# Motivation to learn science and make sense of the concept of malleability through the traditional blast furnace in a grade 9 Physical Science class

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**By**

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## Declaration of Originality

I, Peter Wilfred Kudumo, hereby declare that this thesis is my own original work that is submitted at Rhodes University and has not been submitted at any other university. All ideas, materials and citations used in this study derived from other people are acknowledged and indicated in the list of references according to Rhodes University Education Department Guidelines.

17 December 2020

Signature

Date

## Dedication

This thesis is a dedication to my *late* grandmother Martha Ghupwe Muronga. I owe my *being* to her as she was my beacon of hope and source of inspiration during my educational struggles and successes. I remember when I was young, she used to say to me "*Go to school"*. Understandably, at that time little did I know what the meaning of her statement was until now, in that she just wanted the best out of me with my schooling. It is unfortunate that she could not witness my success because death defeated her. Rest in peace my beloved grandmother!

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# Abstract

The current situation of teaching and learning science in Namibia is of great concern since it does not seem to take into consideration learners' socio-cultural backgrounds. As a result, learners are finding that science is not relevant to their everyday life experiences and hence are not motivated to learn it. This is compounded in part by the fact that the Namibian curriculum seems to be silent on how science teachers should include learners' socio-cultural backgrounds, for example, local or indigenous knowledge in their teaching repertoires. It is against this background that in this study I explored how mobilising the cultural practice of a traditional blast furnace (*mudukuto)* as an approach enables and/or constrains learners' motivation to learn science and make sense of the concept of malleability.

This is a qualitative case study underpinned by a combination of interpretive and Ubuntu paradigms. It was carried out in a rural school in Namibia, Kavango West Region, where I am currently teaching. The participants in the study were grade 9 learners and one expert community member. Focus group interviews, participatory observation, learners' reflections, and stimulated recall interviews were used to gather qualitative data. Vygotsky's socio-cultural theory was used as a theoretical framework and Ogunniyi`s Continuity Argumentative Theory (CAT) was used as analytical framework or lens to analyse the data. A thematic approach to analyse data was employed. That is, qualitative data were analysed inductively to come up with sub-themes and themes.

The findings of the study revealed that the traditional furnace motivated the learners involved in this study to learn science and learners were able to extract science concepts on malleability from the traditional practice. The implication for this study is that when science is related to learners' daily life or real-world experiences, they are enabled to bridge the gap from what they learn at home or in the community with school science. The study thus recommends that teachers should make an effort to integrate local or indigenous knowledge and practices to make science accessible and relevant in their classrooms.



**Key words:** Physical Science, malleability, local or indigenous knowledge, blast furnace, Ubuntu and culture, motivation, sense-making, socio-cultural theory, Continuity Argumentative Theory

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## List of Abbreviations and/or Acronyms

| | |
|---|---|
| JSC | Junior Secondary Certificate |
| IK | Indigenous Knowledge |
| IKS | Indigenous Knowledge Systems |
| LCE | Learners' Centred Education |
| LTSMs | Learning Teaching Support Materials |
| MEAC | Ministry of Education, Arts and Culture |
| MBEC | Ministry of Basic Education and Culture |
| Med | Master's in Education Degree |
| MoE | Ministry of Education |
| NCBE | National Curriculum for Basic Education |
| NIED | National Institute for Educational Development |
| NSSCO | Namibia Senior Secondary Certificate Ordinal level |
| PK | Prior Knowledge |
| SCA | Situated Cognition Approach |
| SCLT | Socio Cultural Learning Theory |
| WMS | Western Modern Science |
| WS | Westernised Science |
| WSK | Western Science Knowledge |
| ZPD | Zone of Proximal Development |

# CHAPTER ONE: SITUATING THE STUDY

## 1.1 Introduction

School curricula in postcolonial Africa seem to experience challenges that are in part a legacy of colonial education that has remained in place decades after political decolonisation (Quan-Baffour & Bayaga, 2009; Shizha, 2013). Quan-Baffour and Bayaga (2009) pointed out that colonialism did not take into cognisance indigenous knowledge. Instead, it encouraged teaching and learning and assimilation of western ideas and values at the expense of indigenous knowledge, skills, and values. As a result, colonialism led to the colonised losing their epistemology and ontology and adopting those of the colonisers (Lebeloane, 2017). In light of these foregoing arguments, Lebeloane (2017, p. 5) maintained that "the colonial school system and its curriculum were crafted with the ethics of preparing Africans to remain subservient and assist Europeans to dominate and exploit the African continent through their private capitalist firms".

Yet, the school curriculum content knowledge should resemble the African identity and way of viewing reality. Lebeloane (2017, p. 2) further elaborated that "the intention of decolonial thinking and decolonisation was to re-instate, re-inscribe and embody the dignity, equity and social justice in people whose norms and values as well as their nature, their reasoning, sensing and views of life were violently devalued or demonised by the past". Hence, decolonial thinking and decolonisation had pushed to do justice to the current education system by reviewing and improving the distorted school curriculum by rewriting it correctly to suit the people for whom it was meant (Lebeloane, 2017).

Notwithstanding, the emergence of indigenous knowledge (IK) was not to seek redress for the ruling oppression of the past as perceived by many, but rather it was intended to help learners relate to westernised science. In light of Vygotsky's (1978) seminal work, Mavuru and Ramnarain (2017) emphasised the importance of taking into consideration learners' socio-cultural contexts. Similarly, Mhakure and Otulaja (2017) reiterated that there was a need for

culturally responsive pedagogies. It seemed these scholars believed that when science is relevant to learners' everyday lives, they are motivated to learn and make sense of it. It was against this backdrop that the study sought to explore how the traditional blast furnace (*mudukuto*)[1] enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability.

This chapter thus introduces the study. It provides the background of the study which draws on the challenges of the science curriculum at international level and the Namibian context. Essentially, it has been extended to reflect on the Namibian curriculum, specifically looking at the challenges of the science curriculum in response to the 21st century. This is followed by the statement of the problem and significance of the study. Lastly, the goal of the study, research questions, and data gathering techniques are presented.

### 1.2 Background of the Study

The main goal of the study was to explore how a traditional blast furnace (*mudukuto*) enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability. Essentially, the study was undertaken to make science relevant and accessible to the learners. It was hoped that the integration of indigenous knowledge (IK) of a blast furnace might advance learners' understanding and shift the knowledge thinking that westernised knowledge is not superior to indigenous knowledge. In this chapter, the discussion about the Namibian curriculum as well as the challenges of the integration of indigenous knowledge were explored.

The significance of the school curriculum to the socio-cultural worldview of the African learner, in both orientation and content, is of great concern to African academics and scholars (Mavuru & Ramnarain, 2017; Shizha, 2013). For instance, the forms of teaching in our schools were geared towards the westernised form of knowledge since science teachers themselves were taught in westernised ways of doing things. As a result, in the early 1960s science education was dominated by a transmission mode of teaching in which teachers were perceived

[1] *Mudukuto* is a practice done by elder males at home when they make an axe or hoe for cultivation or clearing of bushes in the field. This indigenous practice involves air being pumped through a wooden hole to light the fire until a metal placed on the fire turns reddish and is then taken out and hammered into different shapes.

as authorities in their areas of specialisation who had to then impart such uncontested bodies of knowledge to their learners (Moji & Hattingh, 2008). It seemed that this culminated in learners being easily turned off science as they were taught something that was new and different from their background and knowledge (Strangman & Hall, 2004). It is recognised, however, that the transition from teaching science in westernised contexts required science teachers to form new identities with regard to worldviews (Mhakure & Mushaikwa, 2014), to dismantle the divide between indigenous and scientific knowledge (Agrawal, 1995). That is, there was a need to look at these knowledges as complementary rather than being mutually exclusive or oppositional.

In light of this, an extensive research work was carried out in Nigeria and South Africa, to establish the reasons for the persistent dismal performance of learners and poor retention in science subjects. The evidence indicated that science learners do not sufficiently comprehend the knowledge and skills underlying these subjects, resulting in rote learning, regurgitation of facts, and superficial learning of basic concepts and principles (Erinosho, 2013). This affirmed Dzama and Osborne's (1999) diagnosis that absence of supportive environments for serious science learning in developing countries leads to poor performance. In my experience, the assumption was that this was attributed to factors such as teachers' poor qualifications and inadequate knowledge base, as well as non-educational factors such as lack of resources and large size classes (Chiwiye, 2013).

In most aforementioned factors, Namibia was no exception in this conundrum. Despite the past experiences faced by African education under the numerous pretexts of colonial domination, it is a cruel irony that the post-colonial state in Namibia under African political leadership had not made fundamental changes in indigenous education (Lilemba & Matemba, 2015). For example, the national curriculum continues to perpetuate the dominance of western ideas and models, leaving indigenous knowledge marginalised in our African classrooms. This is worrisome and Namibian is no exception to this dilemma and vicious cycle.

In an attempt to address these realities, from the advent of democracy the Namibian education system had undergone extensive restructuring. This was intended to respond to the realisation of Vision 2030, Sustainable Development Goal 4 and to complement the ambitions in the National Development Plans (NDP 1-5). Vision 2030 sees Namibia transiting from a literate society to a knowledge-based society (Nambia. Ministry of Education, Arts and Culture

[MEAC], 2018). In consequence, the MEAC has adopted a learner centred teaching approach in Namibian classrooms. The aim of learner centred education was to develop learning with understanding, and to impart the knowledge, skills, and attitudes that contribute to the development of society (Nyambe, 2008; Namibia. MEAC, 2015).

