oil (*okuhenga*), collecting firewood, fermenting fresh milk with *Omunghudi* (roots from an indigenous plant) and many others. These were regarded as norms and values of the *Ovawambo* people. In hindsight, that was the type of education my parents gave me at home. However, there was no link between my lifestyle experience (home education) and

[3] *Oshiwambo* is one of the Namibian common languages spoken by *Ovawambo* people, a tribe in Namibia.

school education. For instance, most of the examples that were used in textbooks were urban-based. That is, textbooks gave examples of totally strange things to me such as a microwave and other things that were not in my environment or that I had never seen. Resultantly, I was forced to operate between two systems that were completely different. My parents also did not see the importance of anything I learnt at school, and so they had little interest in the school system.

Due to my cultural background, the school was not a good place for me and a few other learners who grew up in rural areas, especially at Grade 8 level when we started learning Physical Science. That was exacerbated by the fact that at times, the learners that were well-off (with urban cultural ways of living) belittled us and made fun of us who were rurally raised, since we knew little about the science examples and terminologies from the textbooks. To make matters worse, our school had no science laboratory or science apparatus and reagents to demonstrate what we were being taught. This was so demotivating to me when learning Physical Science. As a result, Physical Science was so abstract and full of complex ideas; for example, learning the kinetic particle theory of matter or the periodic table. It was so difficult for me to learn about things that were not physically visible.

Luckily, I am naturally curious and I have always wanted to know why things behave the way they do. Thus, Physical Science seemed to make room for me to find out more about science-related ideas and hence I became interested in learning it. Also, I was eager to pass and I was thus left with no option but to memorise some science concepts which I hardly understood at all.

Today when I reflect on my rich cultural background, I acknowledge the many skills I learnt at a very young age, not only from my parents but also from other elders in our village and surrounding communities. I strongly believe that my cultural practices such as pounding and sieving maize, sorghum, and Mahangu, collecting and purifying rainwater collected in ponds, collecting and preserving wild fruits and using energy from the sun could have been acknowledged at school, could have been used to reshape my skills from home. If such knowledge could have been used to mediate learning of various science concepts, Science might have been more interesting and relevant to me (Aikenhead & Jegede, 1999; Gwekwerere, 2016). For instance, I learnt how to milk a cow and how to ferment fresh milk using the root of *omunghudi*. The fermentation process of fresh milk to sour milk can be a great resource for

Physical Science teachers. Such IK can be used to mediate learning of concepts such as rates of reactions, catalysts, mixtures, separating mixtures, production of CO_2 (my case study) as well as the concept of acids.

It is only now that I concur with scholars such as Cocks et al. (2012) and McCarty and Lee (2014) who emphasised the importance of cultural revitalisation pedagogies for improved methods of teaching Science.

With all my cultural skills from home, I only came to learn that these were relevant to science as of now. My teachers disregarded the knowledge I had acquired from home because no reference was made to it. It seems that the cultural knowledge I possessed was not required at school and was regarded as irrelevant. Yet, Aikenhead and Jegede (1999) emphasised that taking into consideration such knowledge could bridge the gap between home and school Science. When I graduated as a teacher, I also never considered the learners' rich cultural heritage that they brought to class. Instead, I taught them the way I was taught (Keane et al., 2016). Now, when I reflect on my professional journey as a teacher, I feel like I have robbed my learners of moments of opportunities to learn science that was relevant to them (Gwekwerere, 2016). I regret teaching Physical Science for almost 10 years and never considered integrating learners' IK into my teaching. It is against this background that I focused my study on mobilising the IK of making *oshikundu* and *uumboloto* to mediate learning and sense-making on the topic ofCO_2.

Thanks to Rhodes University, that opened my eyes as far as Science teaching and learning is concerned, today, my lessons are full of enthusiasm and far more lively than before. The several studies done through Rhodes University I referred to earlier and our conversations with learners now, have convinced me that indeed there is science in our traditional practices.

1.5 My Positionality and Reflectivity in the Study

Bertrand and Demps (2018) averred that every researcher inherently carries assumptions and biases into their work and that these positions influence the interpretation and representation of the participants' voices (Thomas, 2013). Concurring, Holmes (2020) explained that researchers cannot completely detach themselves from the social reality they live in and carry out studies objectively. Agreeing with Holmes, I think my beliefs, gender, culture, language, race or ethnic group and other human characteristics I possess may have influenced the study in one way or the other.

In this study, I undertook to use a reflexive approach throughout the research process aimed at understanding the influence of my positionality on the research design, conduct and output (Holmes, 2020). I first indicated that since learners already knew me as their teacher, they might consider me more knowledgeable. To ameliorate such a dilemma, I presented myself as a co-learner and made it clear that the intervention intended to create something new and learn something that did not yet exist (Sannino et al., 2016).

Secondly, I am the Head of Department for Natural Science at the school and the only male staff member in the top management. Thus, I assumed that my position in the school as an authority and the fact that in the *Oshiwambo* culture, which is a culture for both participants and I, it is not acceptable to deny instructions from an elder or your supervisor, may have influenced some participants' choices whether to be part of this study. Hence, the issue of power gradients or dynamics might have had some influence in this regard. Therefore, I tried to be culturally sensitive and follow the protocols of my participants and respect their worldviews (Seehawer, 2018b). In this regard, the *Ubuntu* perspective guided my conduct with the participants. Ubuntu is a "philosophy that is a collective effort characterised by the spirit of togetherness which sees human needs, interests, and dignity as of fundamental importance and concern" (Higgs, 2008, p. 453)

I thus addressed the issues of positionality by ensuring that all the participants knew and understood that their participation in this study was voluntary. Moreover, they would be free to withdraw from participating in the research at any time they felt like doing so without being prejudiced. I, however, rephrased this when explaining to my participants, since, like Mayana (2020) and Mutanho (2021), this ethical phrase of telling participants to *withdraw at any time they want* which in *Oshiwambo* (my culture) means (*with or without you I can carry on with my study*) is a sign of rudeness. I also rectified and informed them that the position I held in the school had nothing to do with this study. Instead, the study had to do with improving Science teaching practice and enhancing learning.

1.6 Statement of the Problem

The NCBE (MoE) supports the integration of IK and the use of hands-on practical activities using easily accessible resources in Science (Asheela et al., 2021; Mavuru & Dudu, 2021; Shinana et al., 2021). Hence, it encourages teachers at all levels to wisely consider learners' existing knowledge to create new knowledge. This is based on the notion that learning begins with the learners' motivation and experiences. However, this seems to be a challenge since the curriculum documents do not give clear guidelines on how IK should be integrated into Science teaching (Asheela, 2017; Nikodemus, 2017).

Observably, this is a confirmation of Seroto's (2012) claim, who avowed that at times, poor performance is caused by inadequate school resources, under-preparedness of teachers to teach science, poor command of the Language of Learning and Teaching, negative attitudes that are accompanied by lack of insights into the value of science, low self-efficacy and poor-quality environments for learning science.

Admittedly, in rural settings such as where I currently teach, there is a lack of resources needed to carry out hands-on practical activities. As a consequence, there is an observable increase in negative attitudes in learners towards learning Science. In addition to what Seroto noted earlier, I would argue that the theorisation of practical investigations by many teachers seems to make Science more complex and demotivating to learners (Asheela et al., 2021). Moreover, misunderstanding of science concepts by learners and foreignness of science in rural schools (Cetin-Dindar & Geban, 2017) seem to be barriers to learning science.

Notably, habitual rote learning of Science in rural schools also seems to be impeding learners' conceptual understanding of Science. This is evident in the Ministry of Education's national examination results for rural schools report (MoE, 2017-2021). These factors call for interventions that will contextualise and make Science relevant and accessible to learners (Gwekwerere, 2016), especially in rural contexts. Also, it is worth noting that many studies conducted before in Namibia on the integration of IK into Science teaching (see Asheela et al. 2021; Shinana et al., 2021) were mainly done with teachers instead of being conducted with learners. Yet, according to Learner-Centered Education (LCE), learners should be central in the learning process. Thus, learners' voices regarding interventions in many cases seem to be overlooked.

Drawing from Vygotsky's (1978) seminal work that proposes a need for the socio-cultural approach to be considered in Science classrooms, the indigenous technologies of making *oshikundu* and *uumboloto* to mediate learning on the topic of carbon dioxide and motivate learners to do Science were deemed to be ideal in this regard. The integration of learners' indigenous practices in the learning environment space has the potential to promote their active participation (Sedlacek & Sedova, 2017)

It is against this background that this study wished to mobilise the IK of making *oshikundu* and *uumboloto* as easily accessible resources to carry out hands-on practical activities to support Grade 8 Physical Science learners to learn and make sense of the topic of CO_2.

1.7 Rationale and Significance of the Study

Carbon dioxide (CO_2) is an important gas in the ecosystem and hence it is a key concept in the Namibian Science curriculum. This interventionist study, therefore, sought to mobilise the indigenous technologies of making *oshikundu* and *uumboloto* to motivate and enable sense-making of the concept of CO_2. It was anticipated that the study might add value in addressing three aspects of Science learning in the Namibian context, namely 1) contextualising Science in rural schools by integrating learners' IK in science to support learning; 2) improvisation of resources to overcome lack of resources by using easily accessible resources to carry out hands-on practical activities in poorly resourced schools, and 3) promote education for sustainable development which upholds both intrinsic and extrinsic rewards to learners and which may motivate learners to do science (Govender, 2014).

This study might also help fellow educators, curriculum developers, textbook authors and examination officials to recognise opportunities that may be provided by learners' IK when used to mediate the learning of scientific concepts, especially in under-resourced rural schools such as mine. It might also help teachers (including myself) to improve practices and hopefully enhance learners' performance in Physical Science (Asheela, 2021).

1.8 Research Goal and Research Questions

The main goal of this study was to mobilise the indigenous technologies of making *oshikundu* and *uumboloto* (homemade bread) as easily accessible resources to carry out hands-on practical activities to support Grade 8 Physical Science learners to learn and make sense of the topic of CO_2. To achieve this goal, the following research questions guided the study.

Research Questions

1. What are Grade 8 Physical Science learners' perspectives and motivations for learning the topic of CO_2 before the intervention?
2. What do learners know from their homes and communities about CO_2?
3. In what ways do the Grade 8 Physical Science learners interact, participate, and learn (or not) the concept of CO_2 during the practical demonstrations on the making of *oshikundu* and *uumboloto* by the expert community members?
4. How do the presentations by the expert community members on the making of *oshikundu* and *uumboloto* shift (or not) Grade 8 Physical Science learners' perspectives and motivations to learn and make sense of the topic of CO_2?

1.9 Theoretical and Analytical Framework

This study is informed by Vygotsky's (1978) socio-cultural theory and Ogunniyi's (2007a) Contiguity argumentation theory (CAT) as theoretical and analytical frameworks respectively. Vygotsky's (1978) sociocultural theory (SCT) asserts that learning occurs through social interactions. That is, learners interact with cultural materials in their society as well as with more knowledgeable others. Within the SCT, I focused on the following concepts: mediation of learning, culture and language, social interactions and the Zone of Proximal Development (ZPD) as lenses.

On the other hand, Ogunniyi (2007a) stresses that the contiguity argumentation theory (CAT) is used when two different cultures co-exist and/or are in conflict and is only possible through cognitive shifts to accommodate each other. He maintains that argumentation has been used as a rhetorical and instructional tool in many different societies. According to Ogunniyi (2007a) and Hewson and Ogunniyi (2011), CAT is divided into five categories in which conceptions within a learner's mind can move. These five cognitive states of conceptions are in a constant state of uncertainty about what should be done or what is right or wrong within a person's mind. Ogunniyi (2007a) referred to this as amalgamated cosmologies.

Hewson and Ogunniyi (2011) described these five conceptions as: dominant – a dominant view explains and predicts facts; suppressed – an idea becomes suppressed in the face of valid evidence; assimilated – a less powerful idea might be suppressed by a more powerful one; emergent – there may be circumstances where no prior knowledge exists and the new knowledge has been developed, and equipollent – when two competing ideas have equal intellectual force. It is the equipollent state that is at the centre of this study as Taylor and Cameron (2016) put it that Westernised Science and IK systems should be considered as complementary rather than being mutually exclusive.

1.10 Data Generating Techniques

Four data gathering techniques were used to gather data for this study and these were:

1) focus group interview;
2) group activity;
3) participatory observation;
4) journal reflections.

1.11 Definition of Key Concepts used in the Thesis

In this study, IK encompasses local knowledge and traditional knowledge. Some of the key concepts used in the thesis are:

Indigenous Technology: This refers to community based skills or ways of doing something.

Indigenous Knowledge: A legacy of knowledge and skills unique to a particular indigenous culture and involving wisdom that has been developed and passed on over generations (Kibirige & van Rooyen, 2006).

Oshikundu: This is a non-alcoholic traditional beverage that 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 (Shinana, 2017).

Homemade bread (*uumboloto*): Mostly practised by *Ovawambo* people, *uumboloto* (homemade bread) is *Oshiwambo* traditional bread which is prepared almost like modern bread, mainly using Bakpro white or all-purpose bread flour, sugar and salt, instant dry yeast and warm water.

Contiguity Argumentative Theory (CAT): Rooted in the Aristotelian Contiguity Theory this is Ogunniyi's (2007a) theory which asserts that one or two worldviews readily rely on each other to create an optimum cognitive state.

Ubuntu: This is a "philosophy that is a collective effort characterized by the spirit of togetherness which sees human needs, interests, and dignity as of fundamental importance and concern" (Higgs, 2008, p. 453).

Westernised science: In this study, the term refers to school Science whose content and contexts are Western-based, which is foreign to Africans.

1.12 Thesis Outline

Chapter One: Situating the Study

This chapter presented the international, regional as well as Namibian context of the integration of IK into the Science curriculum. Thereafter, the statement of the problem, purpose and significance of the study, research goal, questions and theoretical and analytical frameworks were discussed. Lastly, the data gathering techniques were introduced, followed by the definition of key concepts used in this study.

Chapter Two: Literature Review and Theoretical Framework

The second chapter provides an overview of the relevant literature about IK integration into science teaching and learning. Carbon dioxide (CO_2), prior knowledge, IK, *Oshikundu* and homemade bread as indigenous practices for hands-on practical activities as well as the role of language in teaching Science in Namibia are discussed. The chapter ends with a discussion of the theoretical and analytical frameworks.

Chapter Three: Theoretical and Analytical Frameworks

The third chapter looks at the theoretical and the analytical frameworks of this study.

Chapter Four: Research Methodology

This chapter presents an overview of the research design, paradigm, and approaches employed in the study. I outline the research goal, questions, and process of the study, thereafter, the research site, participants, sampling, positionality, research methodology, and data generating techniques are discussed. The chapter also explains how the data generated from the various techniques were analysed. Lastly, the chapter presents a discussion about issues of validity and trustworthiness as well as those on ethical considerations.

Chapter Five: Focus Group Interviews and Group Activities

This chapter presents the data and analysis from the focus group interviews and the group activity.

Chapter Six: Participatory Observation and Learners' Journal Reflections

The sixth chapter presents findings from the participatory observation and journal reflections.

Chapter Seven: Summary of Findings, Recommendations and Conclusion

This chapter presents the findings of this study's recommendations and the conclusions.

1.13 Chapter Summary

In this chapter, I gave an overview of the entire study. I highlighted the background, expectations of the Namibian Science curriculum, the approach to teaching and learning Physical Science in Namibia and the role of hands-on practical activities in Science teaching and learning. I also discussed my own experience, my positionality and reflectivity in the study, the statement of the problem, the rationale and significance of the study, the research goal and research questions and the data generating techniques. Last, I defined key concepts used in this thesis as well as gave the thesis outline and the theoretical and analytical frameworks of this study. I also gave a brief overview of each chapter in this study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

In this chapter, I synthesise and discuss literature on IK's role in teaching. Firstly, I start by looking at the expectations of the Namibian science curriculum. Secondly, I discussed CO_2 . Thirdly, literature on learners' prior everyday knowledge and IK is synthesised. In the fourth part, a review of literature on why there is a need for integration of IK in the science curriculum is discussed. *Oshikundu* and *uumboloto* (homemade bread) as easily accessible resources are discussed in the firth part followed by a review of literature on hands-on practical activities and visualisation. Lastly, I present the concepts related to learning that informed this study.

2.2 The Namibian National curriculum for basic education (NCBE)

In the 21st century, science curriculum transformation has become vital for the development of many African countries. Namibia is one of those countries where teaching and learning are regulated by the Namibian National Curriculum for Basic Education (NCBE). The NCBE gives directions in terms of how to plan, organise and implement teaching and learning (MoE, 2016). It aims at providing a framework which ensures uniformity in curriculum delivery in schools throughout the country. One aspect highlighted by the NCBE and of interest to this study is the call for the inclusion of learners' prior everyday knowledge and the use of hands-on practical activities through means of easily accessible resources (Asheela et al., 2021).

The NCBE ruled that in all courses, the first stage of learning at all levels should consider learners' existing knowledge. This is based on the notion that learning begins with the learners' motivation and experiences (Mavuru & Ramnarian, 2020; Nyika, 2017). This is grounded on the premise that learners do not come to school as *empty vessels* but they possess knowledge which is accumulated from their everyday life experiences which can be taken advantage of and capitalised on during the learning process (Freire, 2018; Gwekwerere, 2016). Hence, in response to the NCBE's call, this study sought to mobilise the indigenous technologies of making *oshikundu* and *uumboloto* as easily accessible resources to carry out hands-on practical activities to support Grade 8 Physical Science learners to learn and make sense of the topic of carbon dioxide.

2.3 What is Carbon Dioxide?

Carbon dioxide is one of the gases in the air. Air is a layer of gases that form in the atmosphere of the Earth and is retained by Earth's gravity, surrounding the planet Earth and forming its planetary atmosphere (Eggleton, 2013). By volume, dry air contains 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide and small amounts of other gases. The interest of this study was one component of air which is carbon dioxide. Eggleton (2013) defines carbon dioxide (CO_2) also known as "fixed air" as a colourless gas having a faint sharp odour and a sour taste. CO_2 is approximately 1.5 times denser than air. On cooling at normal atmospheric pressure, it freezes at -78°C to a white solid known as dry ice (Eggleton, 2013). CO_2 is non-flammable, soluble in water and does not support the combustion of most materials. It is non-toxic at usual concentrations and is present in the atmosphere (about 0.03 mole percent) and in our breath, where it results from the biological oxidation of food substances. Eggleton (2013) further echoes that CO_2 is one of the greenhouse gases linked to global warming, but it is a minor component of the earth's atmosphere formed in the combustion of carbon-containing materials, in fermentation, respiration of animals and employed by plants in the photosynthesis of carbohydrates.

Carbon dioxide (CO_2) can be prepared by reacting either carbonates or bicarbonates with acids. A molecule of the compound carbon dioxide consists of one atom of carbon (C) and two atoms (diatomic) of oxygen (O_2). Thus, carbon dioxide is represented by the chemical formula CO_2. Its chemical equation is shown in Figure 2.1:

$$C + O_2 \rightarrow CO_2.$$

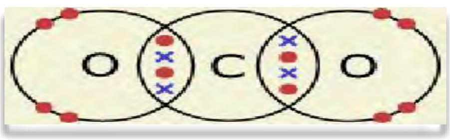

Figure 2.1: The figure shows a carbon dioxide molecule (Kachinda & Jeoffreys, 2017, p. 78)

A CO_2 molecule has a carbon atom joined by four covalent bonds to two oxygen atoms, which have two covalent bonds each. Carbon only has four outer shell electrons and oxygen has six electrons in its outer shell. Double covalent bonds form between the atoms, where two electrons from each atom (dots and crosses) are shared making four bonding electrons in total. The most effective way to test for CO_2 is to bubble the gas through "limewater", a diluted solution of calcium hydroxide (slaked lime). When one bubbles carbon dioxide through lime water, it forms a solid precipitate of calcium carbonate – chalk or limestone. Calcium carbonate is insoluble in water. Thus, if there is CO_2 present in the sample gas used, the limewater turns milky or cloudy white.

What is worth noting and of importance is the fact that CO_2 is one of the greenhouse gases that absorb the infrared radiation and trap some of the energy inside the atmosphere to keep the earth warm; if it was not for CO_2 and other greenhouse gases, the earth would be too cold for most of the animals to survive (Jones et al., 2016). This process of trapping some heat in the atmosphere is known as the *greenhouse effect*. However, too much CO_2 in the atmosphere is dangerous, since it can trap more heat than needed which may contribute to global warming. Recently, scientists have warned nations to reduce their emissions, that is, the amount of CO_2 that their industries contribute to global carbon dioxide levels since much CO_2 is already observed in the atmosphere and is ultimately causing climate change (Jones et al., 2016).

Nevertheless, CO_2 has become one of the important gases due to its new weighty potentialities in the earth's atmosphere, the ocean and biology, and it seems much is yet to be discovered about CO_2. For instance, the United States (US) has committed to working toward the long-term reduction of CO_2 emissions for reuse purposes. For example, the US Department of Energy's Carbon Sequestration Program, along with related Research and Development (R&D) programmes throughout the world continues to make progress toward the goals of lowering the cost of CO_2 capture and ensuring that the CO_2 can be safely and permanently sequestered in geologic formations in a process known as Carbon Capture and Storage. As carbon capture technology becomes advanced, the concept of CO_2 utilisation has attracted more interest due to its potential not only to reduce emissions but also as a means to generate revenue to offset the cost of capture. There are many potential benefits to achieving the goals of the CO_2 utilisation focus areas. The current demand for CO_2 comes largely from the food and beverages industry, winemaking, stunning animals, inert gas, fire extinguishers, supercritical CO_2 as a solvent, agriculture, medical and pharmacological uses, energy fossil fuel recovery, biotransformation into fuel, refrigerants, oil and gas and chemical industries (Damiani et al., 2012). Carbon dioxide (CO_2) is also used in producing carbonated beverages, such as soft drinks. The food industry is the largest user of liquid CO_2. A significant portion of this CO_2 is used in food chilling to keep products cool during harvesting, processing and transport. The oil and gas industry uses CO_2 to enhance hydrocarbon recovery in mature or depleted fields. Enhanced hydrocarbon recovery typically requires large volumes of CO_2 over an extended period. Using CO_2 to recover additional oil is considered a mature technology and, for some large oil fields, CO_2 is delivered by a network of dedicated pipelines. It is sometimes used for formation fracturing in which liquefied CO_2 replaces water or brine as the hydraulic fracturing (fracking) fluid and serves as a carrier of propping agents and/or chemicals. Estimated CO_2 usage is about 200 million metric tons per year (Damiani et al., 2012). There are many potential benefits to achieving the goals of the CO_2 utilisation focus areas as shown in Figure 2.2. Below. Recently, CO_2 has been identified as a commodity chemical with many and varied uses.

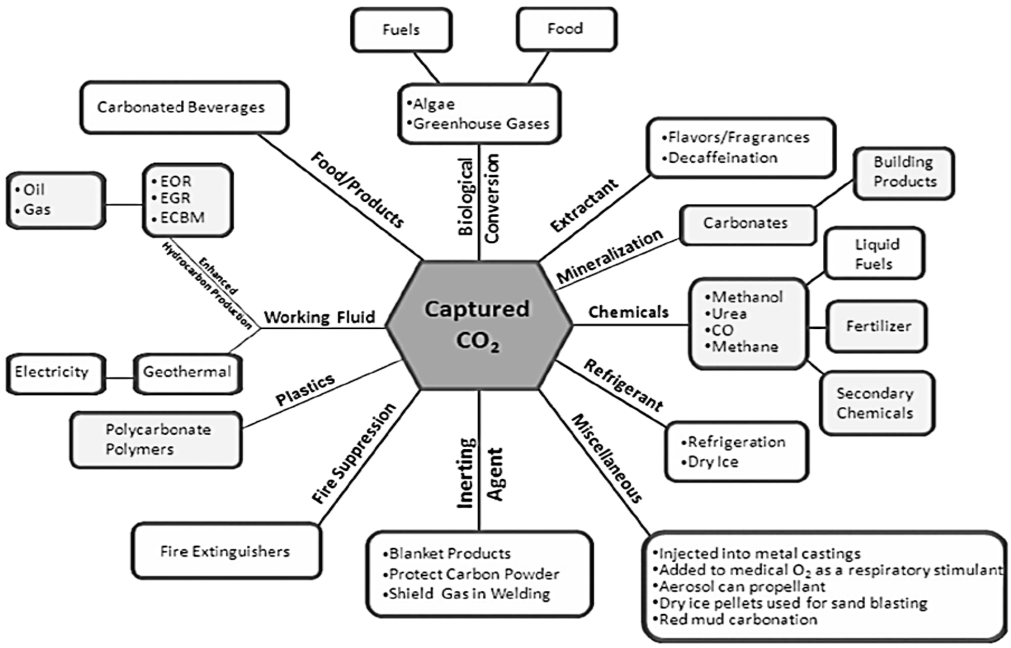

Figure 2.2: Schematic illustrating the many uses of CO_2 (adapted from The US Department of Energy's R&D programme to reduce greenhouse gas emissions through beneficial uses of CO_2, 2011, p. 3)

Having reflected on the potential uses of CO_2, I hoped that this study might be rewarding to Grade 8 learners in terms of their further studies. For instance, the Namibian Senior Secondary Certificate (NSSC) Chemistry syllabus for Grades 10–11 (MoE, 2020) instructs that learners must know and identify gases by testing for unknown gases released in certain reactions. They are also requested to know how CO_2 is formed by describing the formation of CO_2 and its production. It also demands that learners know the commercial preparation and uses of CO_2 and can describe its uses. It is, therefore, against this background that using learners' prior everyday knowledge of making *oshikundu* and *uumboloto* should be taken into consideration when learning science as it may be a stepping stone to scaffolding them into scientific thinking (Le Grange, 2007).

Similarly, Grade 8 learners' knowledge about CO_2 may contribute to an education system that promotes Education for Sustainable Development which talks to the 17 United Nations' Sustainable Development Goals (United Nations, 2015). Learners may see the need to protect and keep the ecosystem safe and to play significant roles that may help them to deal with natural catastrophes such as Covid-19; for example, planting more trees that can capture and keep CO_2 such as the [4]spekboom trees. This intervention may, therefore, motivate learners to do science, as, by the time they reach Grade 11, they might be better equipped to accommodate more complex concepts associated with CO_2 which may also improve their performance in their final examinations. Not just that, if Namibians as members of a global community could understand CO_2 and its related concepts better, they might in future join hands with the rest of the world in making the world a better place for everyone as far as the issue of global warming is concerned.

2.3 The role of learners' prior everyday knowledge in learning science

Kuhlane (2011) and Okanlawon (2017) regard prior knowledge as the experiences that learners acquire from their everyday lives and that they take from previous grades which help them make meaningful connections to the new learning content. Simply put, prior knowledge is the cultural knowledge that learners bring to school from their homes. Kuhlane (2011) suggests that to help learners make the most of a new experience, teachers need to understand how prior knowledge affects learning since new knowledge begins with the selection of ideas from everyday experiences. For Kuhlane, learners cannot learn without having prior knowledge. However, Taylor (1999) warns that not all everyday knowledge provides suitable entry points in the classroom. He further asserts that if prior knowledge is not properly enacted, it might

[4]Spekboom is a type of tree, but unlike other trees, the spekboom is the only tree that is capable of retaining and storing carbon dioxide.

create misunderstandings rather than making learners' everyday knowledge relevant to the learnt new knowledge. Prior knowledge could be in the form of IK.