Notwithstanding, even though Namibia is part of a global world and would like to benchmark its curriculum to international standards with a view to make learners who come out of the education system competitive, the undertaking should be done with good intentions. That is, among other things, the curriculum being developed or taught should not be allowed to ignore learners' socio-cultural backgrounds (Mavuru & Ramnarain, 2017) and experiences and be carried away by the challenges of the 21st century. For instance, Mbeki, a former South African president elegantly reiterated that "We must embrace the culture of the globe, while ensuring that we do not discard our own" (Mbeki, 1998, p. 38). It could be argued that this suggests that science should be decolonised in a reconstructive way as was advised by Lebeloane (2017) earlier, whereby learners are exposed to examples that are related to African ways of knowing and doing things. It was against this backdrop that in this study, the practice of a traditional blast furnace was used as I believed that it was reflective of our African culture and heritage to communicate science in an easily accessible ways to the learners.

### 1.3 Nature of the Namibian Science Curriculum

The Namibian curriculum explicitly provides a coherent and concise framework to ensure that there is consistency in the design and delivery of the curriculum in all schools and classrooms throughout the country. It outlines how teaching and learning should take place and serves as a framework where the syllabi, learning, and teaching support materials (LTSMs) such as textbooks to be used in science subjects, can be developed with a sense of recognising learners' cultural heritage. However, the Namibian curriculum is silent on how indigenous knowledge (IK) should be integrated in science lessons.

Le Grange (2007) concurred with Kibirige and Van Rooyen (2006) that the *absence* of IK in the science curricula had significant consequences for some learners. These scholars argued that due to such absence, learners might experience conflict between their existing knowledge and the knowledge of the various science curricula. Le Grange (2007) refers to this phenomenon as *dissonance*.

To prevent dissonance from occurring, learners need to be practically engaged in the context of the lesson. For instance, the subject policy for Physical Science (2009) states that learners should acquire understanding and knowledge in Physical Science through a learner-centred approach which goes hand in hand with a situated cognition approach (Mukwambo, 2017). Mukwambo (2017) defines situated cognition as a learning theory that proposes that learning does not take place in a vacuum (isolation). Instead, for learning to take place, one must ensure that there are cultural tools (including language) as espoused by Vygotsky (1978) to use for learning to occur as well as a context. To Khupe (2017), language plays a crucial role in the preservation and transmission of IK. Therefore, the Namibian science curriculum needs to develop appropriate methodologies to understand and assess traditional or indigenous knowledge to have a better integration between the two streams of knowledge, (modern and traditional) **(**Subramanian & Pisupati, 2010). These scholars accentuated that science is around us and is part of our everyday life.

### 1.4 Statement of the Problem

In Namibia, the subject Physical Science in grade 9 covers topics in Chemistry and Physics. In the old Physical Science curriculum for grades 11-12 that was phased out in 2020, Chemistry and Physics was taught as one subject. In contrast, in the new curriculum that was implemented in 2016, Physics and Chemistry are taught separately in grades 10-12. This was done to give preferences to both learners and teachers as not all learners and teachers are knowledgeable in both Chemistry and Physics.

In recent years, however, this subject in these grades had been performed poorly, as is evidenced in the past examiners' reports (Namibia. MEAC, 2015; 2017). For instance, the majority of candidates could not score full marks, as they failed to explain in full when having to give at least two reasons why a suggested metal could be used as a frying pan (Namibia. MEAC, 2017). In light of this, the Junior Secondary Certificate (JSC) examiner's report (Namibia. MEAC, 2017) suggested that examples related to everyday life should be used where applicable as most learners showed very little understanding of most concepts.

It was against this caveat that for this study I decided to extend on Asheela's (2017) study that she conducted in Namibia on the use of easily accessible resources. It was worth noting that I was inspired to engage with this study by the fact that I was part of Asheela's study. Henceforth, I crafted my study with the intention of using easily accessible materials (*mudukuto*) with the

hope to facilitate the understanding of the concept of malleability. I was also inspired by Mawere's (2015) assertion that indigenous knowledge can be used as a tool to help learners make westernised science more relevant and moving them from the known to the unknown. In light of this, it was envisaged that the use of an easily accessible material (*mudukuto*) in the study would make science relevant to the learners' real-life worlds so that they would be motivated to learn it.

However, I admit that the application of IK in science had been a challenge due to some teachers, like myself, not being well exposed to IK practices. As a result, learners were deprived from traditional science that they could use to build on to advance their understanding of the science they learn in their classrooms. This dilemma was exacerbated in part by the fact that the national curriculum emphasises the importance of integration of IK, but it is silent on how IK should be implemented in science classrooms. Yet, Klein (2011), Shizha (2013) as well as Mateus and Ngcoza (2019) argued that through the implementation and integration of IK in schools, the learners, parents, and communities can reclaim their *voices* in the process of educating the African child. Cocks, Alexander and Dold (2012) and Smith (2013) refer to this as *cultural revitalisation*.

Cultural revitalisation demands that the curriculum should respond positively to the emergence of traditional science. Concurring, Mhakure and Otulaja (2017) refer to this as *culturally responsive pedagogy*. Worth noting was that most schools in Namibia are not equipped with proper science laboratory equipment or have no science laboratories. Hence, researching about the usage of traditional blast furnaces (*mudukuto)* might enrich learners' understanding as they may only have prior knowledge from a textbook. Keane (2008) too believes that the inclusion of IK practices in the science classroom serves as a resource to be used and contributes to the enrichment of science lessons.

### 1.5 Purpose and Significance of the Study

The study builds on previous studies conducted by Simasiku (2017), Liveve (2017) and Nikodemus (2017) in Namibia, on how to integrate IK in science lessons with a view to making it relevant and accessible to learners. Essentially, the study strived to motivate and ignite a passion for science amongst the learners by using easily accessible resources such as the traditional blast furnace. Similar to the aforementioned studies, this was intended to contextualise and make science accessible to the learners.

Further, the practical demonstration on *mudukuto* might strengthen my knowledge on integration of local or indigenous knowledge in my science lessons in order to improve my teaching practice and those of my fellow teachers in the same discipline. However, it was recognised that local or IK continues to suffer in the academic context, "largely due to a game of 'power and ambition work' whose rules are set and determined by the dominant Western ideological power" (Dei, 2010, p. 89). In consequence, learners struggle to make sense of the science taught in the classroom due to the negation of their existing cultural and indigenous knowledge (Govender, 2016). To combat this difficulty, the integration of IK in science lessons had a potential to enhance learners' level of participation (Sedlacek & Sedova, 2017), motivation, interest, and enjoyment (Agunbiade, Ngcoza, Jawahar, & Sewry, 2017). Similarly, a science curriculum that embraces local or IK affords learners an opportunity to develop critical thinking and had the potential to motivate them to learn science (Govender, 2009).

The keen interest in the study was thus further prompted by my personal experience as a Physical Science teacher teaching in a rural school[2]. A learner, for example, asked a question during the teaching of properties of acids:

> *Are there local everyday examples of acids that we could taste to experience the sourness – especially since hydrochloric acids and sulfuric acids cannot be tasted as they are dangerous and poisonous*?

Admittedly, I struggled to answer that learner's question since at that time I was not exposed to IK myself. The suggestions of sour milk and a well-known vegetable (*mutete*[3]) were subsequently mentioned and learners described their experiences of eating these items. I regret this lost opportunity.

[2] Rural school is a school outside town located in a village.
[3] *Mutete* is a famous traditional vegetable in Rukwangali that has a sour taste.

## 1.6 Research Goal and Research Questions

This section provides the research goal and questions for the study.

### 1.6.1 Research goal

The main goal of the study was to explore how a traditional blast furnace (*mudukuto*) enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability.

To achieve this goal, the following research questions guided the study:

### 1.6.2 Research questions

1. What enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability?

2. In what ways do the grade 9 Physical Science learners interact, participate, and learn (or not) during the practical demonstration on a traditional blast furnace (*mudukuto*) by expert community members?

3. How does the traditional blast furnace (*mudukuto*) enable and/or constrain grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability?

## 1.7 Theoretical Framework

The study was informed by Vygotsky's (1978) socio-cultural theory. Vygotsky described socio-cultural theory as a social process whereby people interact with each other and construct meaning through their social experiences. This theory values the importance of social and personal aspects of learning (McRobbie & Tobin, 1997). In the classroom environment, for instance, learners should interact with their fellow learners and their teachers in order to make meaning that is relevant to what they want to learn. It should be noted that learners construct their meaning through interactions that exist between their peers and teachers in the classroom.

### 1.8 Data Gathering Techniques

- Focus group interviews.
- Participatory observation.
- Learners' reflections; and
- Stimulated recall interviews.

### 1.9 Definitions of Key Concepts

**Blast furnace** is a metallurgical furnace used for heating in order to get industrial metals.

**Culture** is the way people interact with one another in a social setting.

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

**Malleability** is the ability of a metallic object to be hammered into different shapes.

**Mediation**: The intervening process used by the knowledgeable person in assisting learners to make sense of new knowledge (Vygotsky, 1978).

**Motivation** is a method that promotes learners' contribution to learn science and improves their conceptual understanding.

**Physical Sciences:** A subject done at Junior Secondary phase (grade 8-9) that is a combination of two subjects which are chemistry and physics.

**Practical activities:** Learning experiences which are designed to, through action, forge a link between the observations and the theories/ideas of science (Asheela, 2017).

**Prior knowledge:** Prior knowledge is the learners' existing knowledge prior to instruction (Hewson & Hewson, 1988).

**Sense making:** Involves turning a circumstance into a situation that is comprehended explicitly in words and that serves as a springboard into action (Nikodemus, 2017).

**Socio-cultural theory:** This is a social learning theory that focuses on how learning occurs as a result of interactions and how culture, cultural beliefs, and attitudes affect the interactions (Vygotsky, 1978).

**Visualisation** is the process of using concrete materials to bring reality in the classroom, to complement learners' understanding.

### 1.10 Thesis Outline

The study was conducted at Martha Ghupwe Senior Secondary School (pseudonym), a rural school in Bunya Circuit, in the Kavango West Region, in Namibia. The thesis consists of six chapters and the overviews of the chapters are as follows:

**Chapter One:**

This chapter outlined the context of the study on the topic: Motivation to learn science and make sense of the concept of malleability through the traditional blast furnace in a grade 9 Physical Science class. The context was informed by the overview of the challenges of science including the international and Namibian context, as well as the nature of the Namibian science curriculum. The chapter also highlighted the statement of the problem, the significance of the study, research goal, and questions. It also further highlighted the analytical and theoretical framework, data gathering techniques, an outline of chapters of the study, and the chapter summary.