2.4 Indigenous Knowledge

Indigenous knowledge (IK) also known as indigenous technology (IT) (Snively & Corsiglia, 2001) is traditional ecological knowledge or indigenous/native science (Aikenhead, 2006). Kibirige and van Rooyen (2006) defined IK as a legacy of knowledge and skills that are unique to a society. Concurring, Otulaja and Ogunniyi (2017) posited that such knowledge and skills constitute wisdom that is passed on orally from generation to generation. Adding to this, Seehawer (2018b) emphasised that IK is developed locally for the people and by the people of that locality and is then passed on from parents to their children. The elders of the community are the custodians of the IK, which is manifested through different aspects of life such as cultural norms/customs, cultural beliefs, values, songs, languages, technologies, artefacts, games, food, rituals and ceremonies (Klein, 2011; Nyika, 2017; Seehawer & Breidlid, 2021). In this regard, Ogunniyi (2007a, p. 965) uttered that IK is part of the indigenous knowledge systems (IKS) that he referred to as "a collection of knowledge systems encompassing science, technology, religion, language, philosophy, politics and other socio-economic systems". In support of this, Cetin-Dindar and Geban (2017) reiterated that engaging learners in real-life examples embedded in learning process activities enriched with real-world contexts and learners' active involvement in learning processes increases their conceptual understanding (the purpose of this intervention).

The definitions of prior knowledge and IK referred to earlier motivated me to use the indigenous technologies of making *oshikundu* and *uumboloto* to mediate learning and sense-making on the topic of CO_2 in Grade 8 Physical Science. This project was inclined towards the ideas of Battiste and Henderson (2000) who suggest that despite many scholars' contributions to the definition of IK, defining IK is inappropriate because such efforts are about comparing knowledge of which there are no valid existing methods to make such comparisons. Therefore, Battiste and Henderson (2000) suggested that instead of defining IK, scholars should rather try to understand and be open to accepting different realities and recognise the views of indigenous people.

Notably, IK has the potential to provide real-life experiences to the learners, as a cultural tool to facilitate learners' access to science (Rosales & Sulaiman, 2016; Seehawer, 2018; Vygotsky, 1978). Learners bring experiences of IK to class, which should then be used by teachers as a foundation for new knowledge or instructions (Mavuru & Ramnarain, 2017; Nyika, 2017). Kibirige and van Rooyen (2006) posit that science teaching becomes effective when IK is considered as prior knowledge and as a starting point of learning. These authors further indicated that IK promotes communication skills. Thus, it is a guiding tool for facilitating the bridge of what learners already know to what they do not, which makes teaching effective (Nikodemus, 2017).

Correspondingly, Ogunniyi and Ogawa (2008) attested that IK builds a strong link to everyday experience, leading to learners actively participating in lessons. Sharing the same sentiments are Brayboy and Castagno (2008) who posited that integration of IK does not only bridge science to IK but provokes learners' thinking, which leads to critical thinking skills (Magwentshu, 2020). Shizha (2007) asserted that learners tend to engage more when they learn what they relate to. Shizha (2007) further argued that integrating indigenous science and western modern science liberates learners and teachers from cultural alienation. It is through the implementation and integration of IK in schools that learners, parents and communities can reclaim their voices in the process of educating the African child (Shizha, 2013). Moreover, Le Grange (2007) and Mukwambo et al. (2014) advocated for the integration of IK, arguing that it paves the way for authentic Africanisation in teaching and learning.

Cementing this, Le Grange (2007) and Mukwambo et al. (2014) echoed that IK integration could make remarkable strides in contributing to the cultural revaluing of IK. In support, Gwekwerere (2016) indicated that the time has come for science teachers, African teachers in particular, to reconsider the way they teach science to an African child; perhaps then more township learners would choose science and the declining trend would be a thing of the past. This resonates with Mhakure and Otulaja's (2017) idea about culturally sensitive pedagogies, henceforth, the necessity for this study to explore the effect of integrating IK into science lessons on the topic of carbon dioxide (CO_2). Supporting, Hart (2010) argued that researchers must consider the perspective of the local community's values and aspirations, recognising that indigenous culture matters to the indigenous people. Admittedly, Higgs (2008) insisted that all critical and transformative educators in Africa must embrace and integrate indigenous African world views. Hence, it is in response to this state of affairs that this study wished to collaborate with two community elders as more knowledgeable others (MKOs) as espoused by Vygotsky (1978) to impact knowledge creation.

Historically, successful initiatives have been developed by communities themselves using their own ideas and cultural practices. For instance, in the Australian Aborigines' history, cultural and linguistic revitalisation movements have tapped into a set of cultural resources that have recentred the roles of indigenous women, elders and of groups who had been marginalised through various colonial practices (Smith, 1999). Therefore, the idea behind the use of learners' local knowledge is vital in this regard as it serves the agenda of decolonisation of the Namibian Science curriculum (Chilisa, 2012).

A wide range of literature has proven beyond doubt why there is a need for the integration of IK into the science curriculum (Aikenhead & Jegede, 1999; Mhakure & Otulaja, 2017; Mukwambo et al., 2014). For instance, Aikenhead and Jegede (1999) suggested that IK can be used as a bridge between home and school science. Kibirige and van Rooyen (2006) believed that learners might enjoy the process of linking old and new knowledge. Similarly, Abah et al. (2015) noted that the artefacts that are available in learners' traditions are important tools to bridge the gap between what is usually taught in the classroom and what exists outside in society. Likewise, Naidoo and Vithal (2014) have indicated that for schools and curricula to positively respond to the need of making teaching and learning more culturally inclusive, there has to be a paradigm shift from the current predominantly Eurocentric curricula to an Africanised education system.

Concurring, Govender (2014) suggested that integrating IK into science classrooms can lead to learners becoming motivated to learn science. Furthermore, it might increase learners' participation in classrooms (Sedlacek & Sedova, 2017). Equally, this intervention may offer my learners a platform from which they might be able to argue (Nuntsu, 2020) and answer questions in class about CO_2 or even learn more about its related concepts. By doing so, authentic and meaningful learning might take place.

The integration of IK into Physical Science lessons is crucial since Physical Science subjects are core for the growth of sustainable technologies in the sense that they are directly linked to understanding how technologies work, which can lead to the development of newer technologies. Hence, finding ways to make the Physical Science subjects taught in African schools more relevant and applicable to the African context is critical (Gwekwerere, 2016).

Science educators in non-western countries have long realised that a gap exists between Western Science (WS) taught in schools and other traditional worldviews (Aikenhead & Michelle, 2011; Nashon, 2004). This gap has resulted in low achievement rates in Science subjects as well as the low representation of indigenous people in science-related fields (Aikenhead & Michell, 2011). Learners' socio-cultural worldviews affect the way they learn and African worldviews may impact African learners' way of learning (Nashon, 2004).

Kibirige and van Rooyen (2006) agreed that science teaching is enriched when IK is used as indigenous prior knowledge in the classroom and can thus be used as a starting point to explore concepts associated with WS. Westernised Science (WS) is described by Jegede (1997) as Eurocentric science or modern science which originated in Europe and then spread to the rest of the western world and other non-western countries. He argued that western culture sees modern science as the only path of knowledge acquisition and thus separates non-western thoughts and ideas from the body of science. Hence, Science subjects taught in school are alienating for most learners, fewer learners choose to specialise in Science at the college level, and even fewer learners go on to pursue STEM – (Science, Technology, Engineering and Mathematics) related careers (Business-Higher Education Forum, 2010).

Consequently, Science educators have grappled with this challenge for a long time and the methods used to teach Science have been identified as a stumbling block for most learners. Science has traditionally been taught through rote memorisation of facts from a textbook (Gwekwere, 2016). In addition, the scientific terms that are used in science textbooks do not have direct meaning in the everyday language of learners, and most learners do not find the relevance of scientific facts to their daily lives (Gallagher, 2021). To be competent in science, learners must be able to "talk the teachers' talk" (Lemke, 1990) which does not necessarily translate to the application of the scientific knowledge to real life. What this means is that memorising the scientific jargon without understanding its application to real-life does not lead to the desired outcome, which is the development of usable scientific knowledge. What is worrisome is that the challenges confronting science learning are more pronounced among learners who are from cultures whose worldviews are not Western (Aikenhead & Michelle, 2011). Learners from non-western cultures have different life experiences and cultural beliefs from those of their Western counterparts and they struggle to reconcile their preconceived ideas and cultural beliefs with the Western Science presented in school. Ogawa (1995) observed that the way people perceive and explain phenomena differs due to their beliefs and experiences.

Abah et al. (2015) stressed that inclusivity of IK in science can be used as learners' prior knowledge which can serve as a starting point to learning science or as a reference point for thinking about nature and science as well as the contexts for applying scientific skills. When prior knowledge is recognised it forms room for learners to navigate through various knowledge systems which ultimately gives them a broader understanding of science as human activity and makes them scientific critical thinkers and problem solvers. Furthermore, Abah et al. (2015) stated that proper unification of learners' prior knowledge (which could be in the form of IK) and modern science into science teaching activities will greatly support African science teachers and learners to make broad use of hands-on activities, investigative laboratory activities, inquiry-oriented discussion, co-operative learning and performance assessments as pedagogical tools. Within each of these knowledge systems is a body of complementary knowledge and skills which if appropriately applied and leveraged, can serve and strengthen the quality of educational experiences for indigenous learners.

Under properly integrated IK systems, an indigenous science teacher will become capable of developing learners' understanding beyond the simple memorisation of facts since critical concepts will be presented in local meanings. In this way, learners could acquire analytical skills that can be applied to other problems and situations, rather than merely accepting teachers' explanations. Abah et al. (2015) also noted that the artefacts that are available in learners' traditions are important tools that can be used to bridge the gap between what is usually taught in the classroom and what exists outside in society.

Jegede (1999, p. 129), the founder of the collateral learning theory and an advocate for IK, noticed a few aspects experienced by non-western learners when learning science. A summary of key findings on how indigenous learners learn science shows that:

- Socio-cultural background has a greater effect on learning than subject content.
- The indigenous worldview inhibits the initial adoption of Western Science by learners.
- Indigenous (non-Western) learners are involuntarily selective when making observations in science classrooms.
- The indigenous learners might explain natural phenomena in ways that appear as non-rational in the perception of Western Science, but the learners experience no contradictions in their conceptual systems.

- Knowledge learned about school science and through traditional ways is compartmentalized by the learners, giving rise to what Wiredu (1980, p. 23) has termed ‘a kind of ethnic schizophrenia’.

This being the case, Jegede (1999) identified two important implications from his findings. Firstly, any science curriculum that does not take particular account of the learners’ indigenous worldview risks destroying the framework through which the learners are likely to interpret concepts. Secondly, he claimed that “an indigenous learner can perform excellently in a Western Science classroom without assimilating the associated values” (Jegede 1999, p. 129). Jegede (1999, p. 129) wrote: ‘‘A good scientist at school can at home be a traditionalist without any feeling of cognitive perturbation or dissonance’.’ Emphasising his theory of collateral learning, Jegede (1999) posited that duality of thought is created in the memory and schemata of indigenous learners when they learn Western Science, because of the resilience of the IK framework. It is the same way that learners use to cope in a learning environment that is hostile to what indigenous learners bring to the science classroom. He argued that this situation results in collateral learning.

Jegede (1999) identified four types of collateral learning: *parallel, simultaneous, dependent and secured.* Importantly, he cautioned that these types of collateral learning should not be viewed as disparate but rather as occupying a continuum and that a learner could be helped to progress through them for meaningful learning to occur (Jegede, 1999).

Again, this study wanted to tap into Jegede’s (1999) theory and promote the idea of a parallel collateral way of learning between IK and western knowledge (convergence towards commonality). The study also took from Vygotsky’s (1978) views that knowledge is socially constructed and cannot exclude cultural knowledge since the content of education has value underpinning it and is associated with a particular culture. Thus, there cannot be any sustainable use of any resources if the interests of the local traditional communities are not taken into consideration. In my view, modern science must, therefore, accommodate the IK systems and vice versa as alluded to by Abah and Denuga (2015). This vantage point is also supported by Mavuru and Ramnarain (2017), that from a social constructivist view of learning knowledge is socially constructed and context-dependent and that human mental processes are situated within their historical, cultural and institutional settings. The same point is echoed by de Beer (2010) who contended that science teaching and learning cannot only be informed by the discipline but also by the lives of the learners in their communities, and that community, culture and school cannot be treated as separate entities. Views such as the one expressed by de Beer (2010) illustrate the psychological effect that IK may have on humans and the need to teach it concurrently with modern science despite their differences.

Gwekwerere (2016) proposed that developing countries should contextualise scientific knowledge within their local contexts in order to make science meaningful to learners. Contextualism is Deweyan or idea-based social constructivism, which accepts the fact that understandings emerge at the boundary of the person and the environment; that they are situated in context and that they might change as the context changes over time (Horsthemke & Schaffer, 2007). When applied to science learning, contextualism entails using examples and applications of scientific principles to situations that are familiar to learners' lived experiences and worldviews. When taught this way, the principles of science are more easily applicable and meaningful to the learners (Gwekwerere, 2016). This way of thinking about science teaching is based on the understanding that the current scientific knowledge is socially constructed within the Western culture (Lemke, 2001), hence, these scholars saw a need to create opportunities for African teachers and learners to construct science knowledge that is meaningful within their own cultural context and experiences. In the same vein, Baquete et al. (2016) and Ogunniyi and Ogawa (2008) suggest that the integration of IK into curricula could be beneficial in many ways. One way is that it serves as a bridge in classroom discourses to reduce the foreignness of school science concepts and content. Concurring, Govender (2014) suggested that integrating IK into science classrooms can lead to learners becoming motivated to learn science. Furthermore, it increases learners' participation in classrooms (Naidoo, 2010; Sedlacek & Sedova, 2017).

Drawing on Vygotsky's (1978) seminal work, Mavuru and Ramnarain (2020) emphasised the importance of learners' socio-cultural backgrounds (teaching a whole child). It is recognised, however, that teachers themselves should be able to cross cultural borders to be able to integrate IK into their teaching. These scholars elaborated that learners' experiences from home are made up of socio-cultural practices and their everyday experiences which tend to influence what is learned at school and vice versa (see Figure 2.3). Similar to the idea portrayed in Figure 2.3, Ogunniyi (1988) affirmed that the integration of IK into the science classroom is a merge of these two worldviews that appear to be in conflict. In Ogunniyi's (2007a) CAT, he asserted that one or two worldviews readily rely on each other to create an optimum cognitive state. The CAT takes cognisance of the fact that learners have different worldviews concerning scientific phenomena. Hence, CAT incorporates non-rational and cultural knowledge within its framework (see more about CAT in section 3.3 under research methodology). The figure below (see Figure 2.3) shows the socio-cultural backgrounds of the learners.

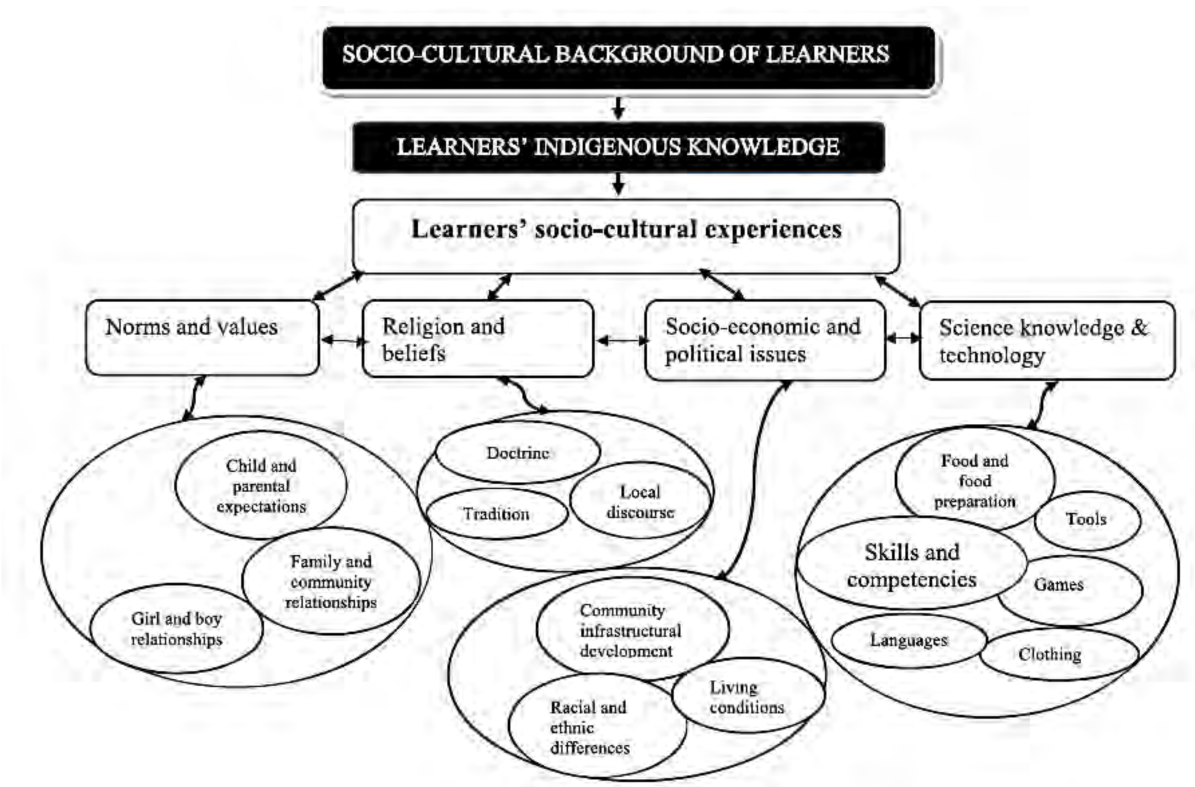

Figure 2.3: Interrogating learners' socio-cultural backgrounds (adopted and adapted from Mavuru & Ramnarain, 2020, p. 1072)

Undoubtedly, there is no way one can learn anything new without referring to the four main spheres (norms and values, religion and beliefs, socio-economic and political issues, science knowledge and technology) of their lives shown in the diagram. Based on wing four of Figure 2.3 above; *science knowledge and technology* as part of learners' IK shows how these two worldviews may be used parallel. The science knowledge and technology in the charter above encompass cultural science knowledge (the making of *oshikundu* and *uumboloto* in this case), which borrows some aspects from Western Science knowledge that is used in some communities (the yeast used to make home bread in this case). Another vital aspect in Figure 2.3 is *Language* as part of the learners' IK – the fusion of the *Oshiwambo* language in science instruction. English is one of the obstructions to science learning, particularly for the marginalised learners (Henderson & Wellington, 1998). In that regard, the use of indigenous languages can support learners (Meyer & Crawford, 2011) since language communicates the traditions, customs, morals and values of a people (Lemke, 1998). The above authors advocated for teaching and assessment which provides equal opportunities for diverse learners, by considering learners' socio-cultural experiences, languages and the local discourse that allows learners to maintain their identities. A closer idea is shared by Taylor and Cameron's (2016, p. 36) approach to IK, which is categorised as an *incorporationist approach* (inclusive) that brings selected IK into science by seeking how "best IK fits into science"; a *separatist approach* (exclusive) that holds IK "side-by-side" with scientific knowledge; and an *integrationist approach* (intersecting) that makes "connections" between IK and science (see Figure 2.4).

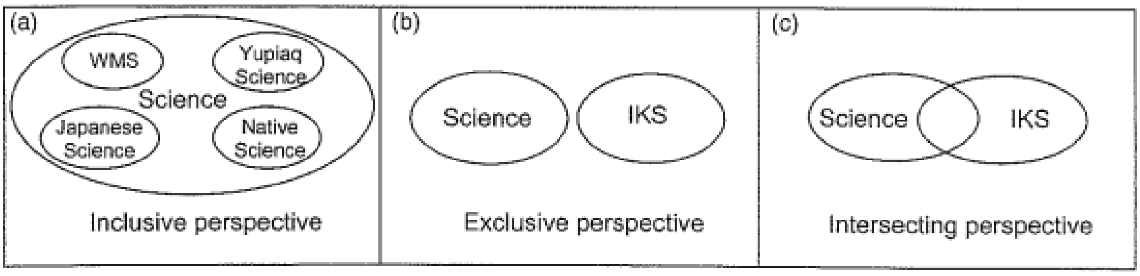

Figure 2.4: Three perspectives of the relationship between science and IKS (adopted from Taylor & Cameron, 2016, p. 36)

For Taylor and Cameron (2016), the inclusive perspective (Figure 2.4) (a) holds that if science is defined as the knowledge and understanding of nature there can be no single way to do or think about it. The exclusive perspective (Figure 2.4) (b) regards science and IKS as different knowledge domains, with IKS "better off as a different kind of knowledge that can be valued for its own merits" (Cobern & Loving, 2001, p. 50). The intersecting perspective (Figure 2.4) (c) sees science and IK as intersecting domains. Taylor and Cameron argued that all three perspectives (in Figure 2.4) acknowledge IKS as valid and useful ways of knowing, although they see their relationships with science differently.

I opted to frame this study in the intersecting perspective as it does not advocate that we replace school science with IK in the curriculum. Instead, it advocates for the use of the intersection between IK and school science. Correspondingly, Mukwambo et al. (2014) asserted the existence of a dialectical relationship between IK and school science. They highlighted that IK is embedded in school science. Therefore, the integration of IK and Westernised Science Knowledge (WSK) would empower citizens and foster social justice in a variety of cultural contexts (Mhakure & Otulaja, 2017). In addition, these perspectives allow for learners' total emancipation to clearly see the value of IKS in relation to, as well as the difference between, these knowledge systems (Taylor & Cameron, 2016). All these suggest that it is vital that science taught in schools takes into consideration what the learners already know from their homes or community.

Recent and of interest to this study, are studies done by Rhodes University's Science Education Department which have also acknowledged the integration of IK into school curricula and science contextualisation both in Namibia and South Africa (Kuhlane, 2011; Nanghonga, 2012; Nikodemus, 2017; Shinana, 2019; Ndevahoma, 2018; Kudumo, 2020; Kakambi, 2020) and others. The outcomes of these studies reflect that learners were able to make links between their experiences which subsequently increased their level of motivation, participation and engagement in general. Learners asked more questions and eventually understood the concepts better. These studies claim that, other than various advantages accorded to the integration of IK in science, IK is a local resource and is easily available at little to no cost (Asheela, 2017; Liveve, 2017; Shinana, 2019) and it may be used instead of laboratory chemicals and equipment that are often unavailable and expensive for most schools, especially rural schools such as my school.

Moreover, valuing IK in schools might lead to an increase in parental and community members' involvement in school matters (Hashondili, 2020; Klein, 2011; Kudumo, 2020; Lavallee, 2009; Mateus & Ngcoza, 2019). In this regard, a study conducted by Klein (2011) in Namibia discovered that when parents frequently interact with teachers, the parent-teacher relationship is likely to be strengthened. Klein (2011) further observed an improvement in learners' discipline when parents regularly visit the school to support teachers. Given these benefits, one may obviously agree that the integration of IK into science is vital.

It is not in doubt that learners come to school with preconceptions about how the world works either based on their daily experiences or what they learn from those around them. Meaningful learning only happens if learners can make connections between the new information and their prior knowledge (Hailikari et al., 2008). For African learners, the preconceived ideas they bring comprise their everyday experiences as well as some strongly held beliefs or worldviews that have been passed on from generation to generation. When doing science they make sense of the new knowledge by relating it to what they already know, and if what they know does not correspond to the explanations given in school, they may find it difficult to translate the new content into meaningful knowledge. Hence, a need to contextualise the science curriculum. However, there are always challenges incurred with IK integration into science.

2.4.1 Challenges of integration of learners' IK into science

Although some learners show interest when what is taught in the classroom is associated with their socio-cultural setting, some opposing views were revealed by a research conducted by Waldrip and Taylor (1999) which showed that several learners were not impressed with the idea of traditional worldviews. They claimed that it is only good for their parents and that they did not want to be allied with IK. Kakambi (2020) agreed that it appears as if modernisation has outshined many indigenous ways of life and as a result, the youth have no time to learn about their culture. Agreeing with Waldrip and Taylor (1999), Horsthemke and Schaffer (2007) rejected the idea of ownership of knowledge along with indigenous and ethnic divisions. Furthermore, they argued that the term IK has been used uncritically by politicians to further their agendas.

Other challenges of integrating IK in science emanate from the use of African languages. It seems many science concepts and terminologies are yet to be developed in African languages. Mavuru and Ramnarain (2017) affirmed in their studies that learners' home language has the potential to facilitate their understanding of science concepts. However, they admit that teaching a science concept in a home language (other than English) is a challenge because teachers have a limited vocabulary in indigenous languages for scientific concepts. This is true with Oshiwambo language, in Oshiwambo the science terms, power, energy and force all share the same meaning (*eenghono*), this is also true with mass and weight they are referred to as (*ondjudo)*, which is not necessarily the case. Similarly, Klein (2011) cautioned that "IK should not be presented as the answer to all problems and shortcomings in Africa" (p. 82). In fact, romanticising IK (Afonso-Nhelevilo, 2013; Keane et al., 2016; Le Grange, 2007; Ogunniyi, 2007a) might lead to another form of discriminatory system which could spoil the pace of development and sustainability. These scholars underscore that not everything labelled IK is valuable and suitable for use in science lessons. Hodson (1990) acknowledged the benefits and value of IK while maintaining at the same time that IK works well in the contexts in which it was developed. Thus, it should not be valued on its own merits and cannot be accorded the status of science. This is why some scientists have refused to acknowledge IK as 'science' (Snively & Corsiglia, 2001). Some proponents of IK such as Ogunniyi (2007a), Mukwambo et al. (2014) and Mhakure and Otulaja (2017) have also cautioned against exaggerating IK. They suggest that any misconceptions that come with IK should be identified and corrected.

In a nutshell, the above discussions have revealed that it seems both learners' IK and modern science might collectively support the teaching and learning of science. While Modern science offers a broader appreciation of context beyond the local level, indigenous knowledge offers a depth of experience in a local, culture-specific context. This suggests that despite the challenges, indigenous knowledge and modern science are complementary or parallel rather than fundamentally incommensurable. This could be anchored on the fact that both indigenous knowledge and modern science rely on direct observation, experience, experimentation, and interpretation. Nevertheless, this study took notice of the benefits and critics around the integration of IK into science faced by both teachers and learners in closing the gap between IK and modern science. It hopes to teach the topic of carbon dioxide(CO_2) by starting by asking learners simple questions as a way of awakening sense-making of CO_2 in their daily practices. For instance, learners to mention sources of CO_2 in their communities. Through these learner-based experiences, they might be able to discuss, argue and make sense of CO_2. In so doing, learning with understanding might take place. In consequence, learners may make new meanings that they can claim as their own. This suggests that learners may see the science taught in schools as meaningful to them and they may value their indigenous knowledge even more.

2.4.2 *Oshikundu* and *uumboloto* as easily accessible resources to mediate science learning

Oshikundu is a non-alcoholic traditional beverage which is made from *ongudo*, *uushutu,* and *mahangu* flour. 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 essentially to prevent dehydration (Shinana, 2019). The procedure of making *oshikundu* involves the production of the first mixture by adding boiled water to the mixture of *mahangu* (called *uushutu*) which is then left to cool to room temperature (Shinana, 2019). *Oshikundu* is diluted while cool, because if it is diluted while warm, then the enzyme activities are activated faster by the favourable temperature of the dilute. As a result, fermentation will be faster, making *oshikundu* sour at a faster rate. Nelles et al, (2000) explained that when malting the sorghum, the enzyme amylase is activated to break down the starch in the grains into simple sugar. The sugar is then utilised by the lactic acid bacteria and produces lactic acid. This explains why fermentation is likely to take place when malted sorghum or malted *mahangu* flour is added to *oshikundu*, during the process of making *oshikundu*. Sugar is then utilised and produces alcohol (ethanol) (CH_3CH_2OH) and CO_2; thus, it should be noted that the practice of making *oshikundu* highlights the importance of the intersection of traditional practices and technology (Asheela, 2017; Hepute et al., 2017). Moreover, the indigenous process of making *oshikundu* afford learners opportunities to learn many other science concepts related to carbon dioxide. The same happens with the process of making *uumboloto*.