**Chapter Two:**

In this chapter, I reviewed the relevant literature to the study, with the aim of strengthening the importance of undertaking a study of this kind. In this chapter, readings around the concept of malleability, blast furnace, challenges of science curriculum in the 21$^{st}$ century, hands-on practical activities and visualisation, prior knowledge and indigenous knowledge were explored. Lastly, I discussed the conceptual, theoretical, and analytical frameworks that underpinned the study.

**Chapter Three:**

This chapter provided an overview of research methodologies used in this study. The research paradigm, research method, research site, and sampling were discussed, followed by the data generating techniques and procedures, and data analysis. Lastly, issues of validity and trustworthiness, positionality, and ethical considerations are outlined.

**Chapter Four:**

In this chapter, data gathered using different techniques e.g. focus group interview, participatory observations, learners' reflections, and stimulated recall interviews were reviewed and analysed to identify relevant themes. Such themes emerged from the data were represented in the form of tables, figures, and extracts.

**Chapter Five:**

In this chapter, data collected were interpreted and discussed. Research questions, themes, and literature were used to construct this chapter. The themes were consolidated to form analytical statements.

**Chapter Six:**

This chapter summarised the findings of the study per research question and gave recommendations for further studies, limitations of the study, some personal reflections and ends with the conclusion.

## 1.11 Chapter Summary

In this chapter, I presented the contextual background of the study, statement of the problem, significance of the study, research goals and objectives, definition of the terms, and thesis outline. It was designed to guide the reader throughout the thesis. Furthermore, I used the terms *indigenous knowledge* or *indigenous knowledge systems* and *traditional knowledge* interchangeably in this thesis, which was done to distinguish the knowledge advanced by and within individual indigenous communities from the IKS generated through universities, government research centres, and private industry (South Africa. Department of Science and Technology [DST], 2004). The next chapter presents literature relevant to the study.

# CHAPTER TWO: LITERATURE REVIEW, CONCEPTUAL AND THEORETICAL FRAMEWORK

## 2.1 Introduction

The main goal of this study was to explore how a traditional blast furnace (*mudukuto*) enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability. Essentially, the study was undertaken as an attempt to make science relevant and accessible to the learners. In the previous chapter, I looked at the holistic picture of the Namibian curriculum in relation to the integration of indigenous knowledge, its challenges, and the motivation for carrying out a study of this nature in a science classroom in a rural school.

In this chapter, relevant literature to the study was explored and discussed. The first section outlined the expectations of the Namibian curriculum. The second section discussed the role of prior knowledge, hands-on practical activities and indigenous knowledge and language in teaching science to gain insight on how they interrelate to each other in facilitating learners' conceptual understanding.

Lastly, I presented a discussion of the theory that informed the study. The study was informed by Vygotsky's socio-cultural theory, where learning takes place in a social setting. Furthermore, I looked at the discussion around the three frameworks: theoretical, conceptual, and analytical as lenses to analyse the data in the study.

## 2.2 Challenges of the Science Curriculum in the 21st Century

The need for explicit teaching has sharpened efforts to understand what knowledge and skills teachers need in order to engage learners in effective learning in the science classroom (McFarlane, 2013). McFarlane further extended that we should be able to recognise the importance and impact of science education, as well as the current and emerging challenges and opportunities for science education. He thus cautions that the science curriculum is challenged by dismal poor performance of learners. To this, it was my assumption that this

could be attributed in part to teachers' lack of motivation, inadequate learning and teaching support materials (LTSMs) (Asheela, Ngcoza, & Sewry, 2021; Czerniwiecz, Probyn, & Murray, 2000) as well as attitudes of learners to learning. In addition, learners commonly find the science subject matter abstract, couched in complex language, and insufficient to grab their immediate interest (Gilbert, 2004). In light of this, Bartholomew, Osborne, and Ratcliffe (2004) asserted that learners should appreciate that science is an activity that involves creativity. Therefore, science education in the 21st century should focus on developing strategies and solutions to our common problems (McFarlane, 2013).

Physical Science is a subject through which the mysteries of the physical world around us should be disclosed and fundamental laws discovered (Namibia. MEAC, 2009). Teachers should therefore broaden their own horizons to accommodate new knowledge and ideas that are emerging to add value to the current ones, highlighting a need for the improvement in the quality of science teaching and learning for learners. This approach might assist learners develop scientific literacy to cope with the demands of science and technology growth, which has been the goal of every nation in this 21st century (Taiwo, 2005). In light of this, Osborne (2013) avers that the primary goal of science education should be to develop science literacy.

Concurring, McFarlane (2013) elaborated that science literacy requires recognising that learners have a responsibility for their own learning by creating opportunities and strategies for self-experience to become part of formal classrooms. To add to this, learners should have adult assistance to start this development of learning by making it a joint learning activity (Zarenskii, 2016). During this joint learning activity, both the learner and the adult (teacher) establish meaningful and emotional contact with each other, where the learner feels protected, supported, and accepted by the teacher and understands the meaning of the activity and why the teacher's participation is necessary (Zarenskii, 2016). This suggests that Physical Science teachers should be creative and innovative to produce their own teaching and learning materials linked to practice (Namibia. MEAC, 2009).

Admittedly, Gilbert (2004) postulates that the problems in the learning and teaching of science have their roots in the nature of the science curriculum at all levels of educational systems. He describes the curriculum as "sedimentary", meaning that "information is continuously added to it, producing an incoherence of content and an excessive load of isolated 'facts'" (Gilbert, 2004, p.116). This had currently led to the transmission and rote memorisation of factual

knowledge that undermines the possibility of developing learners' 21st century skills, because a lack of relevance leads to lack of motivation, which ultimately decreases learning (Saavedra & Opfer, 2012). For example, teachers should know how the chosen topic relates to the learners' daily experiences and interests so that they can use those experiences to build on. It is precisely for this reason that the curriculum acknowledges the knowledge and experience learners come with as potential that should be utilised and drawn into teaching and learning (Namibia. MEAC, 2009). Therefore, the need for creativity cannot be overemphasised, especially as science education increasingly becomes a competitive factor among nations in the education sector (McFarlane, 2013). This suggests that to respond to the challenges emanating from the 21st century, science curriculum should be relevant to learners' everyday lives.

However, Tytler (2002) argued that to develop a new understanding there is a need for learners to be encouraged to extend their prior knowledge to a new situation. So, science teachers have a great responsibility in ensuring that learning is not a process of dominating and dictating, but one which creatively engages learners' motivation and desire to know and apply what they learn in their daily life (McFarlane, 2013). Regarding the application of science to learners' everyday life experiences, the Physical Science curriculum in Namibia acknowledges the inclusion of indigenous knowledges, yet the irony is that it has no IK included in the curriculum. As a result, teachers find it difficult to include it in their lessons. This is what Adepoju (1991) and Salau (1996) postulate leads to syllabus dissatisfaction and contributes to learners' low performance in science.

It was against this caveat that there was a need to redefine and reconstruct the school curriculum in Africa and de-legitimise western defined school knowledge (Shizha, 2013). That is, this requires recognising that learners should be encouraged to learn science in their everyday lives as there are numerous contexts outside of the classroom wherein learners can learn about science. In the 21st century, we need a science curriculum that creates harmony between the world that learners live in and the world they will have to negotiate (Keane, 2007). Further, this requires adopting a learner-centred pedagogy as learners learn best when they are actively involved in the learning processes (Namibia. MEAC, 2015).

The relevance of the curriculum is of critical significance (McRobbie & Tobin, 1997). Linkson (1992) is of the view that both teachers and curriculum developers should make collaborative

efforts to write support materials that are culturally appropriate such as *mudukuto* in the context of this study. Learning science should be about realising the importance of tangible evidence that learners can relate to and supporting their understanding. The Physical Science curriculum places a strong emphasis on learners' understanding of the physical and biological world around them at local, regional and international levels (Namibia. Ministry of Education, Arts and Culture [MEAC], 2015). It extends further that it is thus important for the learners to acquire knowledge and skills which will foster their understanding of the interaction of human beings and the environment to satisfy human needs.

The implementation of the curriculum should be supported with resources that can enhance teaching and learning. In contrast, lack of resources hinders the attainment of the universal educational goals, namely, *access*, *equity*, *quality* and *democracy* (Tjipueja, 2001). Therefore, the curriculum should value the knowledge and experiences learners bring to school (Mavuru & Ramnarain, 2017). This is important since learners process new science concepts in a way that makes sense to them in their own frameworks of reference, their own world views which they would have used to build up their experiences (Mukwambo, 2017).

In light of this, school science integrated with IK might facilitate the ease with which learners' cross-cultural borders into school (western) science (Ogunniyi, 1988). Jegede (1995) refers to this as collateral learning. According to Aikenhead (2002), collateral learning encourages meaningful learning of science. However, it seems that learning experiences of formal schooling in Namibia hardly relate to the needs and environment of the African learner. The consequence might be massive turnout of learners who are strangers to their culture, unemployable and who hardly contribute to the socio-economic and political advancement of their respective communities (Quan-Baffour & Bayaga, 2009). Furthermore, the curriculum has led to African learners being exposed to fragmented and compartmentalised knowledge contrary to holistic learning which they are used to in their villages and communities (Shizha, 2013).

With the above dilemma, the Namibian curriculum encourages teachers to integrate everyday examples in their lessons, but my experience as a science teacher is that in some cases there are no available teaching materials that could complement learners' prior everyday knowledge. To Katonga (2017), if the issues surrounding localisation were not treated with the seriousness they deserve, they risk remaining a mere superficial rhetorical policy acknowledgement.

Hence, indigenous learners might lack epistemological access to westernised and decontextualised scientific concepts in formal education processes (Ngcoza, 2019).