Uumboloto is a traditional bread made from a mixture of all-purpose bread flour or Bakpro white bread flour, sugar, salt, instant dry yeast, and lukewarm water. The process of making *uumboloto* is less the same as that of modern bread except that *Oshiwambo* people have been practising this technology for decades and now forms part of their indigenous practices. The first step in making *uumboloto* involves mixing flour, yeast, sugar, and salt, and then thoroughly stirring for about four to five minutes before adding lukewarm water. After mixing the ingredients, the dough is left to rise for about 20 to 30 minutes. This is the time CO_2 is produced due to yeast and sugar. Thereafter, the baking process can then be done. The whole process of baking homemade bread takes about eight to 15 minutes. *Uumboloto* is commonly sold in public places in *Ovamboland*. They are rich in carbohydrates and commonly used as a staple food on many occasions. At this point, I should state that I did not find any research on *Oshiwambo* homemade bread. Yet, many scientific concepts are associated with this process. For instance, gas, reactants, CO_2, catalyst, temperature, and expansion just to mention a few. These indigenous technologies will offer my learners opportunities to do hands-on practical activities.

2.5 Hands-on practical activities and visualization

Hands-on practical activities are learning experiences which are designed to, through action, forge a link between the observations and the theories/ideas of science (Asheela, 2017). Wiebe et al. (2001) stress that using indigenous technology as a cultural tool for mediating classroom science allows for the visualisation of scientific concepts, presenting learners an opportunity to make sense of new science concepts in new but familiar contexts. Cook (2006) referred to visualisation as a teaching and learning approach in which science instruction is combined with visual and verbal information.

The Namibian Physical Science curriculum recommends hands-on practical activities in each topic for learners to observe and develop their scientific skills (Physical science syllabus grade 8-9). Nhase (2019) argued that hands-on practical activities of observing and intervening are important for promoting understanding. Asheela et al. (2021) also echoed the same sentiment that hands-on practical activities help learners' conceptual understanding of science concepts, as they are encouraged to predict, explain, explore, observe, and explain (PEEOE) when carrying out practical activities. Suarez et al. (2018) supported that the purpose of quality hands-on practical activities is to help learners develop their understanding of scientific concepts and make sense of them. Suarez et al. (2018) claimed that practical presentations stimulate learners' curiosity to learn science. Shinana's (2019) study also revealed the usefulness of hands-on practical activities in the teaching of science, thus she recommended that teachers should be involved in authentic practical investigations by making use of local and low-cost resources such as *oshikundu* to mediate learning. She further emphasised that it should be recognised that hands-on practical activities are a form of visual presentations, which are vital in learning. Similarly, Hashondili (2020) observed that as a result of attending presentations by community members, her participants viewed indigenous knowledge as visualisations and they made sense of science concepts embedded in the IK she used in her intervention.

In addition, practicals should enable learners to autonomously steer the course of hands-on practical activities that require complex role changes for both teachers and learners. Hands-on practical activities should, therefore, redistributes the responsibility of learning to learners for them to become active participants in the construction of their own understanding of scientific phenomena (Zion & Slezak, 2005).

Adding, Zion and Slezak (2005) claim that an effective practical activity provides rich visual representations. Arcavi (2003) asserts that visual representations are tools of communication which are vital to our biological and socio-cultural existence. Correspondingly, Lioyd (2015) defines visualisation as “a language of image'' (p. 5). The images are shapes, colours, forms, lines, patterns, objects, people, and numbers (ibid.). To Rundgren and Bao-Jun (2014), visualisation in science education is a cognitive domain that has the role of making invisible ideas visible and more importantly illustrating abstract concepts and making them explicit.

In the context of this study, the practical presentations by community members were viewed as visual representations and were meant to mediate learning on the topic of carbon dioxide (CO_2) in a grade 8 class. This coheres with Mavhunga and Rollnick's (2013) assertion that representations play a significant role as they serve as teaching aids which could assist learners to make sense of what is being taught. This suggests that visual representations play an important role in how learners make sense of science concepts which is the motive of this study. Hence, this study offered learners an opportunity to visualize and observe presentations by community members to enhance learning.

2.6 Role of language in learning science

Vygotsky (1978) averred that language is the most vital tool with which knowledge can be constructed. Agreeing, Oyoo (2017) claimed that effective teaching and learning requires language, whether it is written in books or shared orally during classroom discussions. The role of language is noted in the Namibian context, with English as the medium of instruction despite it being a second language. However, Wellington and Osborne (2001) warned that poor English proficiency among Namibian learners has a huge impact on their education and may lead to poor academic achievement. The nature of scientific language is another burden for most Namibian learners in understanding science. Msimanga and Lelliott (2014) claimed that some learners may not be confident in using English, hence, they should be allowed to use their home language to engage with difficult concepts. This intervention used the *Oshiwambo* language which is more convenient for all participants, which was then translated into English. In agreement, Ekele and Milcah (2016) and Mavuru and Ramnarain (2019) echoed that the incorporation of the home language helps to boost the indigenous learners’ self-esteem which ultimately increases their engagement in the classroom.

2.7 Concepts related to learning

The following concepts were used in this study, namely: conceptions, dispositions, motivation to learn and sense-making. I now discuss them below.

Perspectives

A perspective is a point of view or a specific attitude or manner through which a person thinks about something (Vázquez at el., 2015). Learners' perspectives in this study gave an idea as to where the rural school learners stand as far as learning science is concerned; that is finding out their attitude toward learning science.

Conceptions

Jong et al. (2015, p. 22) defined conceptions as "a general notion or mental structure encompassing beliefs, meanings, concepts, propositions, rules mental images, and preferences". Conceptions concern learners' abstract ideas or mental symbols towards a specific subject (carbon dioxide in this case). This study was keen to explore the grade 8 learners' conceptions of learning and sense-making of the concept of CO_2. It seems as if learners thought of CO_2 as being foreign and complex to learn and understand. Learners' conceptions influence their dispositions.

Dispositions

Jong et al. (2015) referred to dispositions as a tendency to act in a specified way, to take on a particular position. In other words, dispositions are qualities of characters, habits, preparations, states of readiness, or tendencies to act in a specified way that may be learnt. The interests of this study are centred on the desire to understand how learners position themselves and their learning experiences with respect to the concept of CO_2 that is, evaluating learners' attitudes towards science. It included observing the way learners felt about the science practical activities, how they took part or participated, and whether they like/dislike, enjoy or not, working on science before and after the indigenous technology interventions with the community expert members. I used Atallah et al, (2010) criteria to understand learners' conceptions and dispositions towards science. It should be acknowledged, however, that conceptions and dispositions are related to motivation.

Motivation

Motivation is one of the most critical factors affecting science learning (Hambaze, 2020). Bolte et al, (2013) defined motivation as the internal state that arouses, directs and sustains learners' behaviour. whilst Brophy (1983, p. 200) described it as the "enduring dispositions of learners to find learning process relevant and worthwhile for them to take pride in the outcomes of experience involving knowledge acquisition or skills development". These scholars believed that motivated learners achieve academically by engaging in class participation, asking questions, seeking advice, studying, and participating in study groups. Through experiencing motivation, a person develops an interest or an enduring desire to interact with those activities that enhance learning.

It is obvious that when learners are given a lecture on a subject, they are overloaded with facts. However, at the end of the lesson, most of the learners learn very few things or may be nothing. The important thing is to find the way by which learners learn more effectively and retain the knowledge. Learning is fun and exciting, at least when the curriculum is well matched to students' interests and abilities. Learners are motivated when they have the background and the desire for what is to be learned. Therefore, learners are intrinsically motivated when they engage in activities that they can relate to (Cetin-Dindar & Geban 2017).

In a study conducted by Certin- Dindar and Beban (2017), they recommended that to deal with learners' difficulties science teaching and learning should be to engage the minds of learners and motivates them to learn through real-life events. Their study revealed that motivated learners enjoy learning science, believe in their ability, and take responsibility for their learning (Certin- Dindar and Beban, 2017). Sharing the same sentiments are Schunk and Pajares (2001) who claimed that learners are more persistent in the process of conceptual learning when they are more intrinsically motivated. Furthermore, Jerome Bruner, a cognitive psychologist, stated that the natural world was interesting for children; hence, they were willing to learn about everyday phenomena and children expressed intrinsic motivation when they were engaged in the learning process by doing and discovering, which enhance meaningful learning (Certin-Dindar & Geban, 2017).

Cetin-Dindar and Geban (2017) argue conceptual understanding could be ensured not only by using appropriate teaching strategies but also by taking learners' attitudes, motivation, or self-efficacy into account. Similarly, for learners to be involved in the learning process, they should be motivated to learn by arousing their curiosity. Involvement and participation in the learning process give learners motivation to learn, enjoyment, and satisfaction. Constructivist teaching strategies engage learners in the learning process, allow them to actively participate, and increase their motivation.

Sense-Making

Sense involves turning a circumstance into a situation that is comprehended explicitly in words and that serves as a springboard into action (Nikodemus, 2017). Weick, et al. (2005) defined sense-making as the moment when learners can relate new concepts to their prior everyday knowledge. It deals with whether learners are able to relate a new situation to what they know or experience from their society or environment. Weick et al. (2005) argued that sense-making involves turning circumstances into a situation that is comprehended explicitly in words and that serves as a springboard into action. This study will make room for learners to make sense of the concept of CO_2 by testing for the presence of CO_2 from *oshikundu* and *uumboloto*. I will observe the learners' sense-making of CO_2 by finding their "aha" moments, their moments of sudden discovery and insight. Carpenter (2019) defined the "aha" moment as a sudden, conscious change in a person's representation of a stimulus, situation, event, or problem.

2.7 Chapter Summary

In this chapter, I synthesised and discussed literature on IK's role in education. I started by looking at the expectations of the Namibian science curriculum. Second, I discussed CO_2. Third, literature on indigenous knowledge and learners' prior everyday knowledge were synthesised. In the fourth part, a review of literature on why there is a need for integration of IK in the science curriculum is done. *Oshikundu* and homemade bread as easily accessible resources were discussed in the firth part followed by a review of hands-on practical activities and visualisation literature. The second last part of this chapter looked at the role of language in learning science. Last, I presented the concepts related to learning that informed this study.

CHAPTER THREE: THEORETICAL & ANALYTICAL FRAMEWORKS

3.1 Introduction

Merriam and Tisdell (2015) described a theoretical framework as the structure, the scaffolding and the frame of a study. In this chapter, I thus discuss the theoretical and the analytical frameworks from which views expressed in this study are entrenched. I used Vygotsky's (1978) socio-cultural theory as a theoretical framework and complemented it with Ogunniyi's (2007a) Contiguity Argumentative Theory (CAT) as an analytical framework. I now discuss these theories below.

3.2 Theoretical Framework: Vygotsky's Socio-cultural Theory

Vygotsky's (1978) theory stresses the fundamental role of social interactions in the development of cognition. Vygotsky strongly believed that community plays a central role in the process of making meaning. He claimed that there are connecting links between socio-cultural processes taking place in society and mental processes taking place in the individual (Gindis, 1999). His socio-cultural learning theory is based on the claim that learners are regarded as apprentices in a culturally defined and socially organised world. Intrinsic to this notion of apprenticeship is the recognition that asymmetric relationships are beneficial to the child's development. That is, adult interaction scaffolds or assists the emerging competencies of learners. Learning, therefore, becomes a form of assisted performance (Robbins, 2007).

For Vygotsky, individual development cannot be understood without reference to the social and cultural context within which it is embedded. He claimed that higher mental processes in the individual have their origin in social processes, emphasising that any higher mental function necessarily goes through an external stage in its development because it is initially a social function (Doolittle, 1995). Learning awakens a variety of internal developmental processes that can operate only when the child is interacting with people in their environment and cooperation with their peers or more knowledgeable others (MKOs). To Vygotsky, learning is not development; however, properly organised learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning.

In this regard, Vygotsky argued that learning is a necessary and universal aspect of the process of developing culturally organised, specifically human psychological functions (Lantolf, 2000). In other words, social learning tends to precede development. Individual development cannot be understood without reference to the social and cultural contexts within which it is embedded. Higher mental processes in the individual have their origin in social processes. Within this theory, I looked at the following concepts: mediation of learning, social interactions and the Zone of Proximal Development (ZPD).

3.2.1 Mediation of learning

Generally, for people to interact, first they should have, use or understand each other (share a common language), then through interactions they can use whatever is at their disposal as tools to mediate whatsoever they wish to achieve. Ramasike (2017) defined mediation of learning as a technique or skill incorporated to answer how knowledge is acquired in the learning process, and it is a learner-centred skill that supports knowledge formulation. The central fact about learning from the socio-cultural theory is the fact that learning is attained through mediation.

Vygotsky (1978) posited that mediation of learning introduces the use of tools to attain goals and make learning worthwhile. According to Vygotsky (1978), adults are an important source of cognitive development. Adults transmit their culture's mediational tools of intellectual adaptation that children internalise. Through the mediation of learning, through language as a tool a teacher can clarify some challenging concepts the learner should learn. Vygotsky (1962) described language as both cultural and a psychological tools.

Vygotsky (1962) referred to tools of intellectual adaptation as tools that allow children to use the basic mental functions more effectively or adaptively which are culturally determined. Vygotsky, therefore, sees cognitive functions, even those carried out alone, as affected by the beliefs, values and tools of intellectual adaptation of the culture in which a person develops and they are therefore socio-culturally determined. The tools of intellectual adaptation, therefore, vary from culture to culture. Adding to Vygotsky's view, Lemke (2001) argued that the mental processing of ideas through learning is mediated by cultural tools between people with different knowledge and experience to make sense of learning. Lemke's (2001) argument strongly supports the basis of my study where learners' everyday knowledge of the making of *oshikundu* and *uumboloto* were used to carry out hands-on practical activities (Asheela et al., 2021) in Grade 8 as cultural tools to mediate learning and sense-making of the topic of carbon dioxide (CO_2). The two cultural practices were part of the tools used to see whether there would be a shift in the learners' conceptions, dispositions and motivation to do science.

Supporting this are Mutanho (2016) and Kuhlane (2011) who encouraged the incorporation of various mediational tools in the teaching and learning of science. Kuhlane (2011) believed that the use of learners' everyday knowledge enables social interactions to take place among learners as well as between them and the MKOs through their immediate language as a tool of socialisation (Stott, 2016). In this study a similar idea to that of Nuntsu's (2020) study conducted in South Africa was employed, whereby two community expert members who were more knowledgeable in making *oshikundu* and *uumboloto*, respectively, were invited. This is as proposed by Vygotsky (1978) that in the learning process, experts use cultural tools to mediate learning. These two cultural heritages were used as tools to enhance understanding and mediate learning of CO_2 and its related concepts.

Equally, the Oshiwambo language was used as a cultural tool by the community expert members to interact or demonstrate the making of *oshikundu* and *uumboloto* to the less knowledgeable others (learners, my critical friend and me). Learners were afforded opportunities to interact with the community experts and share with other learners what was transpiring throughout the two experimental activities. In my view, these interventions might have enabled maximum interaction between the participants which could heighten active participation (Sedlacek & Sedova, 2017) and meaningful learning to take place. Through mediation, learners might ultimately attain their Zones of Proximal Development.

3.2.2 Social interactions

It should be acknowledged that we all have mother languages that are spoken in our clans. It is, therefore, through those languages that we start to interact with our fellow men and women. This is as espoused by Vygotsky (1978), who vowed that the world is a social space where individuals interact with each other and negotiate the meaning of their world, hence, social interaction is the process of engaging and interacting with one another. A disciple of Vygotsky, Tam (2015, p. 35) claimed that "the more we participate in collaborative activities, the more we learn from others which in turn maximize our productivity and potentials to the fullest".

For Vygotsky, much important learning by the child occurs through social interaction with skilful tutors or MKOs. The MKO refers to someone who has a better understanding or a higher ability level than the learner concerning a particular task, process or concept (Vygotsky, 1978). So, MKOs may model behaviours and/or provide verbal instructions for the child. Vygotsky referred to this as cooperative or collaborative dialogue. It is acknowledged, however, that learners themselves have the potential to take the role of MKOs as emphasised by Stott (2016).

Children seek to understand the actions or instructions provided by the MKOs and internalise the information, using it to guide or regulate their performance. To Vygotsky (1978), learning is not just an individual matter, instead, it develops within a social environment. That is, learning takes place in a social setting when people interact with each other. Social interaction can be related to learner-centred teaching that is intended to empower learners with practical experience, meta-cognition and self-evaluation through small group interaction (Nyambe, 2008; Nyambe & Wilmot, 2012). Another follower of Vygotsky, Stein (1988) argued that learning is situated, as it normally involves knowledge. Wenger (1998) described the two components of situated learning as social interaction and collaboration where learners become involved in a community of practice (CoP). Wenger (1998) defined a CoP as a group of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly.

In a CoP, people are social beings, and knowing is about participation in a social world. Wenger (1998) asserted that human beings define themselves through active engagement and by how they are viewed by others within the CoP.

The social experience becomes a cornerstone of understanding and interpreting the world. In this regard, Jaramillo (1996) explained that to learn a concept, the learner must experience it and negotiate its meaning in the authentic context of a complex learning environment. It is for those reasons that I opted to use the IK of making *oshikundu* and *uumboloto* in this intervention to create a platform through which learners could interact with the community expert members (MKOs) to impact learners with knowledge about the topic of CO_2. The interaction of learners with indigenous people (community expert members) creates a dais where learners put to test some IK or practices by having critical discussions about them and finding the science embedded in that traditional knowledge or practices. The participation of the community members in this study was purposely done to connect the school to the community and vice-versa, something that would help to improve the participants' understanding of the concept of CO_2. The use of the Oshiwambo language as a vernacular of the MKOs and the learners allowed for smooth mediation.

3.2.3 Zone of Proximal Development (ZPD)

According to Vygotsky (1978), the ZPD is the distance between the actual development levels that are determined through independent problem solving – all this happens under the guidance of the teacher as well as through collaboration with more capable people (teachers, parents, and learners) or more knowledgeable others (MKO). Vygotsky pointed out that a child attains a ZPD through guidance and interaction with others in a classroom. However, Stott (2016) argued that there is an assumption that only learners benefit from attaining the ZPD which is not the case, rather, all participants benefit including the teacher. Vygotsky (1978) further claimed that there are two levels of knowledge development, the level of actual development and the level of potential development. The level of actual development is the level that the learners have already reached when they are capable of solving problems themselves while potential development is where the problem solving is under the guidance or in collaboration with MKOs. Vygotsky (1978) highlighted that through the guidance of MKO, learners may progress to a higher level of understanding and argued that effective learning occurs in the ZPD.

Vygotsky's ZPD concept is considered important in understanding the relationship between socio-cultural and mental processes (Vallerand, 2000). Any function in the child's cultural development appears twice, or on two planes. First, it appears on the social plane, then in the psychological plane, that is, within a child as an intra-psychological category. This is equally true for voluntary attention, logical memory, the formation of concepts and the development of volition (Vallerand, 2000).

The ZPD is seen as the area where the most sensitive instruction or guidance should be given, allowing the child to develop skills they will then use on their own – developing higher mental functions. The ZPD defines those functions that have not yet matured but are in the process of maturation; functions that will mature tomorrow but are currently in an embryonic state. What lies in the ZPD at one stage is realised and moves to the level of actual development in the second. In other words, what the child can do in collaboration today they will be able to do independently tomorrow (Doolittle, 1995).

In this study, through the guidance of the MKOs, participants were taught how to make *oshikundu* and *uumboloto*, and then they collected air samples that they tested for the presence of CO_2. These presentations may not just move learners into their ZPD by learning and making sense of CO_2, but it was also advantageous to them because they learnt how to make *oshikundu* and *uumboloto* which are staple foods that are nutritious for their everyday life. Herein lies education for sustainable development which motivates learners to do science from different worldviews, since there are extrinsic rewards. Thus, the possibilities are that learners might relate their IK to WS and draw their conclusions. Apart from learning how to make *oshikundu* and *uumboloto*, there was the benefit of understanding the topic of CO_2 better, which might improve the learners' understanding of the concept of CO_2 and other related concepts.

3.3 Analytical Framework: Ogunniyi's Contiguity Argumentative Theory (CAT)

Ogunniyi (2007a) stressed that the CAT is used when two different cultures co-exist and can only be possible through cognitive shifts to accommodate each other. He maintained that argumentation has been used as rhetorical and instructional tools in many different societies. According to Ogunniyi (2007a) and Hewson and Ogunniyi (2008), CAT is divided into five categories into which conceptions within a learner's mind can move. These five cognitive states of conception are in a dynamic state of flux within a person's mind, a sort of amalgamated cosmology (Ogunniyi, 2009). These categories might help me understand what my learners thought about the integration of IK into science lessons.

Ogunniyi and Hewson (2008) described these five conceptions as:

1. **Dominant** – A powerful idea that explains and predicts facts and events effectively and convincingly or resonates with an acceptable social norm that affords an individual a sense of identity. For example, a scientific explanation of lightning in terms of static electricity, as opposed to the explanation, proffered for the same phenomenon within an indigenous worldview.
2. **Suppressed** – An idea becomes curbed in the face of more valid, predictive, empirically testable evidence or established social norms. For example, the scientific explanation of the cause of a disease may be suppressed in the face of cultural beliefs about the possible diabolical motives of enemies behind the disease.
3. **Assimilated** – A less powerful idea might be adapted into a more powerful one. For example, the indigenous idea of not leaning against a metal pole, tree or wall which

may have arisen from experience can easily be adapted into the scientific concept of lightning as an electrical phenomenon.

4. **Emergent** – There may be situations where no prior idea exists and a new one has to be acquired or developed. For example, a considerable amount of scientific concepts such as atoms, molecules, magnetism, conservation of matter, laws of motion, etc. have usually been learnt from school science.
5. **Equipollent** – When two competing ideas have comparably equal intellectual force, the ideas tend to co-exist without necessarily resulting in a conflict. For example, the theory of religion versus science. It is the equipollent state that is at the heart of this study.

This study was subjected to a critical analytical review through the lens of the CAT. The CAT is the ideal theory for analysing a situation in which one deals with two different worldviews (IK and Western Science in this case). The CAT deals with the nature of interactions between distinctly different thought systems which is the case in this study. It construes such interactions in terms of the dynamic way in which similar, causal, spontaneous, successive, co-existing and sometimes conflicting schemata or perceptions combine, converge or collaborate to attain a higher form of consciousness (Augoustinos et al., 2014). Moyo and Kizito (2014) retained that argumentations are strongly promoted as a significant teaching approach in science because they provide evidence about knowledge claims, whether they are scientific or indigenous in nature.

Agreeing are Aydeniz and Ozdilek (2015), who argued that learning science through argumentations might assist learners in developing an improved understanding of the nature of science. Moreover, Ghebru and Ogunniyi (2017) indicated that argumentation and argumentation instruction help to promote a teacher's ability to generate classroom discussions. The CAT theory further explains a dialogical framework for resolving the incongruities that normally arise when two (and sometimes multiple) competing thought systems, for example, science, IKS, cultural beliefs, commonsensical or intuitive notions are placed side by side. Such curricula tend to create cognitive conflicts among learners (le Grange, 2007). However, when a conflict arises in the minds of the learners as a result of being exposed to school science the CAT suggests that a sort of internal arguments arise within the learners' minds (i.e. at the micro-neuro-psychical level) between competing schemata in the working memory, where consciousness in an individual is assumed to be most active (le Doux & Phelps, 2008).

It was the assumption of this study that the use of CAT would provide a working framework for resolving the incongruities that might arise in the social interactions where IK and Westernised Science (WS) need to co-exist (Ogunniyi, 2007a). The socio-cultural theory was employed to access how learning is influenced by social interactions that exist among the participants (Vygotsky, 1978). Furthermore, CAT helped me to observe the influence of IK in the teaching and learning of the topic of CO_2.

3.4 Chapter Summary

In this chapter, I discussed the theoretical and analytical frameworks informing this study. I gave an overview of concepts under the socio-cultural theory and the CAT that were used as lenses through which data collected in this study were analysed.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

The main goal of this study was to mobilise the indigenous technology of *oshikundu* and *uumboloto* to mediate learning and sense-making on the topic of CO_2 among Grade 8 Physical science learners in a rural school.

One of its intentions was to make science accessible and appropriate for learners' lived worlds and experiences (Gwekwerere, 2016). To achieve my goal, I needed to establish a methodology with an appropriate research design. In this chapter, I thus present the research methodology underpinning this study. I focus on the research paradigms and the research design employed in this study. Within the research design, I discuss a case research design, site, data collection methods, sampling and the data analysis and end the chapter with a chapter summary.

4.2 Research Paradigms

Kivunja and Kuyini (2017) referred to a research paradigm as the agreed set of beliefs or thinking about how to carry out research and interpret its meaning. Thus, a research paradigm is a worldview that directs the research process (Bertram & Christiansen, 2015). In this study, an interpretive paradigm was used, whose understanding is that reality is socially constructed. This paradigm was used to understand the experiences, behaviours, dispositions and views of the learners about learning the concept of CO_2 before and after the intervention of making *oshikundu* and *uumboloto*. However, the interpretive paradigm is criticised for only focusing on providing descriptions of contexts without seeking to change or improve them (Creswell & Creswell, 2017). For this reason, I complemented the interpretive paradigm with the indigenous research paradigm (Chilisa, 2012).

An indigenous research paradigm entails a process that involves a critique and resistance to Euro-Western methodological imperialism and hegemony. It also calls for the adaptation of conventional methodologies by including perspectives and methods that draw from indigenous knowledge, languages, metaphors, worldviews, experiences and philosophies of former colonised, historically oppressed and marginalised social groups. It is a process that is informed by modern critical theory, postcolonial theory, critical race theory and notions of decolonisation, resistance, struggle and emancipation (Chilisa, 2012). It challenges researchers to invoke indigenous knowledge to inform ways in which concepts and new theoretical frameworks for research studies are defined, where new tools of collecting data are developed and the literature base broadened, so that people depend not only on written texts but also on the largely unwritten texts of the formerly colonised and historically oppressed peoples.

Within the indigenous research paradigm, I focused on the Ubuntu[5] perspective. Hanks (2008) refers to Ubuntu as the glue that holds African communities together. Also, the need to combine the interpretive and ubuntu paradigms was partly influenced by Khupe and Keane (2017) who stressed that African researchers need to develop methods that align with participants' lived experiences and cultural values that recognise the place of local culture in shaping the identities of communities. This philosophy has become crucial in reviewing African education systems. For example, Mkabela (2015) portrayed that the Ubuntu paradigm suits the African research activities as it focuses on African IK and their behaviours. Similarly, Goduka (2005) argued that African research must be done in a respectful way that is rooted in the indigenous way of knowing.

In this regard, le Grange (2012) posits that the use of Ubuntu is not about wanting to live in the past but rather is a way of harnessing togetherness and living in harmony. Concurring, Seehawer (2018b) accentuated that there should be mutual respect between the researchers and participants. That suggests that researchers should respect the indigenous people and the communities where they are carrying out their research.

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[5] Ubuntu is a "philosophy that is a collective effort characterised by the spirit of togetherness which sees human needs, interests, and dignity as of fundamental importance and concern" (Higgs (2008, p. 453).

Higgs (2008, p. 453) claimed that Ubuntu is a "philosophy that is a collective effort characterised by the spirit of togetherness which sees human needs, interests, and dignity as of fundamental importance and concern". This means that Ubuntu is concerned with the welfare of the whole community as opposed to individual needs and interests. Ubuntu comes from the Zulu phrase "*Umuntu ngumuntu ngabantu"*, which means "I am because you are". The word means that a person is a person through other people. Ubuntu is that nebulous concept of common humanity and oneness: humanity, you and me both. Simply put, it is the spirit of togetherness (Seehawer, 2018b).

Seehawer (2018b) posited that in an Ubuntu paradigm, the knowledge is generated and validated through discussions with the concerned community. In other words, the views and opinions of members of the community are equally valued and considered important to the validation of different knowledge emerging from the communal discussion. The Ubuntu paradigm aligns well with the socio-cultural theory of Vygotsky (1978), which claims that people's actions are greatly influenced by the social, cultural and historical context of the activities that they share with the other people in their lives. Through social interaction, learners make meaning out of the activities they are exposed to. It is for these reasons that married the Ubuntu paradigm with the interpretive paradigm as it would recognise the integral importance of the participants' interactions. Within the interpretive and indigenous research paradigms, I employed a case study research design.

4.3 Case study research design

Merriam and Tisdell (2015) defined a case study as an intensive, holistic account and analysis of a single case, phenomenon or social unit. According to Bertram and Christiansen (2020), a case study allows deeper exploration and provides a full and thorough understanding of the particular lived experiences of participants. This study is a case study that examined a single case developed from the perspective of the influence of integrating indigenous practices into the science classroom. I hoped that a case study would help in giving me an in-depth understanding of rural school learners' perspectives on science. My case was a group of Grade 8 Physical Sciences learners from a rural-based school. My unit of analysis was based on individual learners' conceptions, dispositions, motivations and interactions during the practical demonstrations of making *oshikundu* and *uumboloto* as tools or vehicles through which the concept of CO_2 was to be learnt.

4.3.1 Research goal and research questions

The main goal of this study was to mobilise the indigenous technologies of making *oshikundu* and *uumboloto* as easily accessible resources to carry out hands-on practical activities to motivate Grade 8 Physical Science learners from a rural school to make sense of the concept of CO_2. To achieve this goal, the following research questions guided the study.

Research Questions:

1. What are Grade 8 Physical Science learners' perspectives and motivations for learning the topic of CO_2 before the intervention?
2. What do learners know from their homes and communities about CO_2?
3. In what ways do the Grade 8 Physical Science learners interact, participate and learn (or not) the concept of CO_2 during the practical demonstrations on the making of *oshikundu* and *uumboloto* by expert community members?
4. How do the presentations by the expert community members on the making of *oshikundu* and *uumboloto* shift (or not) Grade 8 Physical Science learners' perspectives and motivations to learn and make sense of the topic of CO_2?

4.3.2 The research site

This study was conducted at Aveshe secondary school (pseudonym name) in a rural setup in the Ohangwena region. The school has Grades 8 to 11 and is located approximately 8 km from the Namibian-Angolan border in northern Namibia. The Ohangwena region is about 10 706 km^2 and is located in the northern part of Namibia (see Figure 4.1 below).

Ohangwena is one of the seven northern regions that form the Owamboland district and neighbours regions such as Okavango, Omushati, Oshana and Oshikoto.

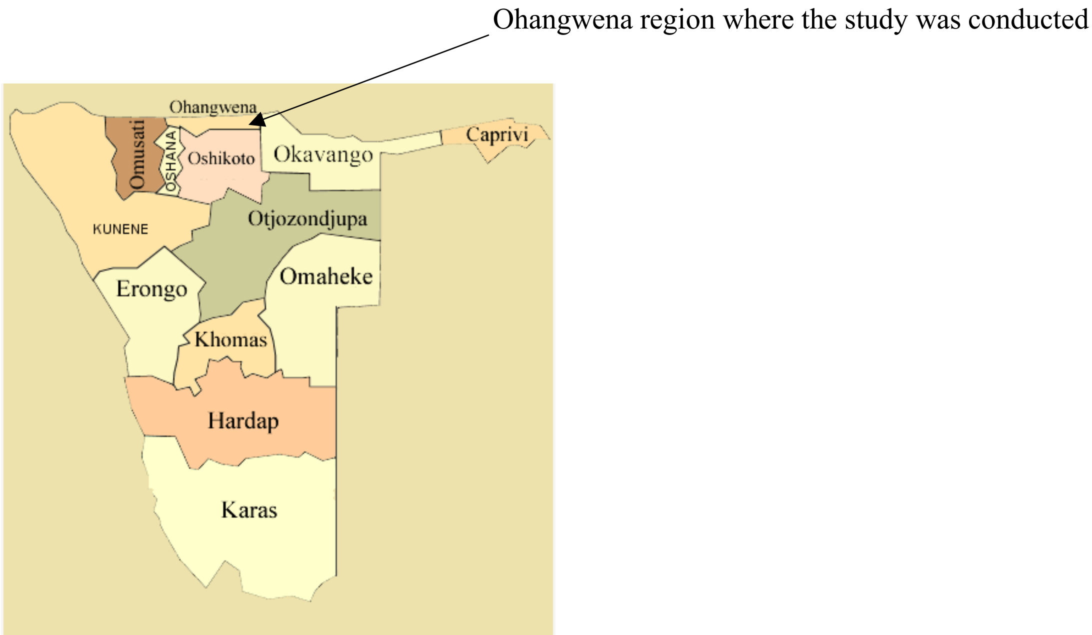

Figure 4.1: The Namibian map with different regions (adapted from the worldatlas.com)

The region had a population of about 245,446 people in 2011 (National Census, 2011). Many of its inhabitants are immigrants from Angola. The region is rich in natural resources such as underground water and it is renowned for its large flourishing forests for farming. Hence, there are several various farming activities in the region from flora to fauna. However, it seems much of the region's resources are yet to be fully discovered.

The region has a rich history of Namibia's fight for freedom since many Namibians who went into exile during the struggle for independence went to Angola via the Ohangwena region and many war battles took place in the same region. Also, the Ovakwanyama people's (the majority in the region) kingdom, which was led by King Mandume yaNdemufayo – one of the most honoured kings, was based in Iihole in Angola, so many residents of the Ohangwena region have their origins and families still living in Angola. Thus, they were only separated by the colonial regime that separated the Ovakwanyama clan into Angolans and Namibians.

Recently, the region has been challenged to accommodate many Angolan street vendors who left Angola due to the economic crises. This has badly affected many of its residents to the extent that many succumbed to COVID-19 as there was no proper control of these illegal immigrants – most of whom did not follow the COVID-19 protocols and were considered high risk as potential carriers of the virus.

About 98% of the learners at the school where this study took place speak Oshiwambo as their first language. The school is guided by the mandate of the MoEAC (2016) policy that makes it mandatory that English should be the language of instruction in all schools. Despite this being the case, many learners at this specific school are not fluent in English, hence they struggle to communicate in English or to use English as the medium of instruction.

During the time of this research, the school had an enrollment of 609 learners, 292 boys and 317 girls respectively, of which about 10% were Angolans and many of them commuted from Angola every day. It had 22 teaching staff members including the principal and two heads of department, one for natural sciences and another one for languages. History has it that the school is one of the oldest schools that were built in the early 1960s and as a result, most of the buildings are dilapidated.

In terms of facilities, the school has no science laboratories or a library. Also, there are very few science apparatus and reagents for carrying out hands-on practical activities demanded by the Physical Science syllabus for Grades 8–9 (MoEAC, 2010) during the time I carried out this study. The school had a soccer field and basketball court. The school was just upgraded include Grade 11 in the year 2020. Grade 11 is, therefore, the only grade that is assessed nationally as an exit point. The school's final examination results for Grade 11 in 2020 in Physics and Chemistry were below 40%. It is against this backdrop that I became interested in conducting a study at this school to mobilise the IT of making *oshikundu* and *uumboloto* as easily accessible resources to carry out hands-on practical activities to support Grade 8 Physical Science learners to learn and make sense of the topic of CO_2.

4.3.3 Sampling and participants

Bertram and Christiansen (2015) defined sampling as the type of specific choices that a researcher makes about which people or groups to include in the sample for a particular purpose.

Learners and teacher

A sample of 30 Grade 8 learners, 15 boys and 15 girls, and one teacher (a critical friend) took part in this study. Learners were divided into groups of six, making a total of five groups. Both the 30 Grade 8 learners and the critical friend were purposively sampled. The teacher was purposively selected because he was more experienced at teaching Physical science and Physics in Grades 8–11 and at the time of the study he was teaching at the school. I briefly explained to the teacher what this study intended to achieve and he was eager to be part of this research since he had been struggling with the improvisation of resources. He was curious to learn how IT could be used to mediate the learning and sense-making of science concepts. Both my critical friend and I were co-learners and I assumed that this research may afford us a chance to professionally develop ourselves and improve our teaching skills. Learners were also selected purposively to get information-rich cases for in-depth study. So, convenient and purposive sampling were used in this study (Bertram & Christiansen, 2015).

Two expert community members

In this study, I invited two expert community members (women) from the community around the school, one was an institutional worker at the school and she demonstrated how to make *oshikundu*. The other one was a community woman who was an expert in making *uumboloto*. Both expert community members were Oshiwambo speakers. Both the institutional worker at the sampled school and the community member, who usually sells homemade bread at the same school, were purposely invited so that they could share their cultural heritages and wisdom with learners. Similarly, this was also done to promote the culture of Ubuntu; the idea that knowledge is socially constructed through social interactions and that all members of society need each other and have something to contribute. Both presentations were translated into English. I should admit upfront that the translating of my mother tongue into English might have dissolved the value of IK, making it an artefact instead of a subject as claimed by Shizha (2007).

4.3.4 Data gathering methods

Data were gathered using focus group interviews, group activity, participatory observation, and journal reflections. I now discuss each of these below.

4.3.4.1 Focus group interview

A focus group interview is a technique involving the use of in-depth group interviews whereby participants are purposively selected (Dilshad & Latif, 2013). I chose this method to get an in-depth understanding of learners' perspectives and motivation to do science. I was, however, mindful of some limitations when focus group interviews are used. For instance, a few vocal participants may dominate other members during the interview and some participants may conform to the responses of others even if they do not agree. I addressed these by making sure that all learners involved in the focus interview took turns in giving answers.

From each group, one learner was chosen by the group members to represent them in the focus group interview that consisted of five participants. This was aimed at answering my research questions 1 and 2. A pilot interview was done first with four learners (two girls and two boys) before it was given to the focus group (participants) (see Appendix G: Learners' profiles; Appendix K: FGI questions and purposes; Appendix L: FGIs questions and answers).

Group activities

In their studies, Shetunyenga (2020), Mayana (2020), and Nuntsu (2020) used group activities as data gathering methods. Similar to them, I employed the group activities strategy so that my participants could ask for information from their homes and community on CO_2. I assumed that this method would provide me with rich data and allow learners to interact freely and engage in arguments to express themselves (Ogunniyi, 2007a). Sedlacek and Sedova (2017) maintained that a group activity has the potential to maximise active participation amongst the participants. To facilitate active participation, learners were divided into six groups (of five each). Each group was required to go and research the questions (see the group activity questions in Appendix N) and bring them to class for discussion in their respective groups.

Learners' responses were written on posters, which learners subsequently used to make some presentations to the entire class. Such presentations were intended to promote group discussions and argumentation amongst the learners (Nuntsu, 2020; Ogunniyi, 2007a) to answer my research question one.

Participatory observation

Observation entails the researcher going to the site of the study to witness what is taking place (Cohen et al., 2018). It gives a researcher an opportunity to grasp the whole scene and a chance to gain first-hand experience and data on a phenomenon (Bertram & Christiansen, 2015). Observation helped me to gain an insight into participants' feelings, sense-making of the concept (CO_2) and their dispositions (Cohen et al., 2018). In addition, it allowed me to dig deeper into understanding the learners' interactions and participation during presentations by the MKOs. My critical friend and I observed all the presentations and with the permission of the community members who were the presenters, all lessons were videotaped. Additionally, learners, my critical friend and I were requested to write some reflections. The observations were meant for my research questions 3 and 4 (see Appendix I).

Journal reflections

Ngulube (2015) explained that journals are a personal account of the learning experience. It is a way of allowing learners to express their feelings and views about the learning experience so that they can make suggestions. As a strategy to prepare learners for writing reflections, I asked all groups from the beginning to write journal reflections on their experiences of the activities they partook in – focusing on issues such as looking at scientific concepts (words web) that emerge from the presentations, interactions between participants and if there were any shifts or not in their perspectives and motivation to learn and make sense of the concept of CO_2 after the intervention. This was an attempt to answer my research questions 3 and 4 again. I made sure reflections were straight to the point and simplified through guided questions. I am, however, aware that giving learners guiding prompts may have limited their reflections, as it might only show what the researcher wanted to see. All journal reflections formed part of the presentation that was done on the last day of engagement in the study. This aimed at addressing research question four (see Appendix N).

4.3.5 The research process

This study consisted of 30 learners as participants. After briefing them about the purpose of the study and giving them all the protocols of this study, the 30 learners were divided into five groups of six learners per group. Groups were asked to name themselves after an animal and state why they chose such names – the reason was to warm them up so that they could express themselves freely before the main activity (presentations). Each group was given questions as a group activity a day before the lesson and they all presented the next day.

From the five groups, each selected one participant to represent their group in the focus group interview. In a sharing circle, focus group interviews were done in the very first lesson of the intervention. In the third lesson, a community expert member was called to the school to demonstrate to all participants how *oshikundu* is made. Learners collected gases from *oshikundu* and tested them for the presence of CO_2 the next morning. In the fourth lesson, another community expert was called in to demonstrate to learners how *uumboloto* is made. Again learners collected gas samples from the dough and tested for CO_2 that same day. Throughout the process, all participants were making journal reflections. All activities were also video recorded.

In the last lesson which was the seventh, I felt that I needed to find out how learners made sense of CO_2, something that did not come out clearly in the first six lessons. Thus, with the help of my critical friend, learners were asked to draw up a mind map about CO_2. They were asked to branch out from CO_2 with whatever came to their minds when they heard of this concept. This was done to see if learners could make sense of CO_2 or not.

4.3.6 Data analysis

Data analysis is a process that involves organising, accounting and explaining data (Cohen et al., 2018). In this study, qualitative data analysis was employed whereby data from all four techniques were coded, compared or contrasted. I recorded all research processes, managed data, and kept all participants' notes, journal reflections and video items in hard and soft copies. As explained earlier, some criteria from Atallah et al. (2010) were used to analyse learners' conceptions and dispositions towards learning science. The use of conceptions and dispositions (see Appendix J) helped me to analyse learners' perspectives and motivations for learning science (the topic of CO2) which was augmented by the learners' reflections. Additionally, Vygotsky's (1978) socio-cultural theory and Ogunniyi's (2007a) CAT five cognitive states were used as lenses to analyse data emerging from the group discussions, community members, my critical friend and me. I adopted a thematic approach to data analysis. That is, data were analysed inductively by coming up with sub-themes. Thereafter, common sub-themes were grouped to form themes. The data gathering techniques helped me triangulate the data so that I could strengthen the validity of my study.

4.3.7 Validity and trustworthiness

Validity refers to the extent to which the study reflects that which it is intended to measure (Graven, 2012). Creswell (2014) viewed validation as a distinct strength of qualitative research in that the accounts made throughout the time spent in carrying out the research study, the description of the study and the relationship between the researcher and participants all add to the value and accuracy of a study. In this study, I made sure that the data gathering tools I used were systematic, credible and transparent (Bertram & Christiansen, 2020). I piloted the focus group questions with four learners to make sure that they were not ambiguous. I also video recorded the participatory observations and audio recorded the focus group interview and then transcribed the videos verbatim to retain data.

The two community members and the critical friend were allowed to discuss and reflect on what transpired during their presentations. All this was done for triangulation purposes. The audio recording of the interview and video recordings of the observations were transcribed and analysed with a colleague, who was my critical friend in the same subject discipline, to reduce inconsistencies that may have arisen through the process of collecting data. I made sure the ethical standards of respect and dignity, transparency and honesty, accountability and responsibility, integrity and academic professionalism were always taken into consideration

The use of different data gathering techniques allowed me to collect a variety of data sets and also helped in data triangulation. Wang (2019) referred to triangulation as a process of using contrasting data sources to enable rich data. To validate this study, I employed the method of triangulation to ensure and enhance the validity and reliability of the data. This study followed the ethical principles of autonomy, no-maleficence and beneficence (Bertram & Christiansen, 2015) which are discussed under ethical considerations.

4.3.8 Ethical considerations

Ethical treatment of participants is mandatory in any research study. Ethics generally refers to an analysis of our values and our conduct when dealing with other people (Brydon-Miller & Coghlan, 2019), that is, what is considered right or wrong (Kivunja & Kuyini, 2017). Bertram and Christiansen (2015) dissected the broad ideas of ethical conduct into three actionable principles or criteria, namely autonomy, non-maleficence and beneficence. Autonomy means that every participant in the research willingly agrees to take part in the investigation after being informed fully about the purposes and potential risks. In addition, autonomy means the participants are allowed to withdraw from the study without penalty (Derry et al., 2010).

Beneficence means that the research process should be beneficial to the research participants, other researchers or society as a whole (Bertram & Christiansen, 2014). This study was carried out to collectively improve learning strategies which was intended to enrich hands-on practical activities with locally available resources for the improvement of learners' understanding and sense-making of the topic of CO_2. Non-maleficence means that the research should not harm the research participants or any other people in any way (Bertram & Christiansen, 2015). Thus, the participants' right to privacy was honoured (Derry et al., 2010). Pseudonyms were used to protect the participants' identities and all the data used have been taken in confidence.

I also respected the autonomy of all participants and Ubuntu was used as a tool when contacting them. I gained the consent of every person who participated in this study. All participants took part voluntarily and had the freedom to withdraw from the study any time they wanted to do so. I clearly explained the aim of the study. As for the learners, consent was obtained from their parents or guardians and the same was done with the school and the ministry of education. Similarly, the two expert community members were thoroughly informed of ethical issues that could arise in carrying out this study, and a consensus was reached between us. Proper consultations were done with the two community elders to make sure they felt respected throughout this study (Seehawer, 2018a)

4.4 Chapter Summary

In this chapter, I first described the paradigms that informed this study – the interpretive and indigenous research paradigms. This was followed by a discussion of the research design, where I discussed a qualitative case study approach, the research goal and questions, the research site and details of the participants of this study. Secondly, data gathering techniques such as a focus group interview, participatory observations and journal reflections were explained in detail. Finally, the analysis of data was described.

CHAPTER FIVE: FOCUS GROUP INTERVIEWS AND GROUP ACTIVITIES

5.1 Introduction

The goal of this study was to explore how the mobilisation of indigenous technologies of making *oshikudu* and *uumboloto* may be used to mediate learning and sense-making of the concept of CO_2 in Grade 8 rural schools. The study was motivated by the need to contextualise and make science accessible and relevant to learners' lived worlds (Cetin-Dindar & Geban, 2017; Gwekwerere, 2016; Naidoo & Vithal, 2014).

In this chapter, I present, analyse, interpret and discuss data generated from the focus group interviews (FGIs) and group activities (GA). The FGIs were semi-structured and in the form of sharing circles (Lavallee, 2009). Sharing circles are consistent with indigenous research methodologies and are intended to encourage discussions and sharing of ideas. Additionally, they afford all participants equal opportunities to share information and to make sure everyone's contribution is respected (Afonso-Nhalevilo, 2013; Goduka, 2005; Lavallee, 2009; Seehawer, 2018b).

Henceforth, I firstly discuss the FGIs whose data were generated from an interview which consisted of five learners (two boys and three girls) in a sharing circle. Thereafter, I looked at group activity (GA) which took the form of presentations by learners in groups. The presentations lasted for about 40 minutes. Both the FGIs and the GA were video recorded with the participants' permission.

5.2 Focus Group Interviews

The FGIs were done with five learners who were chosen by others to represent their groups. This was done to give agency to learners so that they could take responsibility. Both English and the *Oshiwambo* language, learners' mother tongue, were used during the interviews.*Oshiwambo* was used to enhance participation which eventually heightened social interactions between participants (Vygotsky, 1978).

The FGIs were done as a semi-structured interview for follow-up question purposes. What stood out from this interview is the fact that participants were not restricted to discussing a specific question(s) at a time. Instead, they were free to add or highlight anything they remembered that they could have said or wanted to say in the previous or any other question(s). This strategy was employed as part of ethical considerations since it gave freedom to the participants to express themselves openly and kept their answers in a good sequential flow. This strategy eventually gave the whole interview a good flow of ideas and participants were at liberty to answer either in English or in *Oshivambo*. While the participants' quotes are verbatim, some may have been grammatically edited for clarity.

Participants were coded L1 to L5 and the gender codes M and F are indicated at the end. The specification of gender was cruial because in the school where this study took place Physical Science is regarded as a males' subject. Hence, I assumed that gender might have an influence on their perspectives and/or motivation towards learning science. For example, L1M represents learner 1 male, L3F represents learner 3 female and so on (see Appendix G for the focus group participants' profiles).

Figure 5.1: Shows the teacher and three of the five learners during the focus group interview

5.2.1 The development of themes

The data from the FGIs were coded and the following themes emerged: Learners' perspectives and motivations for learning science; challenges when learning science; and the role of learners' prior knowledge, culture and IK.

Table 5.1: Shows the main themes that emerged from focus group interviews and group activity

Themes	***Theorists***
Learners' perspectives and motivations for learning science	Agunbiade et al. (2017); Atallah et al. (2010); Bolte et al. (2013); Brophy (1983); Cook (2006); Govender (2016); Hambaze(2020); Mukwambo et al. (2014); Mavuru and Ramnarain (2020); Mhakure and Otulaja (2017); Oloruntegbe and Ikpe (2011); Schunk and Pajares (2001)
Challenges when learning science	Aikenhead (1997); Asheela et al. (2021); Hashondili (2020); Haimene (2018); Millar (2004); Oloruntegbe and Ikpe (2011); Rundgren and Yao (2014)
The role of learners' prior knowledge, culture and IK	Asheela et al. (2021);Cobern and Loving (2001);Dziva et al. (2011); Erinosho (2013); Hashondili (2020); Keane et al. (2016); Higgs (2010); Kuhlane (2011); Kibirige and Van Rooyen (2006); Makhure and Otulaja (2017); Abah et al., (2015); Mavuru and Ramnarian (2019); Mukwambo et al. (2014); Nyika (2017); Ogunniyi (2007a); Otulaja and Ogunniyi (2017); Roschelle (1995); Shiza (2013); Stott (2016); Tylor (1999); Tylor and Cameron (2016); Sedlacek and Sedova (2017); Seehawer (2018a); Vygotsky (1978)

5.2.2 Discussion of themes from FGIs

In this section, I present the themes that developed from the FGI data, in relation to the theory and literature as alluded to earlier. The literature and/or theory assisted me in interpreting and discussing the findings in this chapter. For instance, the FGI was informed by Vygotsky's (1978) socio-cultural perspective and I used it to understand how learners expressed their views and experiences about science. Since the role of learners' prior knowledge, culture and IK has also appeared under the group activity, the first two themes of learners' perspectives and motivations for learning science and challenges when learning science will precede it and will be discussed under the group activity. The FGIs aimed at addressing the research question 1:

> What were Grade 8 Physical Science learners' perspectives and motivations for learning the topic of CO_2 before the intervention?

5.2.2.1 Learners' perspectives and motivations for learning science

During the FGIs, learners were probed to share their views on how learning science (CO_2) makes them feel and why. All five participants' responses showed that they have positive perceptions of learning science, for instance, L1M indicated, "*It makes me feel good because it teaches me more about CO_2 and its importance to humans and plants".* Likewise, L2F also avowed that "*it makes me feel good because I learn more about CO_2, how it is produced and in which ways it is used".*

L3F posited that she feels good because the study of science helps her to know more about CO_2 – how it is produced, how it is consumed in everyday life and how it is important to the environment and all living organisms.

The above excerpts showed learners' positive conceptions and dispositions towards science as espoused by Atallah et al. (2010). All these describe learners' attitudes to learning CO_2; that is, what they think CO_2 is and why it should be included in the school curriculum. Indeed, it could be surmised that learners value the usefulness of science in their everyday life (Gwekwerere, 2016).

Furthermore, in agreement with L1M, L2F and L3F is L5M who strongly reasoned that learning science truly makes him feel good. He narrated that it teaches him much about his environment and helps him to understand things better than his fellow community members who never learnt science at school. These learners' views seemed to have an affinity with Kuhlane's (2011) assertion that we are surrounded by science. Again, this is a gesture that learners are aware that science plays an important role in their lives and surroundings.

Participants were also asked about their views on how they would like to be taught new concepts in science at school in order to motivate and ignite a passion for science in them. All five participants highlighted their satisfaction with the current teachers' approaches, however, they uttered that there is a need to relate science lessons to their daily life experiences and real situations (Freire, 2018; Gwekwerere, 2016). Furthermore, learners stressed the need for teachers to focus on everyday real-life experiences since most of the science practices are done in their communities, but they do not know how to apply such community grown skills to school science. In this regard, L1M commented that:

> *The ways teachers are teaching us is just fine with me, many times they try to explain clearly. But sometimes when teachers are explaining, learners do not get the ideas well, therefore, teachers or whoever is responsible for teaching must bring in a lot of touchable things that learners can see, such as videos because they help learners to understand more things in detail. Teachers should also let us do practical activities, because science is all about mixing things and that will help us to learn more about science.*

From this excerpt, it could be deduced that since this learner values science, he suggested that the best methods be used to teach it. His view coheres with Oloruntegbe and Ikpe 's (2011) that there is a need for teachers to consider using real-life experiences in their science classrooms for effective mediation of learning to take place. Oloruntegbe and Ikpe (2011) supported that teaching methods should build on learners' relevant experiences and could heighten their motivation in science. Cetin-Dindar and Geban (2017) avowed that learners' motivation to learn science is affected by their conceptual understanding of science concepts. Therefore, science taught in class should include familiar situations. In addition to real-life experiences, learners have called for hands-on practical activities in science lessons (Asheela et al., 2021; Shinana et al., 2021).

The learners' perspectives about a subject influence their motivation and vice-versa. In this case, understanding the application of science in learners' everyday life stands out as a motivation for them to engage in science activities (Hambaze, 2020). Brophy (1983, p. 200) described motivation as the "enduring dispositions of learners to find learning process relevant and worthwhile for them to take pride in the outcomes of experience involving knowledge acquisition or skills development".

The positive attitudes demonstrated by learners about science have influenced their motivation to do science. For instance, when learners were asked what motivates them to learn science at school, four out of five participants resonated that they are fully motivated to do science because they understand the role it plays in their everyday lives. For example, L1M remarked that science teaches them about things that are related to real life. He further indicated that science helps them to learn many things. He added on saying, "*It also teaches us what to do and what not to do; also most of the things we learn in science are also things that we do at home, so it helps us to do things better at home".*

In addition, L2F reflected that "generally science is school-based but it also includes things we do at home, so what motivates me most is to know better the things we do at school and the things we do at home". This finding resonates with Aikenhead and Jegede's (1999) views that there should be a link between the micro-culture of the family and the micro-culture of the school, otherwise learners will find it hard to connect between these two cultures. Hence, Aikenhead and Jegede emphasised the importance of taking into consideration knowledge that could bridge the gap between home and school science. Interestingly, learners also indicated the relevancy or importance of physical science concepts that they learn at school in their everyday lives. For example, L1M stated that "some of the things really help us at home. For example, learning things like CO_2 will help us at home not to cut down trees because trees absorb CO_2 which can be harmful to our environment".

L2F and L3F shared the same views, with L2F stating:

> *We at times apply some things we learnt from school at home. For instance, sometimes the things we learn at school help us to do things better at home, for example, in Agriculture, we learn about gardening and pests controlling something that we can also apply at home in our gardens and fields*.

Similarly, L3F cemented the above statement by saying "Wherever we are at home we are always applying science, so the things we do at school help us to improve how we do things at home".

The above excerpts justify that learners are motivated to do science. As L4F clearly put it: "*Some of the things help us to teach our parents the best ways of doing things. For example. telling our grandmothers not to burn tyres anymore because that produces too much* CO_2". These claims serve as an indication that learners appreciate science.

Equally, learners were requested to state in what ways they think their home-based knowledge can be used or applied during Physical Science lessons. Again, a number of them believe that the link between home-based knowledge and classroom science is one of the motivations to do science. For example, L1M said: *"It helps me to understand and to explain to others things teachers don't explain clearly in the Physical Science lessons. You can also use your home-based knowledge to give other learners many examples that sometimes teachers don't give"*.

L2F added that:

> *Sometimes the things we do at home are the same as those that we do at school, which helps us not to find science difficult or to understand science at school because you know some of the things already. Also, when we are studying we can just skip some parts because we already know them from home and they are permanently in our minds*.