Consequentially, indigenous knowledge might continue to remain in the margins of science. The relevance of traditional knowledge (TK) systems had been considered obscure, irrelevant and exotic, despite the majority of indigenous people predominantly subscribing to traditional worldviews (Subramanian & Pisupati, 2010). IK needs to be addressed and integrated into educational programmes since the reasons for the lack of education in rural areas go beyond access to schooling, affordability, and lack of resources (Srikantaiah, 2005).

The Physical Science curriculum promotes knowledge with understanding whereby learners are expected to develop self-confidence, self-knowledge, and understanding of the world in which they live through meaningful scientific activities. Meaningful scientific activities are activities that learners can relate to and are able to facilitate their understanding of scientific knowledge. According to Cornbleth (1991), curriculum is an ongoing social activity that is shaped by various contextual influences within and beyond the classroom and accomplished interactively by primarily the teachers and learners. Malleability is one of the concepts in the Physical Science curriculum that learners struggle to understand.

### 2.3 Malleability

Malleability is the ability of a metal to be extended or shaped by hammering or applying pressure on it. Malleability is explained in terms of electrostatic force between metal ions and delocalised electrons (Cheng & Gilbert, 2014; Cheng & Oon, 2016). In the learning of the malleability of metals, learners must be oriented with metallic bonding. In a metal, atoms are held together by strong forces and a lot of energy is needed to pull them apart. During metallic bonding, metal atoms lose the outer shell electrons and form an electron sea. The metal atom becomes a metal ion and an electron sea.

The electron sea model (Cheng & Gilbert, 2014) is a representation of metals as metal ions and delocalised electrons. It is postulated that the electron sea model helps learners make sense of daily phenomena (Cheng & Gilbert, 2014). For example, application of metals (Cheng & Gilbert, 2014) encourages teachers to consider making scientific ideas concrete and visible to the learners. One way is through the electron sea model.

The Physical Science grade 9 syllabus expects learners to know the properties of metals by explaining that their properties can be changed to make them more useful (Namibia. MEAC, 2015). However, in order for learners to make sense of the concept of malleability, they should first be oriented about the particle model of matter. An atomic model is a topic taught in Natural Science grade 7, where learners are expected to understand that atoms are the smallest building blocks of matter and explain that all matter consists of elements or combinations thereof (Namibia. MEAC, 2015).

The grade 8 Physical Science syllabus builds upon the learners' existing knowledge learnt in Natural Science grade 7 which corroborates Hoepfner's (2014) diagnosis that learners' prior knowledge of matter needs to be used as a resource to build understanding. Therefore, in grade 8, learners are expected to know the atomic model and discuss the development of the atomic model. The particle model of matter is an important concept of science as it serves as a baseline for understanding states of matter phase changes and properties of substances (Merritt & Krajcik, 2013).

Hence, in grade 9, learners are expected to apply the atomic models of matter to explain the properties of substances. For example, a model is used to explain the malleability of metals. In this case, a particle model explains the malleability of metals as the spatial rearrangement of particles before and after a metal is stressed (Cheng & Oon, 2016). In addition, learners' understanding of matter originates both from everyday experiences and classroom instruction (Merritt & Krajcik, 2013). Furthermore, the aforesaid authors cogitate that learners do not only need help in understanding models used to explain particle theory, but they also need instruction that helps them to understand the limitations of these different models. Concurring, Nakiboglu (2017) affirms that learners had considerable difficulty in using atomic/molecular level models of matter to explain the properties of substances. This indicates that learners' understanding of the model of matter is relatively limited (Nakhleh, 1992). One of the major challenges identified by Adbo and Taber (2009) in learning about matter is learners' macroscopic ways of thinking and suggested that it should be taught by means of models.

Despite the line of argument pursued, Harrison and Treagust (1996) warn that the use of models to explain a concept might be confusing and challenging to many learners. Agreeing, Skamp (2009) asserts that many concepts have a high conceptual demand that is hardly used in the everyday language of learners. Similarly, Cokelez (2012) claims that some common

misconceptions that learners had about atoms and molecules relate to the size and shape of the atom as well as differentiating between concepts of an atom, molecule, and element. It was against this caveat that Hoepfner (2014) emphasised that knowledge of atoms and molecules forms the foundation for chemistry topics in secondary school. To Cheng and Oon (2016), the understanding of metals losing electrons and becoming metal ions with an electron sea, is key to explaining malleability of metals. In a metal object, electrons are mobile so when the metal is stressed, the particles begin to rearrange themselves. One of the possible ways to achieve this is through mobilising the indigenous practice of the blast furnace as discussed in the section below.

### 2.4 Blast Furnace

The blast furnace is normally used in the extraction of iron from its ore. During this process, the iron ore, coke, and limestone are added at the top of the blast furnace and hot air is blown into the bottom of the blast furnace. The blast furnace process is characterised by numerous physical, chemical, physico-chemical, mechanical and hydraulic processes, homo- and heterogeneous reactions which occur simultaneously and affect each other (Babich, Senk, Gudenau, Mavrommatis, Spaniol, Babich, & Formoso, 2005). It is a chain of metallurgical processes at integrated steel works. That is, the blast furnace is a metallurgical installation used for smelting to produce industrial metals, especially iron (Petrescu, Popescu, & Gligor, 2014).

The oxygen in the hot air reacts with coke (carbon) to form carbon dioxide while limestone (calcium carbonate) breaks down to form calcium oxide and carbon dioxide. Carbon dioxide reacts with more coke (carbon) to form carbon monoxide, then the carbon monoxide reacts with iron ore to form iron and carbon dioxide. In the process, the iron oxide is reduced to iron and carbon monoxide is oxidised to produce carbon dioxide. The molten iron runs to the bottom of the blast furnace where it is collected because it is denser. The diagram of a blast furnace is illustrated below to show how it is used in the extraction of metals, for example, iron.

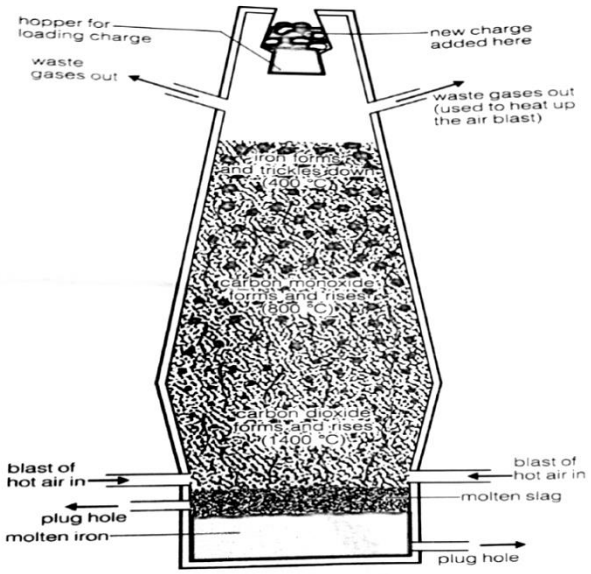


**Figure 2.1: Adopted from chemistry made clear, GCSE edition (Gallagher & Ingram, 1984, p. 146)**

In this study, a blast furnace was used as an intervention for the integration of IK in a westernised science classroom as a mediating tool to help learners understand the concept of malleability. It goes hand in hand with Vygotskian theory that stipulates that the development of the child's higher mental processes depends on the presence of mediating agents in the child's interaction with the environment.

Equally, Cobern and Loving (2001) argued that good science explanations will always be universal even if indigenous knowledge is incorporated as scientific knowledge. Horton (1994) affirms that much of traditional African thought at the lower level does not differ substantially from scientific explanation. It had been shown that the inclusion of IKS into mainstream curriculums can promote conservation as well as cultural revitalisation for indigenous peoples (Saenmi & Tillman, 2006). This supports Dziva, Mpofu, and Kusure's (2011) claim that using local or indigenous knowledge in science classrooms motivates learners and helps address some 'myths' which are against the acquisition of scientific concepts. Concurring, Govender (2016) affirms that local or indigenous knowledge is a valuable teaching resource that engages and motivates learners to participate actively during science lessons (Sedlacek & Sedova, 2017; Vygotsky, 1978).

Mukwambo (2017) suggests that in under-resourced schools' teachers should make use of activities from their communities that reflect science. He concurs with Abrams, Taylor, and

Guo (2013) that using community-based resources and integrating local practices and issues into school science teaching, can help engage learners in science and give them useful practical knowledge that instils a sense of confidence that can be transferred to other aspects of the curriculum and life in general (Klein, 2011; Mateus & Ngcoza, 2019).

Extending on Asheela's (2017) as well as Shinana's (2019) studies, the blast furnace was used in the study as an easily accessible material to teach the concept of malleability to the grade 9 Physical Science learners. It was hoped that the use of *mudukuto* to teach the concepts of malleability would demonstrate that indigenous knowledge co-exists with westernised knowledge (Keane, 2008; Ogunniyi, 2007). Many science education researchers had argued that science is more appealing to learners when it is viewed as relevant to their home background knowledge and livelihoods (Aikenhead, 1996; Ogunniyi, 1988; 2004).

However, westernised science is often praised by people as superior to local or indigenous knowledge, but it does not have the cultural fingerprints that appear to be much more conspicuous in other knowledge systems (Gough, 1998). The study critically explored the use of a blast furnace in a rural science classroom and learners' participation and interactions when they were accorded an opportunity to work with the traditional materials used in their surroundings to explain the scientific concepts of malleability. In essence, exposure to this indigenous practice is perceived as prior everyday knowledge as emphasised by Kuhlane (2011). Furthermore, the traditional blast furnace was used as an indigenous technological knowledge in the study to facilitate learners' understanding and ignite a passion for science. The fact that indigenous knowledge is mostly evident in practical activities (Senanayake, 2006), qualifies it to be referred to as indigenous technology (Kimbell, 2008; Robyn, 2002). For example, material (physical) technology such as bows and arrows are of a visible and tangible nature and these expressions are technologies because they are meant to address people's problems, needs and/or wants (Gumbo, (2016). Indigenous technical knowledge (ITK) is knowledge that has been developed by people based on their experiences and tested over long periods of use, adopted into local culture and environments through informal experimentation (Roy, 2014). Thus, this was technology learnt through observation and hands-on experience. However, it remains ironic that most development of technology in science is Eurocentric, as lack of indigenous knowledge about indigenous practices in many technologies might lead to failure (Khodamoradi & Abedi, 2011**)**. In light of this, it was my assumption that

the use of indigenous technical knowledge in the study might also debunk the belief that modern technology is not the only viable alternative to enhance learners' understanding.