Likewise, L4F commented that: "*When you bring home experience to school or say in the Physical Science lessons, it makes science at school easier and it motivates others to learn science too; sometimes you make them remember things they do at home"*.

From the above excerpts, one can hypothesise that learners have positive views about doing Science at school especially if it is related to their everyday lives as reiterated by Gwekwerere (2016). Hence, learners' positive attitudes towards learning science determine their motivation to do science (Atallah et al., 2010). In this regard, L4F indicated that she thinks experience from home is helpful because it helps one to understand science more. For example, she stated that a learner who knows that *oshikundu* produces CO_2 would be at an advantage when they cover the topic of CO_2. She said that at least this prior information about CO_2 will help him because he already knows a bit about CO_2 from home.

These findings have an affinity to Mavuru and Ramnarain's (2020) view that integrating learners' socio-cultural backgrounds into science teaching provides them with a holistic and authentic view of science. Hence, this leads to learners making a meaningful contribution to understanding scientific concepts better. In light of this, Mukwambo et al. (2014) posited that learning is understood to be dependent on the learners when they link their existing knowledge with the content of instruction. This is also a congruence with the Physical Science Subject

Policy (MEAC, 2009), which states that the learning process of science may be amplified by linking science to real-life situations.

From the discussion, it was evident that L1M, L2F, L3F and L5M are of the view that it is advantageous for them to learn science. There is no doubt that this is their perspective which also acts as a motivation for them to do science. These participants emphasised the relevance of home science in their learning of school science and vice versa, hence this stands as a motivator for learners to learn science. These ideas align with Govender's (2016) views that IK is a valuable learning resource to motivate learners to understand science.

5.2.2.2 Challenges to learning science

Though learners indicated that they were motivated to do science, L4F pronounced that she thinks she does not have any motivation to learn science. She uttered that most of the things they learn in science at school are not workable or applicable at home and many concepts are hard to understand. Similarly, L3F put it that not understanding science experiments, the difficult things that they do in science and sometimes not getting teachers' explanations, demotivates her to do science. She further echoed that "*also the English used in science is difficult to understand"*.

From these learners' views, it could be argued that L4F could not understand science application at home which means that strides should be made to familiarise this learner's lived experiences with school science. Similarly, L3F could not understand the science language. Language can be a hindrance for learners to understand science. Language thus becomes a key element in science education: it is a tool that allows us to understand the natural world, express our ideas about it and develop scientific knowledge. Despite science language being problematic to learners, English as a second language is one of the impediments to science learning, mainly for the marginalised learners (Henderson & Wellington, 1998). In that regard, the use of indigenous languages can support learners (Meyer & Crawford, 2011) since language communicates the traditions, customs, morals and values of a people (Lemke, 1998).

Nevertheless, it can be concluded that to abate challenges such as those alluded to by learners, science lessons should tap into learners' socio-cultural backgrounds. This suggests that teachers should at least use easily accessible resources to do hands-on practical activities that will afford learners a chance to use their five senses to learn as advocated by Asheela et al.

(2021). This proposes that teaching and accessing should provide equal opportunities for diverse learners by considering learners' socio-cultural experiences and languages and making use of local discourses that allow learners to maintain their identities (Mavuru & Ramnarain, 2020). This is an idea also supported by Kibirige and van Rooyen (2006) and Mukwambo et al. 2014) who argued that teachers should expose learners to easily accessible materials since their use makes learning relevant to the learner's immediate environment.

Moreover, L4F and L3F indicated that they often feel discouraged doing science because of some of the difficult things that they have to learn and do, especially those they do not understand or have never seen before. L3F specifically indicated that such things make her feel like giving up on science. This literally means that the lack of hands-on practical activities may deprive learners of broadening their existing knowledge and at times demotivates them to do science. This finding coheres with Oloruntegbe and Ikpe (2011) who accentuated that when learners are not exposed to hands-on practical activities, they might not be able to relate science to real life at home which would help them visualise the science concepts.

Furthermore, both L3F and L4F expressed the need for experimentation. This is a major challenge, especially in rural schools where there are no science laboratories and adequate apparatus. For instance, L3F specified the need to see (visualisation) which is important when learning science (Stott, 2016). Similarly, Rundgren and Yao (2014) posited that through visualisation, abstract knowledge and ideas can be expressed in a simpler way that is understandable to the learners. Indeed, learning science is about seeing, handling and manipulating real objects and materials (Millar, 2004). For this reason, Haimene (2018) postulated that hands-on practical activities enable learners to develop positive attitudes towards science. Therefore, hands-on practical activities are essential for developing learners' scientific knowledge (Millar, 2004).

In light of these arguments, the Namibian Senior Secondary Certificate (NSSC) examiner's report for physics (MEAC, 2021) highlights the use of everyday practical examples. That is, it gives some relevance to the subject matter of science that arouses learners' interest and better understanding because of its relevance to everyday applications and raises awareness among learners with multiple experiences (Oloruntegbe & Ikpe, 2011). Therefore, there is a need for science teachers to be aware of the knowledge that is appropriate in science to enhance learners' conceptual understanding (Hashondili, 2020). In addition, Mavuru and Ramnarain (2020) suggested that teachers need to value learners' outside-classroom experiences to contextualise their lessons. One thing worth noting in this activity was that the indication of gender in coding did not add value as the gender of learners showed no differences in their responses/ perceptions.

5.3 Group Activity

Learners were given questions (see Appendix N) to go and research CO_2 in their homes or communities. That is, each learner had to bring their findings to their group and thereafter, compile a summary of their findings on one poster which would be presented to the class. The rest of the groups were then allowed to ask questions after each group had presented. This was done to answer question 2 of this study:

What do learners know from their homes and communities about CO_2?

Thirty learners participated in the group activity; 15 boys and 15 girls. They were placed in five groups of six, three boys and three girls per group. Groups were asked to name themselves using any animal name they wanted and were asked to briefly explain why they chose such names. This was done as a warm-up for learners to minimise their nervousness before they presented their findings. Additionally, this was done to make them feel free to express themselves during the presentations as they seemed to be a bit nervous at first.

Here are the groups' names and reasons for choosing such names:

1. The Lions (L): they referred to themselves as the kings and queens of science.
2. The Tigers (T): they referred to themselves as the strongest in all they do.
3. The Mouse (M): they said that although they seemed to be the smallest, they had smart minds.
4. The Jackals (J): they were clever ones.
5. Bunnies (B): lovely and peaceful.

Groups members were coded as L1L to L6L (learner one from the lion group to leaner six in the lion group), L1T to L6T (learners from the tiger group), L1M to L6M (learners from the mouse group), L1J to L6J (learners from the jackal group) and L1B to L6B (for learners from the bunnies group). The gender of each participant is indicated with F (for Female) or M (for

Male), for example, L1LF represents Learner 1 from the lion group female and L2JM (learner 2 from the jackal group male) and so on.

In the activity, I wanted to understand what learners knew about CO_2 from their homes and communities – focusing on the third theme alluded to earlier (the role of learners' prior knowledge, culture and IK). Under this theme, I looked at two categories: good/rich prior knowledge and poor prior knowledge (see the learners' responses as per colour used in Appendix M).

Part A

Part B

Figure 5.2: Part A and Part B show learners in their groups working on the group activity in the first contact session

5.3.1 The role and appreciation of learners' prior knowledge, culture and IK in learning science

After all the groups had presented, a 15-minute session was used for questions, suggestions and comments. It was considered important to understand learners' prior knowledge about CO_2 to validate if it was necessary to carry out this study at the Grade 8 level. Also, learners' prior knowledge was vital in this regard since it informed me on where to start with this class on the topic of CO_2.

An interesting aspect that demonstrated a good prior knowledge of CO_2 came to light when learners were asked to mention some cultural practices or activities that they knew from their homes and communities that produce CO_2. The Tigers answered that *oshikundu* and burning firewood produce CO_2. At this point, many learners were keen to learn and understand how *oshikundu* produces CO_2. A respondent from the Tiger group who had earlier brought up this point indicated that he was not too sure of how *oshikundu* produces CO_2, but he was just told by his mother that the gas that comes out of *oshikundu* when it is fermenting or when one shakes it contains CO_2.

This finding coheres with Otulaja and Ogunniyi's (2017) view that such knowledge and skills constitute wisdom that is passed on orally from generation to generation. Adding to this, Seehawer (2018a) emphasised that IK is developed locally for the people and by the people of that locality, and is then passed on from parents to their children. This was so relevant to this study because it intended to mobilise the learners' IT of making *oshikundu* to mediate learning and sense-making of the concept of CO_2. This was considered good prior knowledge demonstrated by this specific learner. It also highlighted the knowledge passed on from the mother to the child which needs to be strengthened as this serves as the learner's IK.

Govender (2014) posited that part of the African learners' poor performance is partly exacerbated by how African learners learn science. They learn abstractly because science is taught without reference to their local or indigenous experiences. It is for these reasons that some scholars believe that IK should be seen as an alternative approach to assist in the teaching and learning of science (Klein, 2011; Opoku & James, 2021; Rosales & Sulaiman, 2016). With the absence of IK in a school system, Aikenhead and Jegede (1999) warned that learners find it difficult moving between the micro-culture of the family and the micro-culture of the school. As a result, it affects their success in science.

Later, my critical friend asked learners to mention some of the advantages and disadvantages of CO_2. L1JF responded:

> *One of the advantages of CO_2 is that plants breathe in CO_2 so that they can give out oxygen which is crucial to the lives of all animals, including human beings. The disadvantage of CO_2 is however that, too much CO_2 is dangerous to humans' lungs.*

L2MM added that one more disadvantage of CO_2 is that too much of it can cause breathing problems that may cause suffocation in humans and animals. That is why sometimes if we wear our nose masks for too long, CO_2 becomes more than oxygen and we experience breathing problems.

In the above excerpt, the learner revealed a good prior knowledge about CO_2, however, there were some misconceptions that plants breathe in CO_2. On the contrary, plants do not breathe, but they rather take in CO_2 and oxygen as well, many through the conducting tissues called xylem and many through leaves. Carbon dioxide (CO_2) is also taken in through tiny holes (stomata) in their leaves and is used together with water and energy from the sunlight to make their own food during the photosynthesis process. This type of conception can always be corrected if teachers give learners the chance to mention what they know from their communities before or during their lessons. This agrees with the view that the starting point for teaching and learning is the fact that learners bring to the school a wealth of knowledge and experience gained continually from the family, the community and through interactions with the environment (Freire, 2018). Learning in school must involve, build on, extend and challenge the learners' prior knowledge and experiences (Kuhlane, 2011; Nyika, 2017; Ogunniyi, 2007a; Okanlawon, 2017; Roschelle, 1995).

Participants were also asked to define CO_2. The lions retorted that CO_2 is a colourless gas breathed out by humans and animals. The bunnies indicated that it is a gas formed when things burn; it is breathed out by humans and animals. Likewise, the jackals put it that CO_2 is a natural gas that can cause too much heat and skin cancer when there is too much in the atmosphere. These three groups' responses indicated good prior knowledge of learners' understanding of CO_2 because when they were probed further after their presentations, they were able to reason further.

The mouse group narrated that burning plastics to control locusts (pests), respirations and decomposition are the main sources of CO_2 in their community. These views were also shared by the bunnies and the jackals, that CO_2 is caused by the burning of cattle dung to prepare traditional clay pots, burning of millet's (Mahangu) stalks or straws to prepare for fields for cultivation, bush fires, fire gathering for storytelling and burning firewood for cooking purposes. This prior knowledge can be mobilised to teach CO2 and science-related concepts. This aligns with the call that teachers should employ teaching strategies that induce and challenge learners to use their socio-cultural background experiences and cultural worldviews in class to make sense of science concepts and to fully explore opportunities embedded in IK, therefore enhancing learning with understanding (Erinosho, 2013; Mavuru & Ramnarain, 2020; Vygotsky, 1978). Similarly, Kibirige and van Rooyen (2006) posited that science teaching becomes effective when IK is considered as prior knowledge and as a starting point to learning. These authors further indicated that IK promotes communication skills. Thus, it is a guiding tool for facilitating the bridge of what learners already know which makes teaching effective (Nikodemus, 2017).

Even though a large number of learners revealed a good prior knowledge of CO_2, a few other groups seemed not to have good prior knowledge. For instance, the mouse group was asked to shed more light on respiration and photosynthesis and state how they knew CO_2 is about 0.03% of the air. On this question, they indicated that they did not know – they just got the information from a textbook. L1MM asked the lions to explain what fossil fuels and greenhouse gases are. Again, the lions could not give any answers; they indicated that they copied it from somewhere. Similarly, L2JF questioned the bunnies, asking them to explain how deforestation produces CO_2 and to clarify why they referred to cement manufacturing as a cultural practice. The bunnies could not answer further either, which indicated that some of the answers were just copied directly from textbooks without understanding. Even though CO_2 is a common concept in Grade 7 in the Natural Science syllabus, these Grade 8 learners demonstrated poor prior knowledge of CO_2.

Even though this was the case, this did not mean that learners from those groups had no prior knowledge at all about CO_2. Obviously, they were aware of all the other cultural practices that were mentioned by others. For instance, even though the bunnies could not say much about how deforestation contributes to CO_2 they gave good examples, explaining that vehicles' exhausts and wood burning contribute to the production of CO_2. Thus, recognition of learners' prior knowledge will always have a positive impact on learners' engagement with the subject. Ogunniyi and Ogawa (2008) supported that prior knowledge and IK build a strong link to everyday experiences, leading to learners actively participating in lessons. Sharing the same sentiments are Brayboy and Castagno (2008) who posited that integration of IK does not only connect science to IK but provokes learners' thinking, which leads to critical thinking skills (Magwentshu, 2020). Shizha (2007) asserted that learners tend to engage more when they learn what they relate to and further argued that integrating indigenous science and western modern science liberates learners and teachers from cultural alienation. It is through the implementation and integration of IK in schools that learners, parents and communities can reclaim their voices in the process of educating the African child (Shizha, 2013). Moreover, Le Grange (2007) and Mukwambo et al. (2014) advocated for the integration of IK, arguing that it paves the way for authentic Africanisation in teaching and learning.

5.4 Chapter Summary

In this chapter, I presented data on Grade 8 Physical Science learners' perspectives, motivations and prior knowledge of CO_2 and their attitudes towards learning the topic of CO_2 before the intervention. The data were generated using FGIs and GA respectively. The findings revealed that learners understand what science is all about and they have positive views about learning science – they are well motivated to do science. For instance, they indicated that the science they learn at school helps them to improve their living standards in their respective environments. In addition, the learners seemed to demonstrate an understanding of the importance of science and they have rich prior knowledge about CO_2 as they alluded to several cultural activities from their communities that produce CO_2. In the next chapter, I analyse, present and discuss the data generated from participatory observations and learners' reflections.

CHAPTER SIX: PARTICIPATORY OBSERVATION AND LEARNERS' JOURNAL REFLECTIONS

6.1 Introduction

This study is rooted in cultural revitalisation ideology (Cocks et al., 2012; Smith, 1999) as an effort to improve teaching and learning in rural schools. Moreover, the study was intended for learners to embrace diversity and respect each other's cultures and cultural heritage (Seehawer, 2018b). Thus, it mobilised the indigenous technologies of making *oshikundu* and *uumboloto* to mediate learning and sense-making of the concept of CO_2.

In this chapter, I thus present, analyse, interpret and discuss data from the participatory observation and journal reflections. These two methods are aimed at addressing research questions three and four which are:

- In what ways do the Grade 8 Physical Science learners interact, participate and learn (or not) the concept of CO_2 during the practical demonstrations on the making of *oshikundu* and *uumboloto* by the expert community members?
- How do the presentations by the expert community members on making of *oshikundu* and *uumboloto* shift (or not) Grade 8 Physical Science learners' perspectives and motivations to learn and make sense of the topic of CO_2?

6.2 Participatory observation

The participatory observation was used to get a general depiction of learners' participation and social interactions during the presentations on the indigenous technologies of making *oshikundu* and *uumboloto* by expert community members. It was hoped that learners' conceptual understanding of the concept of CO_2 could easily be realised if they do hands-on practical activities using common indigenous technologies. It was for this reason that *oshikundu* and *uumboloto* were used since they were familiar to learners' lived experiences (Gwekwerere, 2016).

In an effort to mobilise IK, I invited two expert community members as More Knowledgeable others (MKO) (Vygotsky, 1978) to share their expertise with learners, my critical friend and me. The two community experts were women and they were thrilled to share their knowledge with us. Something that they could not hide about their excitement was the fact that they requested me to use their real names because they felt that it was important for children to learn their cultural practices while they were at a young age so that they could pass them on to the next generations. They insisted that they wanted their real names to be used so that any other persons who may come across this study and want more information about related Oshiwambo practices that they know, such as making *omalodu*, *okunyenga*, *omalunga* or many others, may contact them at any time.

Unlike in the previous chapter, in this chapter I could not specify the learners' numbers in their respective groups hence I used for example LMF to mean a Learner from the Mouse group Female, LLM a learner from the lion group male and so on. Again the group name was necessary for identification of learners' groups and the specification of gender was also crucial since the two practices done in this study are regarded as feminine chores in the *Oshiwambo* culture. Hence, I assumed that gender might have an influence on learners' prior knowledge. In contrast, however, it was realised later that both genders participated fairly equally. The expert community members' quotes have been translated into English for this thesis. First, I present the indigenous technology of making *oshikundu.*

6.2.1 The making of *oshikundu*

Meme (mama) Natalia Hamutenya who was a cleaner at the school and a former learner at the same school where this study was conducted demonstrated how *oshikundu* is made. She was the MKO in this regard. She was so excited to be allowed to share her knowledge with all the participants. Learners were fascinated by her teaching. Meme Natalia started her presentation by motivating learners, demanding them to work hard and always behave well at school. After her words of encouragement, she continued saying.

> *Firstly, I should thank you all for welcoming me and for volunteering to take part in this activity. I believe this will be helpful to you. I see you as the lucky ones to be taught by people who truly care about you and love you unconditionally, who make efforts for you to be taught in platforms such as this, something that was never done or thought of during our era.*

She reflected on a time when she was a learner at the same school saying:

> *During our time as learners at this school, there was not a single teacher who saw any importance in our cultural practices, I am even surprised when I was approached by your teacher regarding this. We never experienced such favors and we never knew if oshikundu could be spoken about in a class for a purpose of learning, it was more of a taboo.*

She has also applauded learners for being fluent in English at their age and asked them to take advantage of that because they can read, write and understand whatever is written in English, unlike her and her peers who could hardly understand English when she was at school. She continued saying:

> *During our time subjects were so tough to understand because we could not understand the English language or Afrikaans language plus school work was given little attention from home, it was not too important. Therefore I just decided to drop out of school at standard 5 (Grade7) so that I could go look for employment to feed my family.*

She kept on emphasising good behaviour as she concluded her words of encouragement to the learners. Learners were eager and keen to hear more from her. Thereafter, Meme Natalia took the things she came with – a cup of ready prepared *oshikundu* (*oshipifo*), *omahangu* flour and o*ngudo*. She started by asking a few questions and the whole discussion was in Oshiwambo.

For instance, Meme Natalia said: "*Who knows what is oshikundu and how it is prepared?*" Almost the whole class raised their hands, except a few boys (LLM, LMM and LJM) who indicated that they only knew of *oshikundu* but they did not know how it is prepared because it is not made at their homes. Meme Natalia then asked; "*Who has never tasted oshikundu before?*" Again almost the whole class indicated that they had drunk *oshikundu* before, except a boy (LLM) who indicated that he never tasted it because it was never done in their home but he would like to taste it.

Other learners were shocked to hear that he had never drunk *oshikundu* before. Meme Natalia acknowledged the boy's response and assured him that he would surely taste it the following day. Then, she further asked: "*Would you please mention some cultural beliefs that you know or heard about oshikundu?*" This part was mainly dominated by girls' answers, except for one boy (LTM) who indicated that *oshikundu* is normally done by women and girls, not by boys.

LLF responded that: "*According to my grandmother, oshikundu was used to serve as breakfast in place of tea and coffee before these two came into villages. Oshikundu was used as peoples' energiser between morning hours and lunch hours, so it was served normally around 9:00 am and 10 am*". Many learners laughed at *oshikundu* being used as breakfast, but they confirmed the time for taking *oshikundu*.

Another girl, JLF, responded by saying; "*Apparently, oshikundu is very nutritious, it was a must for every house and even more especially if that house has kids* (ages between 0 and 10 years old)". JLF added on saying:

> *Culturally, oshikundu is brewed at night and it was mainly done by women (wives) or grandmothers and young girls are normally tasked to keep on stirring it until it is ready to be mixed with ongudo, but after diluting it you don't pour it all once in the main container (olwiyo) you have to leave a half that you pour in the next morning otherwise it will be too sour.*

LTF said: "*Apparently, raw oshikundu was used as food for babies who lost their mothers during delivering or who were just left younger than a month old in place of milk for them not to die of malnutrition*". LBF surprised the class when she asked: "*I want to ask the class who is responsible for giving oshikundu to the housemates and why?*" Of course, the elders and the class responded. LBF continued saying yes, but there are reasons for that, what were the reasons? The class murmured for a while and no one answered the question posed. Ultimately, one boy responded and said: "*I don't mind distributing oshikundu to my housemates because I don't see anything wrong if someone asked me to do so, either a girl or a boy can just do it*".

JLF retorted saying she was not too sure why wives or elderly women were entrusted with this task but she thought it was done by elders because young ones may put too much sugar in *oshikundu* and elders do not like too sweet things. The class laughed out loud and some learners shouted that there was no sugar by then. However, the class could not give a satisfactory answer to LBF's question. She continued giving the reasons as, one, it is for equal sharing, to make sure no one drinks more than others; two, it is for saving the resources whatever the circumstance. She said she heard that rats like drinking *oshikundu* too and many times they would drown in *oshikundu* since it was never completely or tightly closed due to the containers that were used then.

She emphasised that even with modern containers it is discouraged to fasten the cover on *oshikundu* because the container may rupture due to the pressure of the gas *oshikundu* produces during the fermentation process. Thus, an old lady would remove a rat or anything they found in *oshikundu* and just give it to the housemates as if nothing happened. Several discussions about *oshikundu* emerged such as the traditional beliefs. For example, LMF said she learnt from her grandmother that sometimes elderly women could read signs from *oshikundu* about any bad news that they were about to hear or an announcement of a relative's death. This last remark shocked the class, but Meme Natalia confirmed it and added that sometimes if your *oshikundu* is not ready the next morning, chances are that you may receive bad news, or the preparation process was poor.

After checking on learners' prior knowledge about *oshikundu* Meme Natalia asked: "*Who can briefly tell the class how oshikundu is prepared?*". Another girl narrated the process of how *oshikundu* is prepared. Meme Natalia was very happy with the response and invited the girl who answered to join her upfront.

They started putting flour in a bucket (container). They boiled water and let it cool down for about 10 minutes before pouring it into the bucket. Meme Natalia explained every step she took and learners eagerly observed every step. From her explanation, it seemed Meme Natalia knew the work very well as it was succinct, and the participants listened attentively while taking notes. This coheres with Shizha's (2007) assertion that learners' participation takes on a special dimension when IK is made visible in science education.

Furthermore, Meme Natalia added that people should not use water that is too hot – as long as it is warm it is ok, otherwise, the *oshikundu* would taste sour. She instructed LJF to keep on stirring until the mixture cooled down. From our observation, it was evident that the practice of making *oshikundu* is rich in scientific concepts. For instance, Meme Natalia kept on stirring to speed up the reaction. Also, though she could not really determine why people do not use very hot water, scientifically it is a fact that hot water may kill the enzymes that are responsible for breaking down the carbohydrates in the flour. Once again, this gave us an opportunity to link the cultural practice of making *oshikundu* and the scientific concepts embedded in the practice – for example, reaction, mixture and enzymes.

For the first five minutes, the mixture of flour was hard (like pap) and only started to become liquid when she added about a hand and a half of ongudo (sorghum flour). At this point, one learner, LBM, questioned: "*Why is the amount of flour not the same as ongudo and how do you know that the little ongundo you have used was enough?*" Meme Natalia answered:

> *Though there are no quantitative tools used to measure, everything was measured mentally just by looking. People knew that a specific amount of flour will need a certain amount of ongudo, if we add too much ongudo it will become too watery. It is just like what most of you do when you dilute your juice. Do you normally need the same amount of juice like that of water, or how do you measure the two? Obviously, you know how much will be enough without physical measurement.*

LBM responded with an "*ok*" which was an indication of satisfaction. LJF asked why *oshikundu* became more of a liquid when *ongudo* is added? Meme Natalia responded and said "*I don't really know what happened but it is a well-known factor that once one adds ongudo to oshikudu it becomes more of a liquid*".

LLF requested the following: "*Could please sir explain scientifically what happened to oshikundu when ongudo is added?*" My critical friend intervened and explained that there are enzymes in *ongudo*, so they break down the carbohydrates in the first mixture that looked like pap, hence it turns into liquid.

Right at the end, it was time to dilute the *oshikundu*. Meme Natalia asked LJF who had been stirring to carry on stirring as she poured water into the 10 litres container until it was full. Later, she poured in a cup of ready-made *oshikundu* (*oshipifo*). Learners asked why she added the ready-made *oshikundu*. She indicated that it is important to add a bit of a ready-made *oshikundu* because it acts as an activator (catalyst) in making o*shikundu* ready the next morning. She further said that if the ready-made *oshikundu* was not added, chances are higher that it may not be ready by the time it is expected to be ready.

After the presentation, three bottles of 500ml were filled with *oshikundu*. From the three containers, there were three test tubes connected to collect gas from the *oshikundu*. The gas collected was to be tested for CO2 the following day.

Finally, a learner was given a chance to give remarks of thanks to Meme Natalia. The learner started with a song "*Let us give thanks to our elders*". She then indicated that she was very happy that God placed them in good and caring hands such as the elders who unconditionally sacrifice their time to make sure they learn things the easy way. The whole class with excitement gave Meme Natalia applause. The day's practical lesson ended.

The next morning, the gas that was collected in the three test tubes was tested for CO_2. Learners were fascinated and could not wait to see how the testing of CO_2 from *oshikundu* was going to be done. Thus, it was important that learners first learn how the test for CO_2 was done. Just before testing the gas from *oshikundu* my critical friend came in with a test tube with clear lime water and asked if there was anyone who wanted to make bubbles in the lime water through a straw. Almost everyone raised their hands to go experiment. A boy was called forward to do the testing. The class was so curious to see what would happen and learners were amazed by what happened. The teacher asked them to say what they observed and LJM said "*The water became dirty and there is fat*". Several learners said the water became whitish. We explained why the water became whitish and that it was an indication of ***CO_2*** in the gas the boy blew into the lime water.

LBM asked, "*Sir, lime water is made from what, is it not poisonous*?" My critical friend then said it is made from dissolving calcium hydroxide in water and when CO_2 reacts with calcium hydroxide it forms calcium carbonate. Calcium carbonate is an insoluble substance, which means that it does not dissolve and disappear in liquid, and it is the one that causes the whitish colour of lime water. He further said, "*we are going to learn more about all this in due course*". He then continued saying yes, clear lime water may cause some stomach problems when swallowed but that is also something he and the learners could discuss in detail later.

Thereafter, the gas collected from *oshikundu* was bubbled into the clear lime water and the lime water became whitish. Lastly, three lit match sticks were placed one at a time into one of the test tubes and they all went off immediately. We asked learners what the possible causes could be for the lit match sticks going off. No learners could explain why the sticks went off. We then explained to them that CO_2 does not support combustion, hence it is used in fire extinguishers. It was so important that we involved lit match sticks in this test because these are easily accessible resources that learners can make use of at home at no cost. Learners were so surprised to see this, though they knew what the results would be as was demonstrated by my critical friend earlier. Many learners were astounded to see how the gas from the *oshikundu* changed the clear lime water to cloudy or milky and to learn that CO_2 switches off glowing sticks. However, LMF seemed worried and he asked: "*Sir, since we were taught that human beings breathe out CO_2 and too much CO_2 is said to be dangerous, having seen what has just happened, will drinking too much of oshikundu not going to feel our bodies with too much CO_2?*". That question was redirected back to the class. Many learners seemed not to have answers, except LJM who responded: "*I think human bodies are special machines that control themselves, I have been drinking oshikundu but I never experienced any breathing problem, I think when there is too much CO_2 in my stomach I just burp several times*". Many learners laughed out loudly at his comment. My critical friend responded to this question that CO_2 was not in *oshikundu* but it was rather produced during the fermentation process and it was in a minimal amount which is why he used a little amount of lime water to do the test. If he used more lime water then the CO_2 collected would hardly have changed the lime water's colour.

Learners were surprised by the results and thanked the teacher. For example, LTF said: "*Thank you for this sir, as from now on even though it seems as if there was nothing in the test tube I now know there is a colourless and invisible gas that can turn the lime water into something like whitish*". LBF added: "*Sir, you are the best science teacher I have ever met before, so science is this simple, no matter how forgettable I am I will never forget that CO_2 can be produced from oshikundu – but will I get a mark if I write this in the examination sir?*" My critical friend said yes, but he cautioned the learners to use mostly what is prescribed by the syllabus because some people do not know what *oshikundu* is.

The boy who never drank *oshikundu* had a chance to drink it. One of the learners made a funny remark saying "*Guys I will only give you two weeks and you have to contribute to my new school uniform because I will be wearing size 40, I will start making my own oshikundu"*. He continued and said: "*Sir you know what? I think other teachers must start making things clear like you, those things in the books are for smart people, people like me will only get 100% if teachers start teaching this way otherwise they should always mix methods and give relevant examples to us slow learners*".

A numbers of learners who were not participants in this study were also invited to take sips of *oshikundu* and they were so thankful. One of them remarked, "*Yes! I wish we could have this type of science project every day sir, please tell your colleagues to do the same*". LMM proposed that it would be good if we asked all learners to bring *mahangu* flour and *ongudo* to school and then they could have *oshikundu* as a school feeding programme. LJF added on saying, "*It would be a great initiative if all of us make an impact by making oshikundu because learners will not only learn science through making oshikundu, but even those who find it hard to get no pocket money for fat cakes and uumboloto at school will at least have something to eat or drink during break times*".

Figure 6.1A

Figure 6.1.B

Figure 6.1A: Shows Meme Natalia explaining how to make *oshikundu* and figure 6.1B shows containers filled with *oshikundu* for CO_2 collection purposes

Figure 6.2A

Figure 6.2B

Figure 6.2A: Shows *oshikundu* before putting in *ongudo* and Figure 6.2 B shows *oshikund*u after diluting it

Figure 6.3: Learners drinking *oshikundu* after they were done with testing for the presence of CO_2 in it

6.2.2 The making of homemade bread (*uumboloto*)

Another community expert member was Meme Hilya Lukas Nangolo. She normally sold *uumboloto* at the same school and was invited to come and share her expertise in making *uumboloto* with the participants as a More Knowledgeable Other (Vygotsky, 1978). Interestedly, though Meme Hilya did the presentation in Oshiwambo, she also spoke English very well. Therefore, she asked learners to speak in a language that they were more comfortable with. At the time of this study, Meme Hilya was 51 years old, a local person and had been making *uumboloto* for almost 30 years after learning it from her mother who also used to make it. Meme Hilya said she dropped out of school at the Grade 9 level.

After greeting the learners, Meme Hilya started by saying:

> *Thank you dear teachers and learners for calling me here today to come and share my skill of preparing uumboloto. This is something that I never thought of since I never knew if my knowledge of making uumboloto would be useful in science learning. I therefore would like to request all learners to be free and ask freely anything that you might not be getting well, you may ask either in Oshiwambo or English. Although upon completing my Grade 9 my English was poor I don't have much problem with it anymore, because I came to learn English better after I had dropped out of school. I*

> *also want you to study very hard so that you may become prominent people in the future. Thank you.*

Meme Hilya came with Bapro flour 500g (baking floor), sugar, salt and instant yeast. Meme Hilya asked: "*Is there anyone of you who knows or has seen how homemade bread is made?*" Only about half of the class responded with a yes. LLF was then given a chance to narrate how homemade bread is prepared. Meme Hilya thanked LLF and she started by explaining each ingredient she came with. She said: "*This is the Bapro flour, it is the one used to make uumboloto, this is sugar, this is salt and this is instant yeast used to raise the dough*". At first, she mixed sugar, yeast and salt by stirring. Thereafter, she mixed the salt, yeast and sugar and she started to put in flour (Bapro) and continued stirring until all the ingredients were completely mixed.

Later she warmed the water and poured lukewarm water into the mixture. Afterwards, she instructed that the bucket containing the dough should be covered and placed in the sun. At this point my colleague asked the class "*You guys can remember why warm water neh?*" The class responded with a yes. LJF asked, "*What is the function of yeast in this process and what will go wrong if I did not use it?*" Meme Hilya responded and said: "*The main function of the yeast is to raise the dough so that it can become much, so if the yeast is not used the dough will not raise*".

Another learner asked: "*Can sir highlight anything from a science understanding?*" These questions were redirected back to the class, but it seemed that learners had no idea in this regard. Learners were then informed that yeast is just like *ongudo*. It also has enzymes and the two principle enzymes in yeast are maltase and invertase and these contribute immensely to the total change brought about by yeast activity in the dough. Learners were surprised to see Meme Hilya doing everything scientifically correct though she could not explain all the scientific explanations involved. In this regard, LBF commented: "*So, it is like everything we do has a scientific explanation it is just that we don't know it, this is so funny that we do things that we cannot explain"*.

LMF asked, "*Meme, if I may ask where and how did you learn the function of instant yeast?*" Meme Hilya responded and said:

> *I learned how to prepare uumboloto while I was a child because my mother used to make uumboloto as well, so I just learnt it from home by observing my mother. Our parents rarely teach how things are done and give reasons why – they would just call you to come see how something is done then you learn just by observing.*

LBM asked: "*What will happen if the bucket was not closed and placed in the sun?*" Meme Hilya replied: "*The heat from the sun will hasten the process*". Before the bucket was placed in the sun, two test tubes with stoppers were connected to the bucket lid to collect the gas produced during the fermentation.

After about 20 minutes, the dough had risen. Learners were requested to mention what they thought had raised the dough apart from the yeast. They all replied it was the heat. When asked to shed more light on how the heat raised the dough LLF averred that "*the particles in the dough gained more kinetic heat energy and expand hence the raise*". The class clapped for his answer. Here, they could sense the application of what was learned under the expansion of matter.

LLF was so curious and she asked; "*Sir, can you see that there are small bubbles in the dough, is it possible that it is also caused by CO_2?*" Others responded with yes and one shouted "*I wanted to ask what caused that*". My critical friend acknowledged the learners' observation and said yes indeed, the bubbles were a sign of CO_2 being present. The gas collected in test tubes was bubbled into clear lime water by learners with the help of my critical friend. Learners were so thrilled to witness how the lime water turned milky white. LJM enquired "*Sir, you said you don't know much about CO_2, now who taught you all this? This is so fascinating, which means there might be many things that produce CO_2, maybe it is only that we are not aware of them*". LBF remarked saying "*Ohoo! Now I understand why they call CO_2 a clear gas, I cannot see anything in the test tube but I can see the effect it has on lime water*". Many learners were so puzzled by this practical activity. LJM asked me; "*Sir do you know what is osholololа*? (dehydration oral water solution) *that people get from the hospital when we have stomach problems, it looks just like this lime water now, does that also contains CO_2?*" My critical friend affirmed that yes, there is CO_2 that is why it sparkles. Immediately another learner (LTF) inquired, "*So, does that mean even cool drinks have CO_2 sir, are they?*" My critical friend confirmed that yes, all fizzy drinks have CO_2.

LBF asked "*Sir what is it really that produced CO_2 in the whole process, if there is no burning? I remember in our first lesson we learnt that CO_2 is mainly produced when people burn things in the presence of oxygen*". Again, clarity was given that CO_2 can also be produced through other processes such as respiration and fermentation in this case. LMF commented: "*Ok, I now agree with you sir when you said we learn science in everyday life. It seems we already know most of the things we just have to learn them again and how they are called in science*". Lastly, L4F said "*The presentations on oshikundu and uumboloto changed my mind. I just want to change the statement about my opinion I made in the last interview that science is difficult. I think science is simple because I think though Meme Natalia was not aware that she was doing science she just did everything correctly*".

Later, learners were given an opportunity to ask questions, however, most of them seemed satisfied with the presentation. One learner requested to lead the class in giving thanks to Meme Hilya and she was granted the chance.

Part 1 **Part 2**

Figure 6.4A: Part 1 shows Meme Hilya preparing and explaining how *uumbolot*o is prepared, Part 2 shows the bucket with *uumboloto* dough placed in the sun

Part 3 **Part 4**

Figure 6.4B: Part 3 shows a teacher and learners collecting the gas from the bucket to test for CO_2. Part 4 shows learners observing the effect of the gas collected on clear lime water

6.3 Learners' journal reflections

Reflections were done as a last lesson of the project. Individual learners were requested to bring their reflections to their respective groups so that they could present them as a group. Each group was allowed to present their reflections. Learners' reflections were done to check if there was a shift or (not) in their perspectives and how they made sense of the concept of CO_2 after the presentations by the two expert community members (see Appendix N).

Table 6.1: Shows some scientific concepts that emerged from the making of *oshikundu* and homemade bread (*uumboloto*)

Cultural practices	**Lions**	**Tigers**	**Mouse**	**Bunnies**	**Jackals**
oshikundu	Gas Smell Diffusion Fermentation enzymes CO_2 Boil Melting Dilute	Smell Vitamins Liquid Fermentation Boiling CO_2 Residue Sour Taste	Ingredients Vitamins Gases CO_2 Boiling Energy Ingredient Diffusion bubbles	Water Changing Liquid Gas CO_2 Catalyst Speed Dilute smell	Residue Bubbles vitamins fermentation CO_2 Changing Vitamins Solid Liquid cooling

uumboloto	Gas CO_2 Expand Catalyst Bubbles Heat Temperature	Expanding Gas CO_2 Nutrients Temperature Mixture enzymes	CO_2 Bubbles Warm Water Changing Catalyst Sugar yeast	Sugar Salt enzymes Expand CO_2 Gas Sunlight	Ingredients Expand Mix Luke-warm water Yeast Heat from the sun Changing

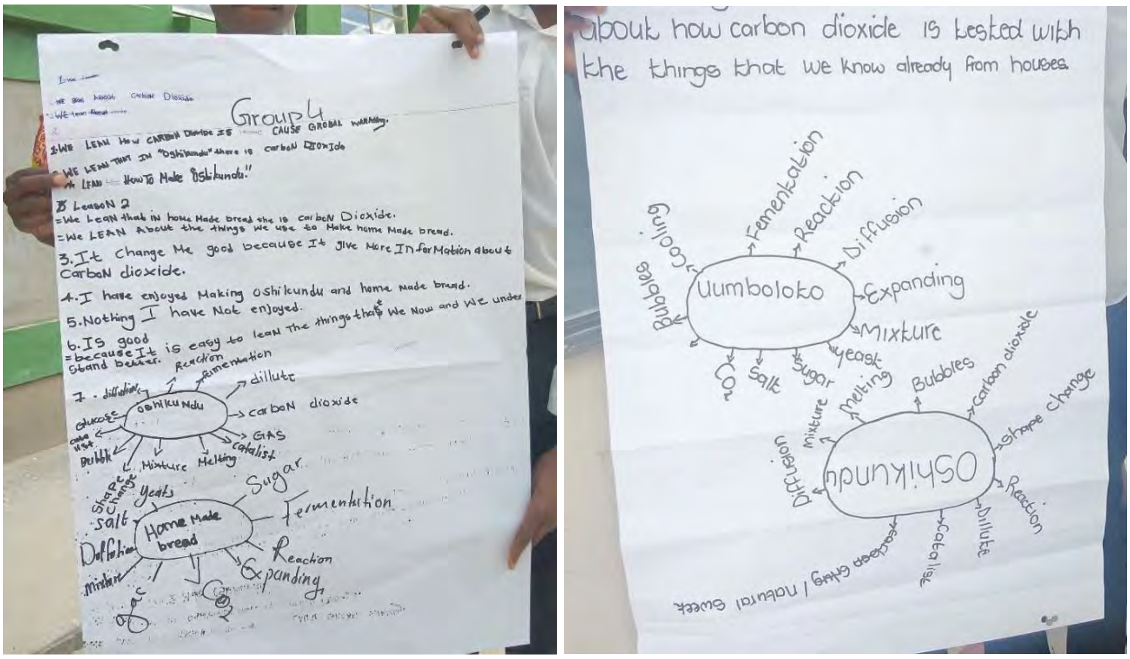

Figure 6.5: Some of the groups' reflections showing words that emerged from the two indigenous practices

6.3.1 Overall reflections

Overall reflections were called for to find out how learners could make sense of CO_2 (What comes to their minds when they hear the term CO_2); unfortunately, since this was done about a week after the week the research was conducted I could only reconnect with 21 participants and they were no longer 30 as before. Together with the guidance of my critical friend learners were asked to write on the chalkboard whatever came to their minds when they heard the concept of CO_2. As a discussion with learners, my critical friend then presented the learners' findings in a mind map on the chalkboard as shown in the diagram below.

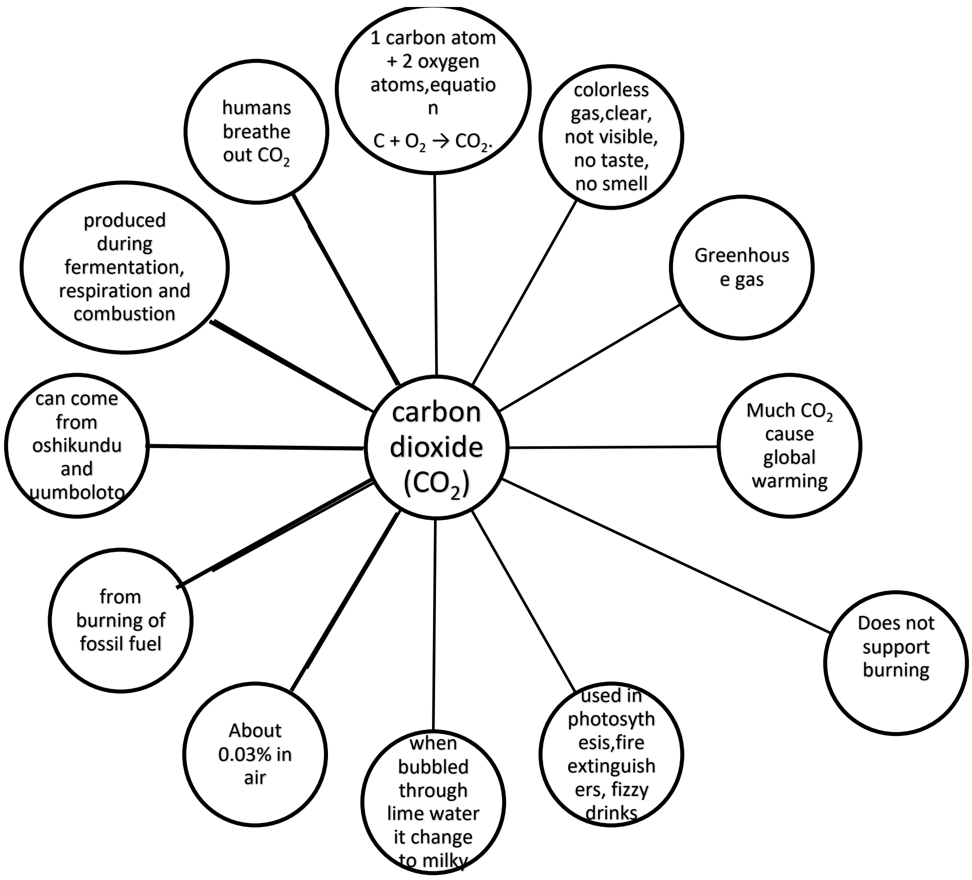

Figure 6.6: Shows learners' mind map of CO_2

From these two data collection tools (observations and learners' journal reflections), the following themes emerged: indigenous knowledge and learning; the role of social interactions, dialogues and participation; and practical activity's role in sense making, learners' perspectives and motivations towards science.

It was very crucial that I used both practical presentations because they were common in the learners' communities. However, I was well aware that conflict between learners' IK and modern scientific understanding might be occurring in learners' minds. To abate this, I used the socio-cultural theory (Vygotsky, 1978) together with Ogunniyi's (2007a) Continuity Argumentative Theory (CAT) to analyse the data from the presentations.

The CAT is rooted in the Aristotelian Contiguity notion of creating a meaningful understanding of learners' experiences to resolve conflicting ideas (Ogunniyi, 2007a). From these, Ogunniyi's (2007a) CAT five cognitive states were used to further explain how conceptions shifted within the learners' minds: dominant, suppressed, assimilated, emergent and equipollent (see Section 3.3). During the presentations, there were arguments before and during the presentations among learners who were questioning what was being observed. Some learners saw it as a conventional presentation that they were exposed to in the community, and others were associating what they observed with what they knew. Hence, it is possible that learners' minds kept shifting along the five cognitive states during the practical activities of making *oshikundu* and *uumboloto*.

Some participants viewed the presentations as simple presentations and not as presentations where they could learn about science in the classroom. This was related to the dominant state. For instance, during the explanations of the community members, learners never thought that the two community experts knew science. Learners thought science was more classroom-based and this was the domain stage kind of thinking they had. This kind of thinking became suppressed when participants were surprised to see how the two community experts were explaining scientific aspects. The new concepts that emerged put learners in an emergent state, as learners began to realise the importance of these practices. Henceforth, the CAT theory was appropriate to use in analysing data from these presentations.

6.3.1.1 Indigenous knowledge or prior knowledge and learning

Like in the previous chapter under group activity, again learners' indigenous and prior knowledge emerged from the presentations. This time I was not interested in knowing whether learners' prior or IK was good or poor, but I wanted to know how learners' IK helped learners to interact, participate and learn. Similarly, I wanted to know how learners prior knowledge enabled learners to make sense of CO_2 and if there was a shift in their prior perspectives and motivations towards science.

The findings revealed that learners made sense and learnt about the topic of CO_2 after their IK was considered a stepping stone towards learning science. For example, when Meme Natlia asked: "*Who knows what is oshikundu and how it is prepared?*", almost the whole class raised their hands. This alone was a good starting point for learning, as it began with the basics (learners' prior knowledge). During the presentations on how to make *oshikundu*, soon after the testing for CO_2 was done, LJM asked me; "*Sir do you know what oshololola is* (Dehydration oral water solution) *the thing people get from the hospital when they have stomach problems, it looks just like this lime water now, does that also contains* CO_2*?*"

My critical friend affirmed that yes there is CO_2 which is why it sparkles. Immediately another learner (LTF) inquired, "*So does that means even cool drinks have CO_2 sir, they all sparkle like oshikundu?*" My critical friend confirmed, "*yes all fizzy drinks have CO_2".* From the questions posed by these learners, it is sensible to assume that these two learners were relating what they had observed to what they already knew – again it is the prior knowledge that enabled learning.

Furthermore, LBF asked "*Sir what is it really that produced CO_2 in this whole process, if there is no burning? I remember in our first lesson we learnt that CO_2 is mainly produced when people burn things in the presence of oxygen*". From this excerpt, a learning opportunity occurred as a result of this specific learner's prior knowledge. This made room for this learner to learn other means through which CO_2 is produced (fermentation and respiration). Initially, she only knew of combustion, this was her prior knowledge, and it is this limited knowledge that forced her to ask this question. Again, this is an indication that prior knowledge in learning does not only work as a foundation on which learning begins, but it also raises curiosity about the unknown which enhances learning as well. Thus this learner was able to learn what was unknown to her – the other processes of producing CO_2 such as respiration and fermentation. This coheres with Nyika (2017), Ogunniyi (2007a), and Roschelle (1995) who proposed that teaching approaches should be built on learners' prior knowledge and experiences from everyday socio-cultural interactions that are crucial in the learners' successive learning.

In this study, it cannot be emphasised enough that the presentations on learners' indigenous knowledge were intended to build on learners' prior knowledge. This is the idea supported by Erinosho (2013), Mavuru and Ramnarain (2020) and Vygotsky (1978), that teachers should employ teaching strategies that induce and challenge learners to use their socio-cultural background experiences and cultural worldviews in class to make sense of science concepts and to fully explore opportunities embedded in IK, therefore enhancing learning with understanding.

Moreover, learners get motivated to learn if the learning content is related to what they know. For example, LMM commented that "*I think teachers must start making things clear like you, those things in the books are for smart people, people like me will only get 100% if teachers start teaching this way otherwise they should always mix methods and give relevant examples to us slow learners*". Notably, when LMM said teachers should start making things clear like you and use mixed methods, he meant teachers should integrate learners' IK into science teaching. Therefore, this learner indicated that new learning content becomes meaningful when it relates to what he knows. In actual fact, prior knowledge welcomes learners to the science classroom; it makes them feel more at home.

The findings indicated that the two *Oshiwambo* indigenous practices done with *Oshiwambo* children and in the *Oshiwambo* language promoted lengthy discussions and interactions that afforded almost all participants a chance to say something. Thus, it was a guiding tool for facilitating the bridge between what learners already knew and what they did not which made the teaching effective (Nikodemus, 2017). This resonates with Kuhlane (2011), who suggests that to help learners make the most of a new experience, teachers need to understand how prior knowledge affects learning, since new knowledge begins with the selection of ideas from everyday experiences. Kibirige and van Rooyen (2006) posit that science teaching becomes effective when IK which is learners' prior knowledge is considered as the starting point of learning. These authors further indicate that IK promotes communication skills.

Correspondingly, Ogunniyi and Ogawa (2008) attest that IK builds a strong link to everyday experiences, leading to learners actively participating in lessons. Sharing the same sentiments are Brayboy and Castagno (2008) who posit that integration of IK does not only bridge science to IK but provokes learners' thinking, which leads to critical thinking skills (Magwentshu, 2020). It is through the implementation and integration of IK in schools that learners, parents and communities can reclaim their voices in the process of educating the African child (Shizha, 2013). Moreover, Le Grange (2007) and Mukwambo et al. (2014) advocate for the integration of IK arguing that it paves the way for authentic Africanisation in teaching and learning. Prior knowledge enhances dialogues and interactions between participants.

6.3.1.2 The role of social interactions, dialogues and participation

In this study, the *Oshiwambo* language was used by the community expert members who were the more knowledgeable others (MKO) in the two indigenous practices (*oshikindu* and *uumboloto*) to scaffold the learners. Undoubtedly, the language played a role in the communication between the community members and the participants. For instance, learners were freer to express themselves and explain things in more detail than in English. Thus, almost every learner had something to say or asked a question. Participation increased rapidly. This was evident when the lions echoed that "*Some people were so excited and we have not* *enjoyed when people were making noise and almost the lesson turned into debates*". This was a good opportunity for learners to learn from each other and create new knowledge.

Learners themselves indicated the vitality of their local language. For example, LTM when asked how they wanted to be taught science indicated, "*I think teachers are trying their best, but my wish is for them to try to explain things further always even in Oshiwambo to make us understand those new and difficult scientific concepts in detail*". The above excerpt resonates with Mavuru and Ramnarain's (2020) claim that language as part of the learners' IK plays a vital part in learning. It was reflected in this study that the *Oshiwambo* language which was used as a mode of learning (communication) eased the learning process through constructive dialogues and that new knowledge was created.

Though the medium of instruction at the Grade 8 level in Namibia is English, several learners could hardly construct a sentence in English and those that tried could hardly do so as they had a fear of speaking what is referred to as '*broken English*' and becoming laughing stocks. Thus, English is one of the impediments to science learning, particularly for the rural school learners as claimed by Henderson and Wellington (1998). The interactions that occurred during the practical demonstrations also proved beyond doubt that teaching and assessment which provides equal opportunities for diverse learners, by considering learners' socio-cultural experiences, languages and the local discourse, will always allow learners to become MKOs in teaching and learning and construct new knowledge. This study coheres with Vygotsky's (1978) SCT that learning occurs through social interactions. Vygotsky's (1978) theory stresses the fundamental role of social interactions in the development of cognition. Vygotsky strongly believed that community plays a central role in the process of making meaning. It was against this background that two community experts were invited to share their expertise in making *oshikundu* and *uumboloto* respectively.

6.3.1.3 Practical activity's role in sense-making, learners' perspectives and motivations towards science

The practical demonstrations conducted by the two community expert members in this study assisted learners to ask questions about what they observed, but even before that, it raised curiosity in learners to find out how *oshikundu* and *uumboloto* would produce CO_2 and many other questions. For instance, LJF asked Meme Natalia why *oshikundu* became more liquid after adding *ongudo*. Meme Natalia indicated that she did not really know why or what really happens but she indicated that it is a well-known fact that once one adds *ongudo* to *oshikudu* it becomes more of a liquid. Another learner (LLF) requested "*could please sir explain scientifically what happened to oshikundu when ongudo is added?*" My critical friend intervened that in *ongudo* there are catalysts known as enzymes which make biochemical reactions happen faster, subsequently, some enzymes in *ongudo* such as pancreatic lipase are responsible for the reaction observed when *ongudo* is added to *oshikundu*. Thus, with the help of water they break down the carbohydrates molecules in the first mix that looks like pap and gradually turn *oshikundu* into a liquid form.

From Meme Natalia's response, even though she could not explain exactly what happened when *ongudo* is added to *oshikundu*, what stood out is the fact that learners were able to visualise what had transpired. Also, excitingly, Meme Natalia seemed to know that there would be a change (reaction) that would always take place and she knew that the result would always be *oshikundu* becoming more liquid as she re-counted that; *"I don't really know what happens but it is a well-known factor that once one adds ongudo to oshikudu it becomes more of a liquid*".

At this point, learners had a chance to make sense of what a catalyst is as mentioned earlier by my critical friend. In this case, learners were afforded an opportunity to learn and imagine the scientific concepts of catalysts and enzymes. Similarly, Meme Hilya requested that the bucket with the bread dough be placed in the open space to get some heat from the sun for the dough to rise faster, which was in actual fact a way of speeding up the reaction and expansion process of the dough as espoused by the kinetic particles theory of matter. From her response, it could be inferred that local knowledge is rich with science that should be embraced to transit from home to classroom science. These are the same views shared by Mawere (2015), that the use of IK makes Western Science more accessible as it moves from the known to the unknown. To this, Jegede (1995) refers to it as collateral learning.

Generally, laboratory-based practical activities arouse learners' interest to learn. However, in the absence of a functional laboratory, indigenous technologies may be used to carry out hands-on practical activities and serve the same purpose. Interestingly, these forms of interventions are even more fruitful since they fall under learners' prior knowledge. The hands-on practical activities of making *oshikundu* and *uumboloto* are learning experiences which are designed to, through action, forge a link between the observations and the theories/ideas of science

(Asheela, 2017). Wiebe et al. (2001) stress that using indigenous technology as a cultural tool for mediating classroom science allows for the visualisation of scientific concepts, presenting learners an opportunity to make sense of new science concepts in new but familiar contexts. Cook (2006) refers to visualisation as a teaching and learning approach in which science instruction is combined with visual and verbal information.

Furthermore, learners were able to relate what was being taught in the classroom to real-life situations and learn something new. This was a sign that they were at an emergent stage. To this, Ogunniyi (2007a) posits that at this stage, learners begin to acquire new knowledge. In the case of this study, they began to relate the science learnt from the indigenous practices of making *oshikundu* and *uumboloto* to classroom science. For instance, during the presentation by Meme Hilya, learners were asked to mention apart from the yeast, what else they thought caused the dought to rise. They all indicated that is was the heat. When asked to shed more light on how the heat raised the dough, LLF indicated that "*the particles in the dough gained more kinetic heat energy and expand hence the raise*". The class clapped for his answer since they could see the application of what was learned under the expansion of matter. This stage is called equipollent because the explanation given by Meme Hilya and LLF were valued the same. According to Govender (2016), at this stage, learners begin to appreciate that the two competing ideas have equal intellectual force and they co-exist. Thus, this understanding demonstrates the importance of local knowledge in science as it contextualises learning.