### 2.5 Hands-on and Minds-on Practical Activities and Visualisation

Practicals are a didactic method of learning and practising the activities involved in science (Bradley, 2005). In Namibia, the Physical Science curriculum recommends practical activities in every topic (where possible) so that learners are exposed to concrete evidence where they can develop scientific inquiries and draw conclusions based on their observations in relation to what they are being taught. Practical activities are essential components of science teaching as they develop learners' scientific knowledge (Heeralal, 2014). Learning science becomes more effective if the child is involved in practical teaching and takes an active part in their learning (Klainin, 1995).

Practical work has been greatly recognised in science (Gacheri & Ndege, 2014). Despite this, it continued to be side-lined in schools, leading to learners being denied the opportunity to verify scientific facts and principles already taught (Gacheri & Ndege, 2014). The scholar believes that the essence of practical work encourages science process skills which provide the foundation of science experience (Gacheri & Ndege, 2014). In contrast, Asheela (2017) concurred with Fischer (2010) that doing practical work is time consuming and is peripheral to the real job of learning. In some instances, teachers lack the knowledge of conducting the practical activities or experiments because they were never exposed to them before or there is a lack of laboratory apparatus. To make this less challenging, teachers can use easily accessible materials (Asheela et al., 2021) when doing hands-on practical activities. These scholars believe that the use of easily accessible materials to mediate learning deepens the notion of inclusivity and stimulates social interactions among learners. For instance, Shinana's (2019) study conducted in Namibia used *Oshikundu* to mediate learning of enzymes. The study revealed that science was contextualised which resulted in greater conceptual learning and sense making of science concepts.

In light of the above statement, Maselwa and Ngcoza (2003**)** caution teachers not to associate activity with learning and suggest that the approach of predict-explain-explore-observe-explain

(PEEOE)[4] should be the focus during practical activities. It is therefore imperative that teachers' moral and personal commitment to teaching science well, with hands-on practical activities and other interactive activities, has an impact on their enjoyment of science activities (Turner & Ireson, 2010). According to Shifafure (2014), science teachers should plan that practical activities be conducted at reasonable times so that all necessary materials can be sorted beforehand and where there is a shortage of materials, local accessible materials can be brought in to fill the void. Nikodemus (2017) and Asheela et al. (2021) agree with Shifafure (2014) that practical activities should be selected with a clear intended purpose, otherwise they will not yield the desired outcome.

For instance, Nikodemus's (2017) study conducted in Namibia concluded that practical activities have a greater potential for meaningful learning if they are carefully designed to focus on the key scientific concepts to be developed and how these concepts are linked. Nikodemus (2017) extends that teachers should be encouraged to design practical activities that encourage individual and group work, thereby involving learners as partners in knowledge creation, rather than only receivers of knowledge. It should be recognised also that practical activities are a form of visualisation. As a result, they had a potential to motivate learners to learn science since learners can visualise concepts.

Visual representations are critical in the communication of science concepts (Mathewson, 1999). It unfolds ideas in science lessons, and it has been widely used in science education to represent scientific concepts for many years (Cook, 2006; Gilbert, 2008). Moreover, Ferreira, Baptista, and Arroio (2013) argued that visualisations are important to learners as they can illustrate an idea that words cannot describe and in the same way can introduce learners to important aspects of scientific research that are frequently neglected in science education. In the context of the study, it was hoped that the practical demonstration on the blast furnace would visualise the hidden scientific concepts or phenomenon since visualisations provide realistic representations of the world.

[4] PEEOE stands for Predict-Explain-Explore-Observe-Explain

The Junior Secondary Certificate (JSC) examiner's report (Namibia. MEAC, 2015) emphasises that demonstrations and letting learners do experiments are proven to help learners to achieve maximum performance. The findings of the JSC examiner's report (Namibia. MEAC, 2015) concurred with Roschelle (1995) that learning within contexts can validate learners' past experiences and prior knowledge and increase learner's willingness to participate and be actively engaged.

The Physical Science subject requires learners to be practically engaged in the context of the lesson. Thus, it can be done through visualisation as it had proven to be effective in enhancing learning. However, not all visual representations necessarily lead to better learning results (Cook, 2005). For example, learners had more difficulty understanding graphics than initially assumed (Wu, Krajcik, & Soloway, 2001). Teachers should thus be cautious in the selection of the visuals they use in their classrooms, otherwise it might not yield the intended results.

Ainsworth (2006) postulates that when learners interact with appropriate representations their performance might be enhanced. Visualisations include solid physical objects or immaterial light projections that utilise images, sounds, text, textures, and other perceptual modifications to convey complex information (Rapp & Kurby, 2008). The use of visualisations in science education relating to the cognitive domain has the role of making invisible concepts/ideas visible but also to illustrate abstract concepts and make them concrete (Rundgren & Yao, 2014). Thus, bringing visuals into the classroom is synonymous to bringing reality to the class that learners can make meaning out of. For example, Kelly and Jones (2006) investigated how learners' explanations of the dissolution of sodium chloride were affected by viewing two animations of the particulate nature of the dissolution of sodium chloride. The investigation found that the particulate animations had a positive influence on the explanations the learners provided of both particulate structures and the functional aspects of dissolution, and they often incorporated features displayed in the animations.

Science concepts, ideas, and methods had a great richness of visual relationships that are intuitively representable in a variety of ways. The use of visual representations is clearly very beneficial from the point of view of their presentation to others, their manipulation when solving problems and when doing research (Guzman, 2002). Presmeg (1992) described visualisation as an aid to understanding. It offers a method of seeing the unseen and we are

encouraged and should aspire to 'see' not only what comes 'within sight', but also what we are unable to see (Arcavi, 2003).

The interpretation of visualisations is highly related to prior knowledge (Tibell & Rundgren, 2010). Thus, learners' prior knowledge plays an enormous role in the acquisition of science concepts, as Cook (2005) alludes that learners construct an understanding from visual representations on the foundation of their existing knowledge, since visualisation is highly related to learners' prior knowledge (Cook, 2006; Wu, Lin & Hsu, 2013). It also depends upon the notion of scaffolding to facilitate learning (Rapp & Kurby, 2008). Murphy (2009) suggests that visualisation processes can meaningfully scaffold the teaching of conceptual understanding of mathematical concepts. However, not only in mathematics but even in science as science provides a body of phenomena, facts, and ideas that can be visualised through both reading and mathematical representations (Gilbert, 2008).

Mayer (2001) argued that relevant prior knowledge facilitates the referential connections made between the visual and verbal mental models. Learners can be engaged and encouraged to participate more actively in learning and the teachers' role could become more focused on enabling learning through interactions (Webb, 2010). Visualisation is not a panacea, (Rundgren & Yao, 2014), so firstly, teachers need to know the key features linked to the concepts embedded in the specific visualisation and how to direct learners' attention towards it. Visualisation can serve as a mediating tool for IK re-contextualisation of science. Kaino (2013) notes that the artefacts that are available in the environment are important tools that can be used to mediate between what is usually taught in the classroom and what exists outside the classroom. However, Mosimege and Onwu (2004) point out that effective re-contextualisation of IK depends on how the teacher deals with the knowledge in the classroom, and how the curriculum design allows the consideration of such knowledge.

### 2.6 Prior Knowledge

Prior knowledge serves as a point of departure for learners in their construction of knowledge. Roschelle (1995) states that it is impossible to learn without prior knowledge. Prior knowledge not only influences subsequent conceptual learning, but also influences perception and attention (Cook, 2005). Admittedly, the knowledge and experiences learners bring to class contribute to their understanding of what is to be taught.

From a social constructivist point of view, learners' prior knowledge which is obtained from everyday experience and home culture serves as the raw material for knowledge construction (Driver, Asoko, Leach, Mortimer, & Scott, 1994; Stamovlasis, Dimos, & Tsaparlis, 2006). To this, Svinicki (1993) argues that prior knowledge affects how a learner perceives new information. That is, when learners relate the information to their everyday life experience, the better they stand a chance of understanding it.

Ledbetter (1993) explains that learners' understanding of science relies heavily on how science is constructed based on their previous experience. To this, Liveve (2017) concurred with both Svinicki (1993) and Ledbetter (1993) that prior everyday knowledge in the teaching of science concepts becomes relevant when the science is connected to what science learners already know. It is precisely for these reasons that Mavuru and Ramnarain (2017) expand on Vygotsky's (1978) seminal work that learners' socio-cultural background is critical during teaching and learning.

Moreover, Mavuru and Ramnarain (2017) explain that effective teaching should recognise the role of learners' prior knowledge and experience and social environment. For example, as evidenced in Nikodemus' (2017) and Shinana's (2019) studies conducted in Namibia, knowledge learners had gained from *Oshikundu*[5] could be carried into formal classes to serve as a bridge between concepts such as rates of reaction, preparation of carbon dioxide, and fermentation.

Despite the perceived advantages of inclusion of prior knowledge, some teachers do not seem to always consider prior knowledge in their lessons (Asheela, 2017). Instead, they tend to neglect prior knowledge arguing that it is time consuming and they are dictated to by the prepared content to be presented in the class within a certain time frame. In contrast, teachers need to contextualise science concepts that they teach so that learners understand it better by relating it to their daily life experiences (Kuhlane, 2011; Mukwambo, 2017). It was against this caveat that Taylor (1999) critiques that not all everyday contexts provide suitable entry points

[5] *Sikundu in Rukwangali* is a non-alcoholic traditional beverage which is made from fermenting three flours, namely, *hingo*, *Etumbu* and *Mahangu meal*. It is a staple drink for many *Kavango* 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.

into school knowledge. This means not all learners' experiences serve as entry points to abstract science concepts. However, when building on what learners know, school teachings might be affirming and helping to develop the agency, voice, and power of learners to own their education (Dei, 2012).