Furthermore, during the group reflections, learners were asked to explain in what ways the presentations or the integration of IK in science lessons changed (or not) their view about learning science. The lions indicated that at first, they thought science was detrimental to them because they could not understand why CO_2 is needed in the atmosphere. After the presentations, they acknowledged the use of IK because it helped them learn more about physical science, the importance of CO_2 in particular and to not forget what they learnt. The mouse responded that "*we have now enjoyed science in these presentations unlike before because we had fun by telling or talking about things we use to do at home. The integration of IK is good in science lessons because it made things clear to understand and they make sense to us*". This was similar to the Jackals who indicated that "*teachers should always teach us new terms using the things we know from home so that we can learn faster in topics on gases, matters, enzymes and others*".

It was apparent from the comments by learners from these groups that there was a shift in their views about science. Again, the first domain stage of science became suppressed as they began to link the two indigenous practices to possible topics in Physical Science, where the making of *oshikundu* and *uumboloto* could be used as a learning support material, for example, to explain what happens to the particles of matter when heated.

Therefore, from the above views, it could be hypothesised that the learners began to link the presentations to other science topics that they had learnt. This demonstrated that there was a shift in the perspectives of learners about science. It could be suggested that hopefully, the shift might have resulted from the dialogues and arguments among learners. It was evident that arguments arose among the participants during the presentations, and that these helped them broaden their knowledge through the exchange of ideas. The knowledge which was acquired during their social interactions contributed to a shift in their ZPD (Vygotsky, 1978).

Indigenous knowledge (IK) does not only smooth the learning process but also gives learners pride in their own culture (cultural identities) and a sense of belonging. Thus, these two presentations did not only smooth the learning of science but it passed on indigenous practices from elders to the young ones. When both community experts asked where they learned how to make either o*shikundu* or *uumboloto*, Meme Natalia affirmed that she observed her parents doing it and Meme Hilya said that it was from her mother. These responses concur with Keane et al. (2016) that IK is living, evolving and travelling with our stories. Stories are a powerful way to disseminate knowledge to indigenous people. Similarly, many IK practices continue to be dynamic and responsive in changing times (Ngcoza, 2019). Again, the presentation by the community members allowed learners to relate their findings to other science topics. As a result, learners were able to extract some scientific concepts that emerged from the presentation and link them with specific explanations or topics in the science classroom. This was evident in the questions asked to assist the participants to make sense of the scientific knowledge that emerged from the practical demonstrations (see Table 6.2; Figure 6.5). The practical activities also made it possible for learners to make sense of what CO_2 is. For example, one learner remarked that she now understands why they call CO_2 a clear gas; she further uttered that though she could not see anything in the test tube, she could see the effect it had on lime water, therefore that meant there was an invisible gas in the test tube. Similarly, L4F avowed that the presentations on *oshikundu* and *uumboloto* changed her mind about what she said before the presentations when she stated in the interview that science was difficult. She continued saying she now thinks science is simple. This was because she could tell that, even though Meme Natalia was not aware that she was doing science, she just did everything correctly.

The involvement of community knowledge in teaching and learning enabled learners to appreciate and respect the knowledge of elders and other community members. The approach supports a good relationship between the classroom and community members as the inclusion of IK ensures that schools are more open to their surroundings. In addition, Klein (2011) notes that the involvement of community members in teaching, builds the relationship between the school and the society in which they live, thus breaking the boundary that schools are an island as often perceived by the community. It was against this backdrop, that the study added value to the natural context by inviting community members into the classroom and even more into teaching science.

Thus, the presentation enriched learners' interest and motivation as they were able to link the community members' explanations to science [equipollent]. LMF commented: "*Ok, I now agree with you sir when you said we learn science in everyday life. It seems we already know most of the things we just have to learn them again and how they are called in science*".

From this excerpt, it can be concluded that IK is science since science starts at home. For instance, LMF commented that she had learnt some concepts of science from the presentations. Thus, it can be concluded that this learner was at an *emergent* stage as there was a shift in his learning (new knowledge acquired) after the presentations. LMF continued that it contributed better to his science understanding by showing how some science processes worked and what the things she only knew from home were called in science. The learner appreciated the two knowledge systems as they complemented each other, which transited the learner to an *equipollent* stage (Ogunniyi, 2007a).

Finally, the statements made by these learners validate that there was a shift in the learning and the learners' ZPD as espoused by Vygotsky (1978). Similarly, learners' reflections showed that there are a lot of scientific phenomena which could be used for culturally responsive pedagogies (Mhakure & Otulaja, 2017). According to Shizha (2005), home and community environments are significant contributors to learning and developing positive attitudes toward science. Therefore, in this context, the process of making *oshikundu* and *uumboloto* were supportive materials that learners were familiar with and could relate to. It can be concluded that IK and western knowledge complement each other (Shizha, 2005) and learners could learn science easily at this equipollent stage as espoused by Ogunniyi (2007a). The presentations helped learners to appreciate their daily life experiences. For example, LBF claimed no matter how forgettable she was, she will never forget that CO_2 can be produced from *oshikundu*. This corresponds with Erinosho (2013), that knowledge of indigenous science can be viewed as a stepping stone, thus, learners find it easier to make the connection between their experiences and science taught at school if their socio-cultural contexts are considered (Fleming & Regmi, 2012). This was also supported by Mukwambo (2017), that IK is constructed using observations and passed on verbally. Moreover, in all the practical activities alluded to earlier, it was ideal to frame this study with the socio-cultural theory (Vygostky, 1978) as indicated throughout this thesis. Additionaly, the vernacular language (*Oshiwambo*) provided a smooth mediation by the MKOs resulting in enhanced social interactions. It is also possible that this platform might have created an opportunity for learners to reach their ZPD as it was reflected in their journal reflections.

6.4 Chapter Summary

In this chapter, I presented data on the participatory observation and learners' journal reflections. The findings revealed that apart from the learners' indications of having enjoyed the integration of IK into science there was a shift in their prior perceptions about science. The presentations motivated them to want to do science and it was through the presentations that learners were able to make sense of the concept of CO_2 and other related scientific concepts that broadened their conceptual understanding of science.

CHAPTER SEVEN: SUMMARY OF FINDINGS, RECOMMENDATIONS & CONCLUSION

7.1 Introduction

The main goal of this study was to mobilise the indigenous technologies of making *oshikundu* and *uumboloto* (homemade bread) as easily accessible resources to carry out hands-on practical activities to support Grade 8 Physical Science learners to make sense of the topic of CO_2. In order to achieve this goal, I employed a qualitative research design to generate data using a variety of methods. I used focus group interviews, a group activity, participatory observations and learners' reflections. This multi-method, multidisciplinary collaborative research was insightful. It permitted cross-validation and facilitated exploration of issues that influence learners' motivation to do science, their perceptions towards learning science and their home (prior) knowledge. This rich triangulation was useful in validating the findings of this study. Data were analysed using an inductive-deductive approach and the discussions were made using relevant literature and theory. A thematic approach to data analysis was employed to come up with sub-themes and themes. To achieve the goal of this study, the following research questions were addressed:

1. What are Grade 8 Physical Science learners' perspectives and motivations for learning the topic of CO_2 before the intervention?
2. What do learners know from their homes and communities about CO_2?
3. In what ways do the Grade 8 Physical Science learners interact, participate and learn (or not) the concept of CO_2 during the practical demonstrations on the making of *oshikundu* and *uumboloto* by the expert community members?
4. How do the presentations by the expert community members on making of *oshikundu* and *uumboloto* shift (or not) Grade 8 Physical Science learners' perspectives and motivation to learn and make sense of the topic of CO_2?

In the preceding chapters, I presented, analysed and discussed data generated from the focus group interview, group activity, participatory observations and learners' reflections. Thus, in this chapter, I present a summary of findings, recommendations, suggested areas for future research, limitations to the study and my reflections. This chapter ends with a conclusion.

7.2 Summary of Findings

In this section, I present a summary of the findings of the study in relation to the four research questions. In doing this, I highlighted to what extent these questions were answered.

7.2.1 Research question 1

> *What are Grade 8 Physical Science learners' perspectives and motivations for learning the topic of CO_2 before the intervention?*

The findings from this study revealed that learners are optimistic about doing science and are motivated to learn science especially if their prior knowledge is mobilised in science lessons. This finding suggests that there is a need to relate science to learners' daily life experiences to create positive attitudes in learners about science (Gwekwerere, 2016). Learners indicated that their lived experiences are important as they assist and enhance their understanding of science. To achieve this, the teaching of science should be based on learners' experiences. Therefore, it should be recognised that learners' daily life experiences act as their prior knowledge and the foundation to build on for classroom science. For instance, L4F commented that when home-based knowledge and experiences are brought to school or say in the Physical Science lessons, it makes science at school easier and it motivates her to learn science. The findings support literature that suggests that the integration of familiar situations motivates learners to learn science (Cetin-Dindar & Geban, 2017). This means that taking into consideration learners' daily life experiences helps them to link outside science with classroom science (Aikenhead & Jegede, 1999; Mavuru & Ramnarain, 2020). This can be achieved using easily accessible materials (Asheela et al., 2021).

However, learners have acknowledged that the absence of science laboratories and a lack of hands-on practical activities demotivates them to do science and deprives them of broadening their existing knowledge. For example, L1M put it clearly that sometimes when teachers are explaining, learners do not get the ideas well, therefore, teachers should bring to class a lot of material and visual things that learners can see, such as videos, because they help learners to understand things in more detail. He further emphasised that teachers should also let them do practical activities, because science is all about mixing things and that would help them to learn more about science. Thus, the findings revealed that learners share a strongly positive view on the use of easily accessible materials to teach science.

7.2.2 Research question 2

What do learners know from their homes and communities about CO_2?

It was observed that learners have an abundant understanding of CO_2 from home, which is rich prior knowledge. For instance, when asked what CO_2 is, the Lions group indicated that CO_2 is a colourless gas breathed out by humans and animals. Other groups gave several sensible answers too. Such prior knowledge shared by learners may be used to accommodate new information (Erinosho, 2013; Mavuru & Ramnarain, 2020; Vygotsky, 1978).

The findings have also revealed that there are numerous indigenous technologies that learners are aware of that may be used fruitfully to carry out hands-on practical activities in science lessons. Though several learners indicated they had good prior knowledge about CO_2, some learners seemed to not be well acquainted with the concept of CO_2. Nonetheless, these learners equally indicated good prior knowledge in the discussions that they were immersed in after the groups' presentations.

7.2.3 Research question 3

In what ways do the Grade 8 Physical Science learners interact, participate and learn (or not) the concept of CO_2 during the practical demonstrations on the making of oshikundu and uumboloto by the expert community members?

It was observed that the two indigenous technologies increased learners' participation and interactions during the Science lessons . This finding is in line with the findings of Kudumo (2020) and Erinosho (2013), where similar case studies were conducted using easily accessible materials. This study revealed that learners were joyous, inquisitive and curious during the presentations. Findings have also shown that interactions, participation and motivation were enabled using easily accessible materials and home languages (*Oshiwambo* in this case). To this, Asheela et al. (2021) posit that easily accessible materials reinforce social interactions that enhance meaningful learning. In this study, the use of home language stimulated learners' active participation (Sedlacek & Sedova, 2019) resulting in them asking questions so that they could learn more from the expert community members.

The community members were glad to be invited to share their knowledge with learners. Their involvement in teaching made them feel fully involved in the school's affairs and they really valued the invitation. The two community experts requested that they would like their real names to appear in this study because they would always be ready to assist with indigenous practices if need be.

7.2.4 Research question 4

> *How do the presentations by the expert community members on the making of oshikundu and uumboloto shift (or not) Grade 8 Physical Science learners' perspectives and motivations to learn and make sense of the topic of CO_2?*

The findings from this study revealed that the presentations complemented the learners' understanding through practical hands-on activities. For example, at first, the Lions group thought science was a bad subject because they could not comprehend it. It was only after the presentations that they realised that science was a good subject for them. They claimed that the mobilisation of IK helped them learn more about CO_2 and that they would never forget what they were taught. In addition, the findings uncovered that apart from the presentations increasing learners' participation and interaction, it also created awareness in learners to value their indigenous technologies. This gradually shifted their perspectives about science and raised a desire in them to do Science. As a result, they indicated a higher motivation to be engaged in school science. This resonates with Hashondili (2020), that the community members' presentations assisted the participants to make sense of the scientific concepts through the practices and that they viewed IK as visualisation.

Learners expressed appreciation for the presentations, claiming that they changed their thoughts about science. They also proposed that teachers should always teach them new concepts using the things they know from home in topics such as gases, matters and enzymes so that they could learn faster.

In addition, the hands-on practical activities also afforded learners a sense of what CO_2 is as evidenced by the mind-maps that the learners developed (see Figure 6.5). The knowledge learners obtained from the community members contributed to their subject content knowledge of the concept of CO_2. Thus, this indicated learners' cultures and traditions as an accessible source of knowledge that could be fruitful in school science.

The findings also revealed that social interactions and arguments that took place during the presentations helped learners to clarify the 'myths' about IK practices that were not science. For instance, learners had different cultural beliefs about *oshikundu* that may not necessarily be scientific that appeared during the presentation on o*shikundu*. Also, from the two presentations, learners extracted science concepts that were embedded within the IK practices. Therefore, the use of Ogunniyi's CAT helped provide insights into how learners framed their arguments when they were exposed to IK practices in school science.

7.3 Recommendations

The study recommends that the traditional practices of making *oshikundu* and *uumboloto* be integrated into the teaching of science in schools, especially in localities or rural areas where these two indigenous technologies are practised. That is, teachers should attempt to use IK practices to make science accessible and relevant to the learners (Asheela et al., 2021; Shinana et al., 2021).

As evidenced in this study, the traditional practices of making *oshikundu* and *uumboloto* could be extended to topics such as expansion, reactions, fermentation and enzymes. It should, therefore, be acknowledged that learners come to school with a wealth of knowledge that can be used as a steppingstone to the learning of science concepts. The mobilisation of IK into science lessons serves as learners' motivation to do science. This finding has affinity with Liveve's (2017) and Khulane's (2011) assertions that it is impossible to learn without prior knowledge. In light of this, teachers should ensure the knowledge and experiences learners bring to the science classroom are used to enhance their understanding (Mavuru & Ramnarain, 2020).

Furthermore, the study recommends that curriculum developers must explicitly state how IK should be integrated into science classrooms. For instance, Majoni and Chinyanganya (2014) postulate that learners learn better when exposed to their cultural experiences. Similarly, Govender (2016) cautions that the segregation of IK poses difficulties in making sense of abstract science concepts. Thus, Klein (2011) notes that IK can be integrated into schools by drawing on the skills and knowledge of the community members, who are the custodians of that knowledge.

7.4 Areas for Future Research

Research on the same topic could be extended to grade 10 Chemistry learners since they deal with the gases of air in-depth. In addition, further research could be done on the same topic carbon dioxide (CO_2), whereby the community members demonstrate to teachers how the making of *oshikundu* and *uumboloto* could be mobilised to mediate learning and sense-making of CO_2 by Grade 8 learners in rural schools. Furthermore, the research could be extended to more schools and even to Grade 7 learners in the region. Lastly, it would be really interesting to see how learners would go about analysing curriculum documents, for example, syllabi and a textbook on how the concept of CO_2 is presented and to hear their voices after doing the exercise. It would also be interesting to look at the importance of analysing school-community partnerships on the integration of IK into science education, including the benefits and obstacles for both parties. Additionally, to research further on the meaning and importance of IK in science education, aligning it with the promotion of STEM education policy and sustainable development goals (SDGs) or education for sustainable development (ESD) in the Namibian (or African) context.

7.5 Limitations of the Study

The focus of the study was to explore how the mobilisation of the indigenous technologies of making *oshikundu* and *uumboloto* may be used to mediate the learning and sense-making of CO_2. The participants were Grade 8 Physical Science learners from the Ohangwena region. The study was carried out with 30 Grade 8 learners, therefore, the findings cannot be generalised to represent all Physical Science learners in the region at large. Nonetheless, the study provided insights into how the making of *oshikundu* and *uumboloto* may be mobilised to shift learners' perspectives and motivation towards learning science and to specifically make sense of the topic of CO_2.

In addition, learners did not analyse the curriculum documents before the presentations, which I think is a lost opportunity. Also, learners did not reflect individually, which I believe could be a great opportunity. In addition, the data collected was done earlier at the beginning of the academic year, so most of the Grade 8 Physical Science topics were not yet covered; learners could have easily related the concepts from the topic of CO_2 to many other topics. This may as well be a lost opportunity as learners mostly referred to what they learnt in Grade 7 only. Another missed opportunity occurred just before we placed the lit match sticks into the test tube with CO_2. Learners could have learnt better if we had asked them to predict and explain using the PEEOE approach as espoused by Asheela et al. (2021), to explain what would happen if we placed a lit match stick in the test tube. In addition, it is also possible that the true essence of what learners meant during their interactions might have been lost through the translation from the vernacular language (*Oshiwambo*) to English. Last, I should highlight that financial constraints may have also played a role as one of the limitations, because we could not get to all the places we wanted to, for example, the bread baking site for Meme Hilya. Finally, if I were to do this study again, I would refer to the Periodic Table of Elements on how CO_2 is formed as well as the chemical reactions of CO_2.

7.6 Personal Reflections

I started my journey of further studies in 2006 at the University of Zimbabwe where I obtained a Diploma in Mathematics Education in 2008. I further enrolled with the University of Namibia where I obtained another diploma in Mathematics Education in 2010. After that I applied for admission at Rhodes University in 2013 and 2017 but I could not secure a place. Fortunately, in 2019 I was granted admission to the same university to do a BEd Honours degree in Mathematics and Science. Therefore, I grabbed the opportunity given to me with both hands; I told myself to not look backwards but to keep on moving forward. My mission had just begun and my dream was to leave Rhodes with a red gown, that is, to study further until I graduated with a PhD.

My initial passion was Mathematics since it is the subject I have been teaching for the past 12 years. However, something happened in my second year of the BEd Honours programme. I was introduced to IK as one of three components of our study of Science education. We had a mini-activity on the cultural beliefs of various ethnic groups about lightening. Luckily, our class was so diverse in terms of Namibian cultures. Interestingly, we even had Prof Ken Ngcoza from South Africa and Dr Mutanho from Zimbabwe. That enriched our findings from different local and international cultures. Fascinatingly, answers from all cultures were almost similar. I was convinced to believe that there is a degree of truth in cultural knowledge, otherwise, how did all these diverse cultures provide more or less the same findings? That meant a lot to me because generally, I am passionate about the cultural ways of life. I became so interested and thought of looking at the world from this point of view. I realised that Science was the only subject that could make room for this opportunity, hence I developed more love for Science than Mathematics.

Upon completing my BEd honours programme, the idea of integrating cultural knowledge in science triggered me to research IK. However, I initially struggled to come up with a research topic along these lines because there was a conglomeration of ideas in my mind. Fortunately, with the help of Professor Ngcoza, Dr Mutanho and other scholars from the Rhodes University Science Education Department, I came to read studies conducted by numerous scholars. Luckily, in my first year as a master's scholar, I also had an opportunity to attend an online Research Design Course at Rhodes University. From the presentations, I came to realise that there was a lot of science in the community that seems to be underutilised. I, therefore, came to conclude that I was one of those teachers who did not value learners' socio-cultural backgrounds in my science lessons (Mavuru & Ramnarain, 2020). I started integrating learners' lived experiences in my science lessons, and learners developed an interest in finding out more about IK, although at first, they found it hard to believe that their home knowledge could be useful at school. For example, in Grade 8 Physical Science in the chapter on gases of air, there is one specific objective where learners should state the ways of producing CO_2 – the textbook identifies that it is through respiration and combustion, but does not include any indigenous practices. I felt these could be easily learnt if learners' IK was considered in science lessons and textbooks.

With the skills I obtained from various presenters and through numerous readings plus our Zoom meetings that we had several times, I was able to sort out my mind and decided to use *oshikundu* as a common learners' indigenous technology to mediate learning and sense-making of CO_2 at a Grade 10 rural school. Unfortunately, Shinana (2019) had already conducted a study on mobilising the indigenous practice of making *oshikundu* using an inquiry-based approach to support Grade 8 Life Science teachers in mediating the learning of enzymes. Thus, I changed my mind because I did not want to duplicate her study. Consequently, I thought of mobilising the indigenous technologies of making *oshikundu* and *uumboloto* to motivate and enable sense-making on the topic of carbon dioxide by Grade 8 rural school learners. *Oshikundu* would have been sufficient for this mediation but I wanted to cement the findings with the practice of making *uumboloto* which was completely new to me, as I had never come across any study conducted on *uumboloto* for this purpose. Also, I did away with Grade 10 learners because I assumed that they might be in a good position or more knowledgeable about CO_2 already, so I opted for the Grade 8 learners.

However, I was well aware that arguments are likely to occur where different views are administered. Hence, I used Vygotsky's (1978) SCT to analyse the interactions and Ogunniyi's (2007a) CAT to complement the two different worldviews (Westernised Science and IK). I should also acknowledge that with the current world economic crisis, these practices offered an opportunity to do hands-on practical activities at no cost.

From this study, the presentations by the community members were a revelation to me on the importance of indigenous practices that were neglected unknowingly by myself in my teaching. For instance, I came to learn that the processes of making *oshikundu* and *uumboloto* can indeed be used to teach numerous concepts in Physical Science. Furthermore, this study made me realise the importance of home language as a mediating agent in teaching science (Mavuru & Ramnarain, 2019; Msimanga & Lelliot, 2014). Home language activated learners' participation in the presentations (Sedláček & Sedova, 2017); therefore, home language was a liberator of learners' voices.

The invitation of the community members taught me to appreciate the knowledge the community elders possess and how it can be integrated into science classrooms (Klein, 2011; Lavallee, 2009; Mateus & Ngcoza, 2019). Thus, the exposure and experiences from this study contributed to my academic and professional growth as a scholar and science teacher.

Lastly, I should highlight that this study was conducted during the COVID-19 pandemic. Therfore, due to the changes in the school calendar the duration of this study was prolonged. Despite these challenges, through Ubuntu my supervisor kept on motivating us not to lose momentum and to keep on pushing. We have always believed that together we can do better as we keep on using our slogan that says "If you want to walk fast walk alone, but if you want to walk far walk together" (African Proverb).

In hindsight, COVID-19 has taught us to value the importance of technology that should have been given more priority in the 21st century for online classes to take place without disturbance. Moreover, COVID-19 has taught us to persevere in all circumstances – we lived each day as if it was the last day of our lives and thought we would live forever, and we never lost hope.

COVID-19 was a new dawn, there was no previous experience for us to know how to handle the situation – this new experience has created a new normal, where washing hands, sanitising, use of masks and social distancing is the order of the day.

7.7 Conclusion

This study contributes to the current decolonisation or decoloniality debates meant to shift ontological and epistemological orientation to enable the integration of IK in science teaching (Chilisa, 2012). This was done by tapping into the cultural heritage of the community members who were positioned as the MKOs in this study (Vygotsky, 1978). Thus, integrating learners' lived experiences of IK from home and the local community helped the transition to the learning of scientific concepts. Aikenhead and Jegede (1999) refer to this phenomenon as border crossing. As a result of the presentations by the community members, learners acknowledged the use of easily accessible resources in conducting hands-on practical activities (Asheela et al., 2021; Shinana, 2021). Hence, learners were able to link science to their out-of-school environment. For example, learners realised that the explanations given by Meme Hilya on why the bread dough should be placed in the sun and the one given by my critical friend was similar. This finding validates Taylor and Cameron's (2016) advice that IK has the potential to complement westernised knowledge rather than these knowledges being seen as mutually exclusive. That is, there should be a dialogue between these knowledges (Seehawer & Breidlid, 2021). It was against this caveat that this study opted for an integrationist approach (Taylor & Cameron, 2016).

It also emerged in this study that language plays a crucial role in the preservation and transmission of IK (Khupe, 2017). In addition, this study revealed that the use of learners' indigenous language helps learners to learn science. This study, therefore, contributes to the possibilities of how learners' socio-cultural backgrounds can be used in the science classroom as reiterated by Mavuru and Ramnarain (2020). Thus, the science embedded in the cultural practices of making *oshikundu* and *uumboloto* could be optimally used by teachers in their science classrooms to contextualise science lessons.

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Appendices

Appendix A: Ethical clearance letter

RHODES UNIVERSITY
Where leaders learn

Rhodes University, Education Faculty
Research Ethics Committee
PO Box 94, Makhanda, 6140, South Africa
Tel: +27 (0) 46 603 8393
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email: e.rosenberg@ru.ac.za

https://www.ru.ac.za/researchgateway/ethics/

30/09/2021

Prof Kenneth Ngcoza

Education Department

K.Ngcoza@ru.ac.za

Dear Prof Kenneth Ngcoza and Mr Fredinard Nandjedi

Re: Mobilising the indigenous technology of making oshikundu and homemade bread to mediate learning and sense making of the topic carbon dioxide in a grade 8 rural school in Namibia.

APPLICATION NUMBER: 2021-5239-6295

This letter confirms that your research ethics application has been reviewed and **APPROVED** by the Education Faculty Research Ethics Committee (EF-REC). Your permission letter(s) where applicable have been received and you are free to proceed with your study.

Approval is granted for 1 year. An annual progress report is required in order to renew approval for an additional period. You will receive an email notifying you when the progress report is due.

Should any substantive change(s) be made during the research process, that may have ethical implications, you should notify the Education Faculty REC Chair via email. This includes changes in investigators. The REC Chair will advise as to whether a new application is necessary.

Do keep this clearance letter secure and accessible throughout your study and after its completion. It will be needed when a thesis is examined and when publications are submitted to journals.

Please also submit a brief report to the REC Chair on the completion of the research. This can be done via email. The purpose of this report is to indicate whether the research was conducted successfully and whether any ethics-related matters arose that the committee should be aware of, in order to guide future studies. Sincerely,

Prof Eureta Rosenberg

Chair: Education Faculty Research Ethics Committe

Appendix B: Permission to conduct research from the director

REPUBLIC OF NAMIBIA
OHANGWENA REGIONAL COUNCIL
DIRECTORATE OF EDUCATION, ARTS AND CULTURE

Office of the Director
Tel: (+264) 65 290200
Fax: (+264) 65 290224
Enquiries: Mirjam Nambahu
Email: ndapewa.nambahu@gmail.com
Our Ref: 26/1/9/8

Harelbecke Street, Greenwell Complex Building
Private Bag 88005
EENHANA

24 September 2021

Mr. Fredinard Nandjedi
+264 81 4055423
fnandjedi@gmail.com

SUBJECT: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN OHANGWENA REGION

1. Receipt of your letter dated 21 September 2021 is hereby acknowledged.
2. The request has been evaluated and found to have merit.
3. Kindly be informed that permission to conduct research at Engela Secondary School has been granted under the following conditions and requests:
   - The data to be collected only be used for the completion of your studies.
   - You have to liaise with the Principals concerned 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. In addition, we wish you all the best with your studies.

Yours Sincerely,

27/09/2021

Isak Hamatwi
REGIONAL DIRECTOR

Ohangwena Regional Council
Directorate Of Education Arts and Culture
Office of the Director
27 SEP 2021
Tel: 065-290 200 • Fax: 065-290 224
P/Bag 88005 • Eenhana
REPUBLIC OF NAMIBIA

Appendix C: Permision from the school principal

MINISTRY OF EDUCATION, ARTS AND CULTURE

OHANGWENA REGIONAL COUNCIL: DIRECTORATE OF EDUCATION
Engela Secondary School, Ohangwena Circuit, Engela Cluster

Private Bag 501, Ohangwena-065 260190, E-mail engelajuniorsecondaryschool@gmail.com

Enquiries: Ms F. Kashikatu
Cell: 0812450862
E-mail: fmkashikatu@gmail.com

23th September 2021

Dear Mr Nandjedi

RE: PERMISSION TO CONDUCT A RESEARCH PROJECT WITH LEARNERS AT ENGELA SECONDARY SCHOOL

With reference to your letter dated 21st September 2021 seeking permission from the principal, to contact research at our school in completion of your Master Degree in Education at University of Rhodes, permission is hereby granted to you to carry out your research at Engela SS.