Learners' interest in science in developing countries has decreased because the school science being taught is like a foreign culture (Maddock, 1981). Learners were surrounded by western ideas that do not affirm their way of life (Riyad, 2006). According to Hodson (2009), learners' worldviews that they bring into the classroom should be acknowledged and celebrated to facilitate the emergence of Afro-centred pedagogies and reduce the foreignness. Learners' prior knowledge can be unlocked by using analogies as suggested by cognitive psychologists because it explains something difficult by relating it to something easy to understand or already understood by pointing out its similarities. Analogies is the use of familiar or visualised materials to facilitate learners' understanding concerning a topic.

Roschelle (1995) posits that research has shown that learners' prior knowledge often confounds an educator's best efforts to deliver ideas accurately and that learning proceeds predominantly from prior knowledge. The use of everyday contexts in science classroom teaching has been promoted in Africa for purpose of curriculum relevance (Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda, & Campbell, 2005). Learners' prior knowledge can be enhanced through actively engaging learners through hands-on practical activities (Asheela, 2017; Maselwa & Ngcoza, 2003). It should be recognised that prior knowledge could be in the form of indigenous knowledge or practices.

### 2.7 Indigenous Knowledge

Indigenous knowledge (IK) has been ignored for many years in science curricula (Kibirige & Van Rooyen, 2006). This had led to several authors such as Abah, Mashebe, and Denuga (2015) and Mhakure and Otulaja (2017) submitting that in order for schools and curricula to positively respond to the need of making teaching and learning more culturally inclusive, there was a need for a paradigm shift from the current predominantly Euro-centric curriculum and school systems of Africa. Battiste (2010) postulates that the challenge is to raise IK to its rightful and equal place in the academy. The scholar extended further that without IK, language maintenance and educational self-determination, educational priorities for indigenous peoples might remain negligible. Van Rooyen and Kibirige (2006) elaborate that the absence of IK in

science curricula had significant consequences for some learners, because they experience conflict between their existing knowledge and the knowledge of the various science curricula.

Mukuka (2010) views indigenous knowledge as a body of knowledge with value that can also be taken as a commodity. The inclusion of IK in education curricula encourages critical thinking and can attract more learners to science (Govender, 2009). In addition, it helps learners to see that science can be arrived at from other epistemological pathways (Corben & Loving, 2001). In all indigenous groups the knowledge systems are based on local, social, cultural, historical, and environmental contexts (Fleming & Regmi, 2011). The absence of IK in science classrooms might be filled by exposing teachers to IK in their training. This agrees with Owuor (2007), that teachers' attitudes and beliefs about IK determine whether or not they will integrate it into the formal curriculum in their classrooms.

Teachers should be able to understand learners' languages and cultures (Lee & Fradd, 1998) in order to respond to the diversity of learners in their classrooms. The rich indigenous knowledge (IK) and cultural practices in many areas in the country provide learners with a good entry point into the scientific world (Beer & Mothwa, 2013). Afonso-Nhalevilo (2013) sees school curricula in post-colonial Africa moving through a series of stages in regard to the treatment of IK. The current curriculum and old curriculum do not make space and place for the implementation of IK as there are no examples of IK in the curriculum, even though the Namibia Senior Secondary Certificate Ordinary Level (NSSCO) examiner's report (Namibia. MEAC, 2007) emphasises that a link should be made between teaching and learning of Physical Science in the classroom to the learners' everyday life experiences in order to remove the foreignness and abstract nature which learners often experience in the study of science. Keane (2008) elaborates that IK and western Science have intersecting domains and IK belongs to science classrooms because it is science.

In support of Keane (2008), Taylor and Cameron (2016) discussed the three perspectives of the relationship between science and IKS (Indigenous Knowledge Systems) (see Figure 2.2), namely, the inclusive perspective; exclusive perspective; and an intersecting perspective.

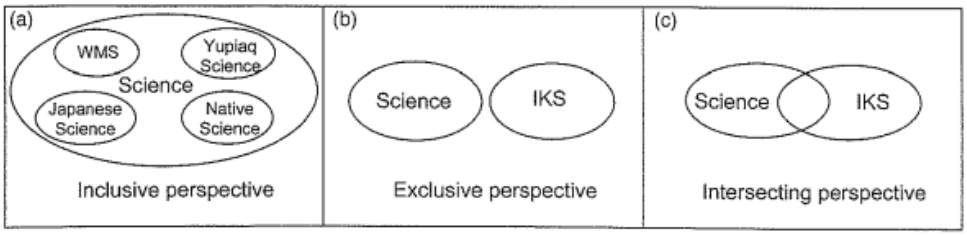


**Figure 2.2: Three perspectives of the relationship between science and IKS (adapted from Taylor & Cameron, 2016, p. 36)**

Taylor and Cameron (2016) describe that the inclusive perspective (Figure 2.2.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. However, the exclusive perspective (Figure 2.2.b) regards science and IKS as fundamentally 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 third perspective (Figure 2.2c) sees science and IK as an intersecting domain (Cobern & Loving, 2001; Keane, 2008).

The perspectives provide a way for science teachers to think about what examples of IK are suitable for use in the classroom as well as ways to use them (Taylor & Cameron, 2016). 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, the perspective allows learners to clearly see the value of IKS in relation to, as well as the difference between, these knowledge systems (Taylor & Cameron, 2016). In the study, I therefore opted for the integrationist perspective believing that these knowledges complement one another rather than being mutually exclusive.

It was recognised, however, that the implementation of the integration of two worldviews in the classrooms depends largely on the teacher's knowledge (Le Grange, 2007). Subsequently, science teachers must have a thorough understanding of the relationship between IKS and beliefs in their own communities (Mhakure & Otulaja, 2017). Keane (2008) postulates that rural communities had ways of knowing and being that could contribute to enriching science education. So, it was time the new transformed curriculum offers a voice to the neglected and marginalised to highlight common themes, perspectives, and practices of the various

participating voices (Shizha, 2013). In conclusion, Mhakure and Otulaja (2017) concede that successful integration of IKS and WSK in science classrooms depends on the training of teachers on how to manage the two worldviews and availability of resources.

IK had been challenged by various scholars that it is not applicable in a multicultural classroom because learners come from different backgrounds. Khupe (2014) demonstrates that the inclusion of examples of only IK in a science curriculum would render a watered-down version of the knowledge and value of the community and inadvertently degrade the fullness of the knowledge. Similarly, there are proponents of IK who caution against the dangers of romanticising IK, for example, Ogunniyi (2007a), Keane, Khupe and Muza (2016) and Mhakure and Otulaja (2017). In line with the argument pursued, romanticising IK might result in its adoption as a hegemonic knowledge system, replacing western science (Klein, 2011). Thus, Corben and Loving (2001) critiqued the integration because the IKS worldview lacks the absence of rules of evidence.

In addition, Horsthemke and Schafer (2007) oppose the integration of IK saying that learners see it as outdated, irrelevant, exotic, backward, and culturally alienating. In contrast, Erinosho (2013) emphasised the importance of using IK for contextualising school science instruction because it forms part of learners' prior experiences. However, Mhakure and Otulaja (2017) argued that IK may not be compatible with WSK. For example, in WSK, discharge of electricity between clouds causes lightning while in IKS, lightning is caused by witchcraft believed in most African countries (Mhakure & Otulaja, 2017). Namibia is not an exception regarding the African 'myth' or belief about witchcraft.

Considering the above, Keane, Khupe and Seehawer (2017) caution that the type of knowledge generated in IK research should relate back to the lives of those who contributed to the research. It was argued that research into IK is motivated by the recognition of its neglected and threatened status crossing the barriers between 'self' and 'other' (Keane et al., 2017). In cognisance of Shinana's (2019) study, Namibia is a multicultural country with diverse culture and language, and each cultural group practice a variety of cultural and traditional practices. Despite this, the mode of transfer of IK lessons had been embedded in the structure of indigenous languages, cultural, and traditional practices (Battiste, 2010). With the use of language, Mavuru and Ramnarain (2019) caution that the use of it should not culminate in the exclusion of other learners since Namibia is a multicultural country. Moreover, although

learners had different backgrounds, there is a sense of IK in their experiences that might be different in terms of name or colour, but it shares the same meaning with others. For example, an Oshiwambo learner calls alcohol '*Omalovu'* while an isiXhosa learner calls alcohol '*Umqombothi'*.

### 2.8 Role of Indigenous Knowledge in Teaching Science

Many scholars of science had advocated for the integration of indigenous knowledge in the science curriculum (Mukwambo, 2017; Nikodemus, 2017; Shizha, 2007; Simasiku, 2017). These scholars believe that indigenous knowledge serves as an entry point to learners understanding of western science and encourages meaningful teaching and learning in the science classroom. For instance, Nikodemus (2017) alluded that the inclusion of local or IK in the curriculum had several societal benefits.

Learning science should be viewed by learners as the process of culture acquisition, where all learners are able to cross cultural borders from their everyday world into the subculture of science (Aikenhead & Huntley, 2002; Aikenhead & Jegede, 1999). Aikenhead and Huntley (2002) emphasised that the integration of indigenous knowledge with school science is important as it prevents a cultural clash whenever learners attempt to learn meaningful school science. In light of this, Vygotsky (1986) stated that the acquisition of scientific concepts arises from their presentation to school learners in the form of precise verbal definitions.