It is very important that your research does not interfere with normal teaching and learning process at school and that participation is on voluntary basis.

Thank you for showing interest to contact research at our school. It is our sincere that the information you are going to get will be quite useful in completion of your study.

Yours faithfully

Frieda Kashikatu (The Principal)

Appendix D1: Letters to parents

RHODES UNIVERSITY
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14 February 2022

Komudali omufimanekwa

Oshinima: Eidilo opo upitike okaana koye ka kufe ombinga moshinyangadalwa shelihongo moshihongwa shoPhysical Science

Edina lange ame Fredinard Nandjedi, ondi li omuhongi woPhysical Science pofikola pEngela ss ame ondi li yoo omulongwa koshiputudilo sho pombada shedina Rhodes University koSouth Africa oko a ndi lilongele ounongononi (science). Oshitwa shopokati melilongo lange osho okuninga omapekapeko ena sha nomhuku womhepo yedina Carbon dioxide. Onghee ne onda faneka ndi ninge oshinyangadalwa eshi novalongwa vo mondodo onihetatu (8) moshilongwa shoPhysical Science.

Onda dilaadila nee opo ndi longife imwe yoinima yomomudingonoko wetu okulonga ounongononi u na sha nomhuku woCarbon dioxide opo ndi dule okukandulapo oupyakadi woku hena oilongifo yopaunongononi oyo ili inai henena meefikola detu, unene tuu dokoitopolwa yokomikandi. Moshinyangadalwa eshi ohatu ka longifa ***Oshikundu*** osho yoo ***oumboloto*** opo tu hange elalakano eli.
Moshinyangadalwa eshi, ohatu ka kala novanhu vavali vadja momudingonoko ovo tave ke tu ulikila nghene **Oshikundu** n**oumboloto** hava ningwa, onghee nee oto indililwa nefimaneko linene opo u pitike okaana koye ka kufe ombinga koo kashiive nghene oinima ei ivali hai ningwa koo kelilongeleko ounongononi ou wo kushiiva kutya oCarbon dioxide oshike naanaa na ohai di peni. Keindilo eli okaana koye oka u lika nale ehalo lokukufa ombinga. Onda faneka opo oshinyangadala eshi shi ka kwate alushe oule wovili lwaapo konima yedimbuko na ota shi kakwata oule woshivike shimwe momwedi Februali 2022. Ngeenge twa tameke oha tu ku shiivifile.
Ngeenge nee oto pitike okaana koye kakufe ombinga moshinyangadalwa omu, kwafe nge opo upenge ouyelele ou.

Aame …………………………………………… (Edina lomudali/omutekuli wokaana), ohandi yandje eefelo opo okaana kange kedina …………………………………… (Edina lokaana) ka kufe ombinga moshinyangadalwa eshi.

Okushaina: …………………………….
Efiku……………………………..

Weni
Fredinard Nandjedi

	Fredinard Nandjedi	Prof. Kenneth Ngcoza	RU Ethics coordinator
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Appendix D2: Learners' letter

RHODES UNIVERSITY
Where leaders learn

Enquiries: Mr Nandjedi FN 14 February 2022

Dear …………………………………………… (Learner's Name)

Re: Request for your participation in a research on the integration of local knowledge to mobilise learning of the topic Carbon dioxide in a Grade 8 after school

I am Fredinard Nandjedi, a part-time student doing masters in science education at Rhodes University, South Africa. I am Physical Sciences teacher at Engela Secondary School. I hereby humbly request your permission to conduct a research study with me as my co-researcher, during teaching and learning of the topic Carbon dioxide. The study will mobilise the local knowledge of making **oshikundu** and homemade bread (**oumboloto**) with a view to contextualize and enhance learning of the topic carbon dioxide to the grade 8 learners. You will be required to (a) collect data from two community members, (b) present in class, (c) interact with two community members who will be presenting about the alluded on indigenous technologies. Written consents will be sought your parents or guardians. I will also work with a Grade 10 to 11 Physics and Chemistry teacher as a critical friend to observe the two community experts while demonstrating the two practices to the learners. I plan to conduct the research end of February 2022. The exact date for the course will be communicated well in advance to all participants.

I would like to assure you that, should I be granted permission, the research ethics will apply throughout the process of the study. Kindly be informed that participation in this study is voluntary. It is therefore your right to decide whether you wish to participate or not. In addition, participants are free to withdraw at any time they wish. The data that will be collected will not be used for other purposes apart from the study. Please note: If you have any question about the research, please feel free to contact me on the details provided. Lastly, if you agree or do not agree to participate in this research, please complete the consent form below.

I …………………………………………… (Full name of the learner), hereby confirm that I understand the content of this document and the nature of research. I henceforth request you to indicate your choice by making a tick (√) in an appropriate box below. Agree to participate in the study ☐

Do not wish to participate in the study ☐

Signature: ………………………….. Date:…………………………………..

Your cooperation will be highly appreciated in this regard.

Yours sincerely

Nandjedi Fredinard

	Fredinard Nandjedi	**Prof. Kenneth Ngcoza**	**RU Ethics coordinator**
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Appendix E: Teacher's letter

RHODES UNIVERSITY
Where leaders learn

Enquiries: Mr Nandjedi FN 14 February 2022

Dear ………………………………………………………(Teacher's Name)

Re: Request for your participation in a research on the integration of local knowledge to mobilise learning of the topic carbon dioxide in Grade 8 after school

I am Fredinard Nandjedi (Student number: 19N9534), a part-time student doing masters in science education at Rhodes University, South Africa. I am a Physical Sciences teacher at Engela Secondary school. I hereby request for your participation in my research project as critical friend. During teaching and learning of the topic of Carbon dioxide. The study will mobilise local knowledge of making ***oshikundu*** and homemade bread ***(uumboloto)*** with a view to contextualize and enhance learning of the concept of carbon dioxide in a Grade 8 Physical Sciences class. Learners will be co-researchers. You will help me to collect data via group activity, interviews, observation and videotaping. Written consents will be sought from learners' parents or guardians and the learners themselves. I also intend to work with you to help me with data analysis. I plan to conduct the research end of February 2022.

Kindly be informed that participation in this study is voluntary. It is therefore your right to decide whether you wish to participate or not. Also, participants are free to withdraw at any time as they wish to do so. The identity and views of the participants will not be revealed, I will maintain anonymity, and data that will be collected will not be used for other purposes apart from this study. Should you agree to participate in the study, you are reminded that all information and data collected during the study will be kept confidential. The research ethics will apply throughout the process of the study.

I ………………………………………… (Full name of the teacher), hereby confirm that I understand the content of this document and the nature of the research. I henceforth request you to indicate your choice by making a tick (√) in an appropriate box below.

Agree to participate in the study ☐ Do not wish to participate in the study ☐

Signature: ---------------------------- Date: ---------------------------------

Yours sincerely

Nandjedi Fredinard

	Fredinard Nandjedi	**Prof. Kenneth Ngcoza**	**RU Ethics coordinator**
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Appendix F: Community experts' letters

RHODES UNIVERSITY
Where leaders learn

Enquiries: Mr Nandjedi FN 14 February 2022
Komufimanekwa

Oshinima: Eindilo opo ukufe ombinga moshinyangadalwa shelilongo loshilongwa sho Physical science

Edina lange aame Fredinard Nandjedi, ondi li omuhongi woPhysical Science pofikola pEngela ss ame ondi li yoo omulongwa koshiputudilo sho pombada shedina Rhodes University koSouth Africa oko a ndi lilongele ounongononi (science). Oshitwa shopokati melilongo lange osho okuninga omapekapeko ena sha nomhuku womhepo yedina Carbon dioxide. Onghee ne onda faneka ndi ninge oshinyangadalwa eshi novalongwa vo mondodo onihetatu (8) moshilongwa shoPhysical Science.

Onda dilaadila nee opo ndi longife imwe yoinima yomomudingonoko wetu okulonga ounongononi ou u na sha nomhuku woCarbon dioxide opo ndi dule okukandulapo oupyakadi woku hena oilongifo yopaunongononi oyo i nai henena meefikola detu, unene tuu dokoitopolwa yokomikandji. Moshinyangadalwa eshi ohatu ka longifa ***Oshikundu*** osho yoo ***oumboloto*** opo tu hange elalakano eli.

Moshinyangadalwa eshi, ohatu ka kala twapumbwa omunhu ou teke tu longa nghene ***oshikundu*** **ilo** ***oumboloto*** hava dingwa, onghee nee oha ndi ku indililwa nefimaneko linene opo u tu li yambele u ketu longe okudunga oshikundu ile okuninga uumboloto voo ounona vashiive nghee oinima ei ivali hai ningwa.

Tangi eshi to tu kwafa omufimanekwa.

Weni
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Appendix G: FGIs learners' profiles

Table 4.1

Learners' Biographical information	**Category**	**No of learners**	**Learners' codes**
Ethnicity	Ovambo Angolan (uumbundu)	4 1	L2F, L5M L3F L4F, L1 M
Gender	Females Males	3 2	L2F, L3F, L4F, L1M,L5M
Age group	13 14 15	1 3 1	L2F L1M, L3F L4F, L5M
Home language	Oshikwanyama Portuguese	4 1	L2F,L3F,L4F, L5M L1M

Appendix H: How I planned to collect my data

Table 4.2

Days	Learners' Tasks	Facilitators' tasks and the data collection method
Day one	• Learners give their views(perspectives and motivation) about science in general • Learners' view on integration of IK into science • Learners' understanding of the concept CO_2	• ***Focus group interview*** • Familiarisation • Purpose of study • Probe on learners' prior knowledge around the concept of CO_2 • Observations • Video record
Day two	• In groups, learners find information about carbon dioxide in the community. • Present their finding about carbon dioxide in the community • Do reflections	• **Group activities** • A day in advance learners were asked to get information about carbon dioxide in the community
Day three	• Interactions with the expert community member during the demonstration of making *oshikundu* • Ask as many questions as they wish • Experimenting with making with *oshikundu*, collect gas and test for carbon dioxide the next day • Do reflections	• ***Participatory observation*** • Co-learner • Motivated learners to ask as many questions as possible • Instructing learners how to make and collect gas from *Oshikundu* • Observations • Video record
Day four	• Interactions with the expert community members • Experimenting with Making homemade bread collect gas and test for carbon dioxide the following day • Ask as many questions as they wish • Do reflections	• ***Participatory observation*** • Co-learner • Instructing learners how to make and collect gas from bread making • Observations • Video record
Day five	• Interact with each other • Present their reflections	• ***Journal reflection*** • Observation
Day six	• To mention whatever they know about CO_2	• To draw a mid-map on the chalk board showing concepts and features of CO_2

Appendix I: Observation criteria

Table 4.3

Observation Date …………………… Name of the teachers: ………………………

Subject: …... Number of participants: ……………………..

Lesson Topic: …………………………….Observer: …………………………………….

Social interaction	**Remarks**
The participation of learners during the presentations by the community member.	
The interaction of learners with one another.	
The interaction of learners with the community members.	
How community member takes learners' views.	
How learners are motivated during the presentation.	
Learners responding to their peers' thoughts and discussions.	
Sense making	**Remarks**
Learners' everyday ways of reasoning is scientific and reflections	
Learners construct clear scientific explanations from the demonstration	
Learners' questioning invites thinking.	
Learners' interpretations of concepts and ideas emerging from demonstration.	
Learners exploring concepts and ideas emerging from demonstration.	
Learners reached their 'aha' moments.	

Appendix J: Analytical framework (adapted from Atallah et al., 2010, p. 48)

Table 4.4

Conceptions	
C1	Describing what they think what carbon dioxide is (their ideas or thoughts about the nature and origin CO_2)
C2	Drawing what CO_2 is (their mental image of the CO_2)
C3	Describing what they believe is required to learn the CO_2
C4	Describing what they believe is required to do CO_2 related class activities
C5	Describing what they think is the purpose of studying CO_2 (why is it included in the school curriculum, its usefulness in everyday life, …)
Dispositions	
D1	Describing their ability in the topic of CO_2 (themselves as learners)
D2	Describing their attitudes towards learning CO_2
D3	Describing the expectations about the CO_2 (what will it help them achieve?)
D4	Describing the learning approaches used to study CO_2 (for example, deep/surface learning)
D5	Describing the perceived value of the subject

Appendix K: FGIs questions; the main ideas behind each question and the purpose they serve

Table 5.1

The big ideas **(main ideas)**	**Research Question:** What are grade 8 Physical Science learners' perspectives and motivation towards learning the topic of carbon dioxide before the intervention?		
	Questions	**Translation**	**Purpose**
Perspectives and motivation	1. How does learning of Science (CO_2) at school makes you feel and why?	*Okulilonga nokulongwa oilongwa you dindoli (oscience) ohashi kuudifa nghahelipi no molwashike?*	Eliciting learners' perspective and motivation on science
Teaching methodology	2. How would you like to be taught new concepts in science at school and why?	*Omomukalo ulipi wahalwa okulongwa oscience nomolwa shike?*	Eliciting learners' feeling about the current teaching approach or methods
Learners' interest	3. What motivates you to learn Science at school and why?	*Oshike ashi kutu omukumo opo ulilonge oilongwa oscince nomolwa shike?*	Eliciting what arose learners' motivation to do science
Learners' demoralization & the cause of poor outcomes	4. What does not motivate you to learn Science at school and why?	*Oshike ashi fifa uunye wokulilonga oscience nomolwashike?*	Eliciting what make learners lose interests in doing science.
Learners views on (IK) in school	5. Do you think home-based experiences/indigenous knowledge can be used in school?	*Ovanhu momudingonoko weni ohava longifa oscience momikalo dilipi?*	Eliciting if learners are aware of some IK practices from their community that can be useful at school
Indigenous Knowledge and learners' prior knowledge application	6. In what ways do you think your home- based knowledge can be used or applied during Physical science periods?	*Opamukalo ulipi uwete eshivo loye tali dulu longifwa melihongo loye loilogwa yo science?*	Eliciting suggestions on how learners think their Prior Knowledge may be integrated into science

Motivation to learn and application of science at home	7. What relevancy or importance do the physical science concepts that you learn at school have in your everyday life?	*Oilya ei holilonga kofikola moscienca oina oshilonga sha shike keumbo?*	Sense making of the science concepts

Appendix L: Focus Group Interview (FGI) questions and the responses from each participants

Table 5.2

Questions	Learners Answers
1. How does learning of Science (CO_2) at school makes you feel and why?	**L1M**: It makes me feel good because it teaches me more about CO_2 and its importance to humans and plants. **L2F**: It makes me feel good because I learn more about CO_2 how it is produced and in which ways it is used. **L3F**: I feel good because it helps us to know more about CO_2, how it produced, how it is consumed in everyday life, how it is important to the environment and all living organisms. **L4F**: I feel good because I learn more about everything about carbon dioxide and its importance to living things. **L5M**: Ohashi udifa nge nawa shili no hashipenge nokulonga nge shihapu momudingonoko osho vakwetu ava ina vaninga oscience vehe shi. [*It truly makes me feel good because it teaches me much about my environment and helps me to understand things better than my fellow community members who never learnt science at school].helps me to understand things better than my fellow community members who never learnt science at school*.
2. How would you like to be taught new concepts in science at school and why?	**L1M**: The ways teachers are teaching us is just fine with me, many at times they try to explain clearly. Sometimes when teachers are explaining, learners do not get the ideas well, therefore, teacher or whoever is responsible of teaching must bring in a lot of touchable things that learners can see, such as videos because they help learners to understand more things in detail. Teachers should also let us do practical activities, because science is all about mixing things and that will helps us to learn more about science. **L2F**: I think the ways teachers use to teach science is ok, because they try to explain most of the new things in their lessons.

	L3F: Many teachers allow learners to ask as many questions for them to understand new concepts, therefore it is fine with me. **L4F**: Ondi wete kutya ohava longo ashike nawa shaashi ohave tulongo iinima ihapu ipe naai yafimana moshiwana shetu *[I think teachers do us justice because they try to teach us many new things every day and they also caution us about what are the most important things in our environments, I therefore, think the methods they use are ok].* **L5M:** Ondi wete ovahongi otava kendambala ngoo ndele onda hala ngoo ngeno vawedeko opo tu udeko oinima moule, nande oku kala tavafatulula oinima oyo ipe kushe nande omOshiwambo *[I think teachers are trying their best, but my wish is for them to try to explain things further always even in Oshiwambo to make us understand those new and difficult scientific concepts in details].*
3. What motivates you to learn Science at school and why?	**L1M**: Science helps us to learn many things. It also teaches us of what to do and what not to do, also most of the things we learn in science are also things that we do at home, so it helps us to do things better at home. It also helps us learn what is good for us and what is not good for us. **L2F**: Generally science is school based but it also includes things we do at home, so what motivates me most is to know better the things we do at school and the things we do at home. **L3F:** I have the same idea as learner 2 sir. *A follow up question was then asked***.** **Teacher:** Do you see yourself following science career in the future? **L3F**: I don't know now sir, because that may not be based on the things I am doing now, once I grow up I may change my mind depending on the current situation during that time. I think I am more into culture and history will do for me. **L4F:** I think I don't have any motivation to learn science, because most of the things we learn in science at school are not workable or applicable at home and many concepts are hard to understand,

	therefore, there is nothing that motivates me. I think I don't have any motivation to learn science. **L5M:** Eshi hashi tunge omukumo opo ndili longe osciece alilongo ashike eli li limo, nokatale nawa kange, ngaashi ngoo ngaha eshi atu li longo kombinga yo CO_2 na apa hai di. ***[****The only thing that motivates me to do science is just the fact that I am learning something new and my curiosity to learn. For example, I just want to know what exactly carbon dioxide (CO_2) is and where it comes from]. I just want to know what exactly carbon dioxide (CO_2) is and where it comes from]*.
4. What does not motivate you to learn Science at school and why?	**L1M:** There is nothing that demotivates me. There is nothing that demotivates me. **L2F:** Nothing. **L3F:** Some of the difficult things that we do in science especially the ones I do not understand make me feel like giving up on science. Also the English used in science is difficult to understand. **L4F**: Not understanding science and the difficult things that we do in science, sometime I don't even get what the teacher is talking about. **L5M**: Nothing
5. Do you think home-based experiences/indigenous knowledge can be used in school?	**L1M**: Yes because some of the things we do at home are also based on science, so it helps us to understand science better at school. **L2F**: I think home-based experience is useful at school because everyday life is about science, so even some of the things we do at home consist of science. **L3F**: Yes, because some of the things we learn from home help us to answer questions posed to us by teachers about things that were are not taught and in the process it helps us to talk to each other, teach our fellow learners things that they don't know or not aware of, **L4F**: Yes I think your experience from home is helpful because it helps you to understand science more. For example, like that learner who knows that *oshikundu* can produce carbon dioxide by the time we are going to do that topic he will have much

	information about CO_2 because he already know it from home. learner who knows that *oshikundu* can produce carbon dioxide by the time we are going to do that topic he will have much information about CO_2 because he already know it from home. **L5M**: Yes it will be useful, because you will be having knowledge already or ideas about things before you did not learn at school yet.
6. In what ways do you think your home-based knowledge can be used or applied during Physical science periods?	**L1M**: It helps me to understand and to explain to others things teachers don't explain clearly in the Physical Science lesson. You can also use it to give other learners many examples that sometimes teachers don't give. **L2F**: Efimbo limwe iinima ei hatu ningi komaumbo aya faafana naai hatuni ngi kofikola, so ngeenge hatu liholngo science iha tu mona naanaa idjuu shaashi iinima imwe otwiishi nale. Natango ohashi kala shiwa ngeenge atu li hongo shaashi oinima ei tushi ahatu I skipa po ashike shaashi omo nale ili momitwe detu./*[Sometimes the things we do at home are the same as those that we do at school, which helps us not to find science difficult or to understand science at school because you know some of the things already. Also when we studying you can just skip some parts because we already know them from home and they are permanently in our minds].* *which helps us not to find science difficult or to understand science at school because you know some of the things already. Also when we studying you can just skip some parts because we already know them from home and they are permanently in our minds].* **L3F:** I have the same idea as learner 2. **L4F:** When you bring home experience to school or say in the Physical Science lessons, it makes science at school easier and it motivates others to learn science too, sometimes you make them remember things they do at home. **L5M:** I don't know how home based knowledge can be applied in science, but I think it helps us to explain things to teachers the way we understand them.
7. What relevancy or importance do the physical science concepts that you learn at school have in your everyday life?	**L1M:** Some of the things really help us at home. For example**,** learning things like carbon dioxide will help us at home not to cut down trees because trees absorb

	carbon dioxide which can be harmful to our environment. **L2F**: We at times apply some things we learned from school at home. For instance, sometimes the things we learn at school help us to do things better at home, for example, in Agriculture we learn about gardening and pest controlling something that we can also apply at home in our gardens and fields. **L3F:** Wherever we are at home we are always applying science, so the things we do at school help us to improve how we do things at home. **L4F:** Some of the things help us to teach our parents best ways of doing things. For example. Telling our grandmothers not to burn tires anymore because that produces too much carbon dioxide. **L5M:** I have no idea sir.

Appendix M: Learners prior knowledge on carbon dioxide (group activity)

Table 5.4

Questions	Groups responses
1. What is carbon dioxide?	**The lions:** is a colorless gas breathed out by humans and animals **The tigers:** is the air we breathe out. It dissolves in lime water to form calcium carbonate and water. **The mouse:** A colorless gas produced by carbon and organic compounds and by respiration. It is naturally present in the air about 0.03% and is absorbed by plants during photosynthesis. **The bunnies:** A gas formed when things burn or breathed out by humans and animals. **The jackals:** is natural gas that can cause too much heat and skin cancer when it is too much in the atmosphere.
2. What are some cultural practices or activities do you know from your homes and communities that produce carbon dioxide?	**The lions:** Human resources including cement production and natural resources include ocean release and respiration. **The tigers:** producing *oshikundu* and traditional beer (*omalodu*) and burning firewood. **The mouse**: burning of plastics to control locus (pests), respirations, decomposition. **The bunnies:** burning of cattle dungs to prepare traditional clay pots, manufacturing of cement and deforestation. **The jackals**: burning of Millet (*Mahangu*) stalks or straws to prepare for fields for cultivation, bush fires, during fire gathering for storytelling and dinner and for food preparations using fire wood.
3. What importance do you think the cultural practices and products you mentioned in question 2, have in Physical Science lessons?	**The lions:** it teaches learners how carbon dioxide is produced. **The tigers:** knowing how carbon dioxide is produced, its advantages and disadvantages and the importance of carbon dioxide.

	The mouse: it teaches learners more about carbon dioxide as to how it is produced and how it effects or help our environments. **The bunnies:** knowing the importance and the effects of carbon dioxide. **The jackals:** it teaches learners how carbon dioxide is made and it help learners not to produce carbon dioxide at home.
4. What daily products or activities do you know that have or produce carbon dioxide at your school?)	**The lions:** deforestation and cars exhaust. **The tigers:** fire extinguishers and burning rubbish. **The mouse:** deforestation, vehicles' exhaust and wood burning. **The bunnies:** burning of gasoline from car exhausts and when using electricity produced from generators. **The jackals:** burning of rubbish and cars exhaust
5. What do you think are the effects of carbon dioxide in the environment?	**The lions:** burning of fossil fuel which leads to increase in the level of carbon dioxide and other greenhouse gases in the atmosphere. **The tigers:** more carbon dioxide has bad effects on humans. Carbon dioxide helps plants to produce their food through the process of photosynthesis. **The mouse:** insufficient presence of carbon dioxide may cause some plants to die. **The bunnies;** an increase in carbon dioxide causes irreversible climate change. Eg change in rainfall pattern. **The jackals:** too much carbon dioxide can cause draught and damage the environment.

Appendix N: Prompt questions for learners' journal reflections

Table 6.1.

Questions	**Responses**
1. What have you learned from the first lessons of this study? ***Lesson 1 (Group activity)***	**Lion:** We learned about the effect of carbon dioxide to our environment. **Tigers:** We learned about many cultural things that produce carbon dioxide. We also learned that is carbon dioxide in air. **Mouse:** We have learned more information about carbon dioxide and more things that can produce carbon dioxide from our environment. **Bunnies:** We learned that carbon dioxide causes global warming. **Jackals:** We learned how carbon dioxide is formed, its effect on people and that it is tested using lime water.
What have you learned from the first lessons of this study? **Lesson 2 (*uumboloto*)**	**Lions:** We learned that we use yeast for the uumboloto to expand the dough and to produce carbon dioxide. **Tigers:** We learned how to make uumboloto and how carbon dioxide occurs in uumboloto due to fermentation. **Mouse:** We have learned how to make uumboloto by using different ingredients and how the process of making uumboloto produces carbon dioxide. **Bunnies:** We learned that in the process of making uumboloto, a minimal amount of carbon dioxide is produced. We learned about the things we use to make home bread. **Jackals**: We learned how *uumboloto* are formed and we also learn about the ingredients to use when making *uumboloto* and that when the dough raise it produces carbon dioxide which makes the lime water whites if you bubble it in.
2. What have you learned from the community members' presentations? ***Lesson 1 (oshikundu)***	**Lions:** We learned that oshikundu is important because it can make people to be healthy and that it can provide carbon dioxide.

	Tigers: We learned how carbon dioxide occurs in oshikundu and how it is tested using lime water. We have learned that oshikundu produces carbon dioxide **Mouse:** We learned how to make oshikundu and how oshikundu provide carbon dioxide. **Bunnies**: We learned that in oshikundu there is carbon dioxide. We learned how to make oshikundu. **Jackals:** We learned how to find carbon dioxide in oshikundu, testing for carbon dioxide using lime water and how oshikundu is made.
3. ***In what ways did the presentation or the integration of IK in science lesson change (or not) your view about learning science? Give reasons for your answer.***	**Lions**: At first we thought science was bad because we do not understand why carbon dioxide is needed in the atmosphere. Now science is good. It is good to use IK because it make learners to learn more and never forget what they have been taught. **Tigers:** We get it right that science is something good to learn because we get more information from science. It is not good for the teacher to teach us about how carbon dioxide is tested with the things that we do not know from home or never seen before because we may not understand well. **Mouse:** We have now enjoyed science in these presentations because we had fun by telling or talking about things we use to do at home. The integration of IK is good in science lesson because it made things to make sense to us. **Bunnies:** It changed us good because it opened our eyes to learn new things and give us more information about carbon dioxide. It is good because it is easy to learn the things that we know and understand them better. **Jackals:** In good way because we have learned the definition of carbon dioxide and how it is formed. Teachers should always teach us new terms using the things we know from home so that we can learn faster in topics on gases, matters and enzymes.
4. What have you enjoyed in these presentations?	**Lions:** We have enjoyed learning together with many learners since many people asked questions and were answered by others. **Tigers:** We have enjoyed it because the people who were presenting taught us a lot about oshikundu and

	uumboloto and also that these practices are our cultural ways of producing carbon dioxide. **Mouse:** We enjoyed sharing ideas and answering questions from others together. **Bunnies:** We enjoyed everything in the presentations. **Jackals:** We mostly enjoyed producing oshikundu because we were told it is very healthy and will keep you strong.
5. What have you <u>not</u> enjoyed in these presentations?	**Lions:** Some people were so excited and we have not enjoyed when people were making noise and almost the lesson turned into debates. **Tigers:** Nothing **Mouse:** Nothing **Bunnies:** Nothing we have not enjoyed **Jackals:** There is nothing that we did not enjoy
6. Draw a web map of all the scientific concepts that emerge from the making of oshikundu and uumboloto.	**See table 6.2**