Le Grange (2007) adds that teachers' understanding of learning areas and teaching methods is of paramount importance to effective teaching. That is, teachers need to have a much broader view of science and empower learners from indigenous groups to learn and engage in science (Fleming & Regmi, 2011). This suggests that teachers should diversify their teaching approaches to incorporate IK in their teaching as the methodology is much more familiar to the learners. Thus, this undertaking according to the NSSCO examiner's report (Namibia. MEAC, 2007) enables learners to smoothly cross cognitive borders between classroom science and their everyday life experiences. However, IK contexts require science teachers to form new identities regarding these worldviews (Mhakure & Mushaikwa, 2014). Therefore, it is important for teachers to place emphasis on learners' existing knowledge in their lessons.

In light of this, it would prevent learners' possessed knowledge being lost if not properly harnessed by the teacher (Le Grange, 2004). Learners from indigenous communities learn

science more meaningfully when it is made more relevant to them by recognising and including their cultural values into school science classroom discourses (Aikenhead, 2001; Aikenhead & Jegede, 1999; Jegede & Okebukola, 1991; Ogunniyi, 2011). Teachers are key stakeholders in the integration of IK in the science curriculum, therefore, the integration of indigenous knowledge in formal schooling and integrated science may largely depend on the competence, commitment and resourcefulness of the teachers (Katonga, 2017).

Teachers should acquaint themselves with local materials to have a better understanding of the materials and how they might benefit the transition of learners from local science to western science. As Le Grange (2007) cautioned, there is a danger in ignoring learners' IK. Hence, learners can be easily turned off if they are taught something new that they cannot relate to what they know (Strangman & Hall, 2004).

Learners' underachievement in school had been attributed to the cultural gaps between the expectations of school curriculum and those of the environment in which the learners are socialised (Abah, Mashebe, & Denuga, 2015). The curriculum does not speak to the cultural capital of the learners, as Fakudze (2004) argued that for the learner to realise the link between what they learn and their day-to-day experiences, learning science concepts should take place within a traditional socio-cultural environment. Fakudze (2004) concurred with Aikenhead and Jegede (1999) that the culture of a learner's immediate environment plays a significant role in learning and that it determines how concepts are learned and stored in the long-term memory as schemata. The inclusion of IK might motivate learners to learn science as the classroom setup appreciates their backgrounds and the knowledge, they come with to school.

As much as people want to indigenise the science curriculum, it seems that the curriculum policy document does not explicitly explain how the integration of IK with science should take place (Mosimege & Onwu, 2004; Ogunniyi, 2007). The challenge remains as most science teachers who are supposed to implement such a curriculum have been assimilated into a scientific mode of inquiry (Aangama, Fatoba, Riffel, & Ogunniyi, 2017). To this, Katonga (2017) proposes that if learners were trained to value and incorporate aspects of local knowledge's in their daily classroom learning, the same was highly likely to manifest in their teaching. He extended further that the role of teachers in the transmission of knowledge cannot be overemphasised.

Klein (2011) warns that IK should not be presented as the answer to all the problems and shortcomings in Africa, but it should be viewed as a way of mediating the concepts in the local context. Hodson (2009, p. 118) argues that although there are valid and sound pedagogical arguments for the inclusion of IK there was need to be cautious not to include "anything and everything in the curriculum under the banner of science". For example, some of the IK contradicts itself, as Ogunniyi (2011, p. 102) suggests that for IK to be "worthy of inclusion into the curriculum a better interrogation of its epistemology would be necessary to determine which aspects were compatible with science and not".

### 2.9 Benefits of Community Members in the Application of Local or IK in Science

Indigenous people are the custodians of IK and hence the inclusion of IK in the curriculum requires their input. Indigenous knowledge is communicated through music (songs), dance, stories, proverbs, folktales, and myths (Liveve, 2017). Engaging learners with IK in the process of schooling might help them to respect their cultural values and clarify the misconceptions about IK as lacking value, being unscientific, bereft of useful knowledge and outside the realm of "real science" (Erinosho, 2013, p. 1138). Klein (2011) adds that IK can be integrated in schools by drawing on the skills and knowledge of parents and grandparents. This is done because IK is typically embedded in the cumulative experiences and teachings of indigenous peoples rather than in a library or in journals of applied research (Battiste, 2010).

Several positive outcomes have been reported as a result of this intervention. The study carried out by Mateus and Ngcoza (2019) about the practice of making clay pots revealed that the young generation showed interest and willingness to participate in the practice of making clay pots. The practice was found to be relevant to the teaching and learning of school science, for example it was comparable to the science around food preservation (Hashondili, 2020). Thus, this was an indication that science is embedded in IK that is deeply in the psyche of African indigenous people passed from one generation to the next (Mkabela, 2015). It is believed by the scholar that the context of IK is the environment in all its social, cultural, economic, physical, natural and ideational ramifications. So, the engagement of learners with the community members created an avenue where learners' myths about IK were clarified and they saw some aspects of science emanating from IKS.

Learning is viewed as culture acquisition that requires all learners to cross a cultural border from their everyday world into the subculture of science (Le Grange, 2007). The NCBE stresses

that the community around the school can be an important support resource as well as a source of knowledge for learners to do research and project work (Namibia. MEAC, 2010). Similar to Klein's (2011) study, this study was a community-based study, whereby I went with the learners into the community to tap into the knowledge from an elder about how the traditional blast furnace can be used to teach science concepts like malleability in the classroom.

Community members play a significant role in the application of IK. My assumption was that learners going to the community member would add value to the natural context and break the boundary where school is perceived as an island by the community. Taking learners to the community concurs with the saying that, "the classroom is not the only place that opens someone's mind or knowledge". It is another way of connecting learners with their culture and bringing back the role of parents, community, and elders into education (Khupe, 2014; Mawere, 2015; Msimanga & Shizha, 2014). As Higgs (2012) argues, communities should not only be perceived as important informants, but also as research colleagues with critical perspectives on educational practices. This concurs with Keane et al. (2017), that knowledge generated in IK research should relate back to the lives of those who contributed to the research by honouring their indigenous culture, languages, and practical concerns and creating a different space for engagement. Community members' participation in studies might instil a sense of responsibility in them to take the education of their children seriously. It might build up a sense of confidence in sharing knowledge and the realisation of the importance of the knowledge they possess to society.

Some community had vast knowledge through their cultural practices and cultural artefacts that were used as important tools in environmental conservation, natural disaster management, traditional medicine, and cosmetics that schools can tap from (Klein, 2011; Mukwambo, 2017). In teaching learners, the community members as the experts of IK can be involved to share this vast local knowledge for learners to gain confidence and respond to the worsening environmental problems around the globe. This supports Hashondili's (2020) view that science teachers should consider the use of community members in their teaching to teach their cultural ways, for example food preservation. Ideally, classroom teaching should be supported by excursions to learn about specific flora and fauna as well as places of cultural significance, participation in ceremonies to learn about rituals, songs, and dances and the production of artefacts using local material and techniques (King & Schielmann, 2004). For example,

Mukwambo (2017) explains that surface tension and capillary were phenomena used by indigenous communities in their cultural practices, where water is fetched from the well or spring or borehole in the morning before it is hot because water volume decreases as it gets warm.

Teaching science should take into cognisance the cultural capital that learners from diverse home backgrounds bring to school (Mutanho, 2016). Thus, the inclusion of IK might help learners discover that scientific knowledge is part of their everyday lives and through involving the community in teaching science, they will recognise the educational value of their cultural practices (Nikodemus, 2017).

Through the interaction of the community members with the learners, their skills might improve as they find out more in-depth knowledge of their practices due to the probing questions they might be asked by the learners. However, the challenge of IK in the 21st century was it lacked documentation for future reference as Adeyemi and Adeyinka (2003, p.438) state that, "the death of a traditional doctor without documenting the various herbs of healing the sick, what to mix with what for specific kinds of treatment; and all his knowledge perished with him". That concurs with a saying that, "when an elderly person passes on in a rural area, the death is equivalent to a library burning down as the knowledge possessed by the deceased is irretrievable". Indigenous people are less willing to uphold their IK because of the influence of modern technology (Mateus & Ngcoza, 2019). Globalisation for science education had created more complex societies and causes challenges for indigenous communities (Quigley, 2009). IK that includes indigenous technologies had evolved in communities (Mhakure & Otulaja, 2017) and IK is involved in meeting the challenges of the 21st century in all aspects.

### 2.10 The Role of Home Language in Science Classrooms

Language plays an important role in the survival of indigenous knowledge (Snively & Williams, 2008). Language of instruction in African schools is the major obstacle in learners' cognitive development and learning outcomes (Shizha, 2005). Local language should be viewed as a resource not a barrier to the facilitation of teaching and learning (Mavuru & Ramnarain, 2019; Msimanga & Lelliot, 2014). To Wells (2007), language mediates communications through which thinking is made possible, therefore, teachers need to design materials that support classroom scaffolding strategies for learners to understand concepts

meaningfully and assessment tasks that do not compromise their understanding (Mavuru & Ramnarain, 2019).

The language of the Aboriginal people was oppressed to the extent that their children were not allowed to speak their own language unless they spoke English. The oppression forced learners to perceive their own language as bad and ignore everything that came with learning in their local language as important. This concurs with Cleghorn and Rollnick (2002) that the failure in understanding the importance of culture in African science classrooms where English is a second language leads to poor performance in science.

The decrease in interest shown by science learners in the world demonstrates a worrying concern and requires attention. The exclusion of indigenous knowledge systems including indigenous languages in schooling in Africa had been viewed as a form of "cognitive imperialism" (Battiste & Henderson, 2000, p. 12). Learners are being deprived of tapping into knowledge from their cultural backgrounds to serve as a point of entry to what they are supposed to learn in their classroom. Indigenous language is a vehicle for regaining Africa's memory, a crucial medium for harnessing human resources and grounding scientific knowledge in African realities (Eneh & Eneh, 2015).

Indigenous languages are important in facilitating border crossing among learners (Aikenhead & Jegede, 1999; Shizha, 2007). If learners are exposed to everyday concepts by using their native language, it will be easier for them to understand scientific concepts in a classroom setting (Kocakulah, Ustunluoglu, & Kocakulah, 2005). Learners might know what the teachers are teaching them in their vernacular language but expressing it in English becomes a challenge and they resort to keeping quiet. Thus, this forces teachers to code switch so that learners can understand what is being taught. The JSC examiner's report (Namibia. MEAC, 2012) says language expression is crucial, and many learners find it hard to express the answers in a language that is not their mother tongue in a clear and understandable manner. In most cases, this causes learners to lose marks because some ideas are incoherently stated which makes them factually incorrect. This is what Oyoo (2009) refers to as science having its own *specific register* and *discourse*. Learners struggle to explain science concepts because of the complexity of the concepts.

According to Oyoo (2007), learners had to be proficient in the language of teaching and learning for meaningful learning to be possible. However, making the materials for learning to be accessible and relevant to the learners could be another way of enhancing meaningful teaching and learning in the science classroom. Concurring, Derewianka (2014) explains that learners need explicit guidance as the everyday spoken mode of English is different from the formal academic written mode. Language is a vital component for incorporating indigenous science into the school science curriculum (Shizha, 2007). The demonstration of the traditional blast furnace was done in the local language so that all the participants felt free to express their opinions and understand each other.

Taking into cognisance the participation of the community member, speaking to community elders in a language other than their own could be considered disrespectful as positioned Keane et al. (2017). African Ubuntu is an important approach to take note of when elders are involved in a study. Maluleke (2019) supports the idea that code switching to their home language provides learners with a pedagogic advantage and helps them understand the lessons better. To this, when indigenous languages are incorporated into the science curriculum, they help learners understand scientific principles and link Western science to indigenous ways of knowing, thus sustaining indigenous languages and heritage (McKinley, 2005). In addition, a study conducted in a Korean university revealed that code-switching promoted effective learning in situations where English was used as a second or foreign language (Kim, 2015)

Effective border crossing had been shown to exert a significant positive effect on achievement in schoolwork and other cognitive activities (Erinosho, 2013). Language is not just a tool for communication but expresses our cultural view of the world and our existence (Shizha, 2007). Simpson (2002) added that developing Aboriginal languages within indigenous science and environmental educational programmes is an essential skill for communication within Aboriginal communities and elders. Learners from diverse language communities use their knowledge to make sense of what is being discussed and explored in the classroom. The use of a local language during a practical demonstration was evident in Shinana's (2019**)** study as it revealed that it stimulated learners' interest to learn science concepts around *Oshikundu*, particularly those associated with the concept of enzymes and scientific skills. Thus, there was a smooth transition from the local language to English.

Jawahar and Dempster (2013) explain that some scientific terms for example work, energy, power, and force have different specific meanings in English but would mean the same thing in the local language (*Rukwangali*); for example, force, energy, and power are referred to as [6]*Nkondo*. The challenge of having the same meaning in the vernacular language may result in confusion in learners' understanding. The JSC examiner's report (Namibia. MEAC, 2017), however, encourages learners to explain or describe scientific terminologies by using scientific language instead of everyday language.

Teaching and learning in the local language are aimed at conceptual understanding and making sense of scientific laws, concepts, theories, principles, and application thereof to everyday life. Derewianka (2014) alluded that the use of home language makes science concepts more accessible to the learners. However, Mavuru and Ramnarain (2019) warn teachers to be very cautious with the use of home language to avoid exclusion of some learners.

### 2.11 Teachers' Roles in the Application of Local or IK in Science Lessons

Teachers are the epitome of knowledge in the classroom; therefore, they select learning content and methods based on learners needs within their immediate local environment and community (Namibia. MBEC, 2003). The teaching of Physical Science is based on practical work. The doing of hands-on practical activities will always be to the benefit of the learners –for example, Nikodemus's study (2017) used *Oshikundu* to mediate the learning of rates of reactions. The study revealed that learners sensemaking of science improved as they extracted science concepts associated with the indigenous practice through mind maps. Therefore, the use of easily accessible materials reinforces social interactions that enhance meaningful learning (Asheela et al., 2021). Moreover, Mhakure and Otulaja (2017) postulate that the use of easily accessible materials creates a culturally responsive pedagogy.

Therefore, it is incumbent on new science teachers to be equipped with the necessary skills to have the ability to incorporate and teach environmental concepts in their classroom – as it requires content knowledge but also skills in how to teach the concepts. Owuor (2007) reports that the inclusion of IKs in Kenya was hindered by the western-based schooling system. Moreover, Owuor (2007) extended that this type of schooling recognised teachers as central in

[6] *Nkondo* is a term in *Rukwangali* that means energy, power or force.

classroom knowledge construction, where they prevent any space for classroom dialogue in which the experiences of members of local communities are not incorporated in formal classroom knowledge construction. This thus contributes to learners having little understanding in most concepts and performing poorly when having to answer questions.

The JSC examiner's report (Namibia. MEAC, 2017) encourages teachers to teach the content with understanding, by giving examples related to everyday life where applicable, as most learners showed very little understanding of most concepts. Through the exposure of teachers to IK, they will become the agents of change in the classroom as they can begin with the project of decolonising the science curriculum to be more Afrocentric. The word 'Afrocentric' is loosely used to refer to African or indigenous knowledge. Mukwambo (2017) concurs with Simasiku (2017) that a teacher needs to contextualise science concepts they teach so that learners can relate it to their daily experiences. Therefore, teachers need to understand the importance of not denigrating or discrediting the IK that learners bring to the classroom because it serves as the framework within which they learn science and provides the trigger for learning science (Le Grange, 2007).

However, teachers can only explore different indigenous practices when they are exposed to it through their educational or professional development training. Naidoo and Vithal (2014) acknowledge that teachers find it difficult to recommend examples linked to respective science topics and propose that those topics be more closely related to learners' societal or cultural environments to minimise conflicts that may arise from learners' views of the world. Thus, they find it difficult to incorporate IK in science because their teachers' training programmes were based on the western knowledge education. Based on my experience, I was never exposed to indigenous practices at my institution of higher learning in my first teaching degree although I knew some of the practices – for example, making of *Oshikundu* and beating drums. Little did I know that they could be used to teach science topics like rates of reaction (Nikodemus, 2017), preparation of carbon dioxide, and sound or frequency e.g. beating drums (Liveve, 2017).

African indigenous knowledge is seen as a way of reshaping African curriculum and education systems, thereby supporting the cultural and socio-educational transformation of the African continent's education systems. NNCBE (2016) encourages teachers to take cognisance of learners' IK to address educational goals. However, some cultural meanings would affect the

teaching of certain concepts in the classroom because the learners would find it difficult to relate them to the scientific meanings – for example, the cultural meaning of heat does not involve temperature changes. Therefore, it is the responsibility of the teacher to convince learners that the cultural meaning of heat is different from the scientific meaning.

Teachers should realise that indigenous knowledge and scientific knowledge co-habit together and are resourceful to one another. The incorporation of indigenous knowledge in the classroom can be done by inviting indigenous knowledge experts (*community people*) to schools to give presentations on some identified topics that are science related – this is done so that learners can listen to them, not necessarily agreeing with them but having critical discussions about the knowledge being presented. During the incorporation of indigenous knowledge in lessons, teachers need to know how to use it for the benefit of learners when they translate local science into western science, otherwise it could affect learners' learning process and teaching (Simasiku, 2017).

The study carried out by Hashondili (2020) where teachers were exposed to the presentation of a community member revealed that it assisted them to think critically on how to use IK to mediate learning of science, especially food preservation. Thus, it was my assumption that the exposure to presentations by the community member about the traditional blast furnace might enhance learners understanding and stimulate their curiosity (Shinana, 2019). In the study, learners went to the place of the community member to observe practical demonstrations of a traditional blast furnace as indigenous African peoples are the holders of unique African languages, knowledge systems, and beliefs and possess invaluable knowledge of practices (Shizha, 2013). Our cultural or local community practices are epitome of IK that should be cherished and embraced in the education system. This caveat underpins the rationale for this study to explore how learners hold and develop western scientific thinking alongside traditional knowledge using the traditional blast furnace to motivate them to learn science and make sense of the concept of malleability. I believed that the science embedded in the cultural practice using *mudukuto* could be optimally used by teachers in their science classrooms to contextualise science lessons.

## 2.12 Conceptual Framework

This section provides a discussion about the conceptual, theoretical, and analytical frameworks. Under this section, I discussed the concepts that informed the study and began the section with the conceptual framework.

### 2.12.1 Motivation

Motivation has been recognised as an important factor in science learning (Koballa & Glynn, 2007). It promotes learners' construction of their conceptual understanding of science (Cavas, 2011). In order to motivate learners, there is a need to focus on the constructivist approach.

According to Cetin-Dindar and Geban (2017), the approach emphasises that learners construct their own knowledge through the interaction of what they already know and believe about the ideas, events, and activities they encounter. This resonates with Vygotsky (1978) who believes that learning, motivation, and emotions are interconnected processes. Therefore, it is prudent that in order for the learners to learn, there must be a correlation between the assistance given and their existing knowledge.

Moreover, Vygotsky advocates that humans do not act directly on the physical world without the intermediary of tools. The learners' learning development requires mediating agents such as language to interact with the environment. Mahn (2003) elaborates that to become the agents of learning, learners have to be able to initiate and maintain learning interactions that lead to the mastering of specific content of the learning activity. Therefore, the responsibilities of a teacher as Vygotsky alludes to is a complex one. Such responsibilities essentially go beyond subject matter and teaching activities. Learners' motivation, attitudes, and interest are important elements because the effectiveness of elements correlates highly with success in science learning (Cavas, 2011). The use of models of natural objects and phenomena to explain science concepts through the involvement and participation in the learning process (Sedlacek & Sedova, 2017) gives learners motivation to learn, as well as enjoyment and satisfaction. However, the level of motivation in learners doing science is decreasing due to various factors. Trna and Trnova (2006) postulate that some science teachers do not value motivation, and this implies a lack of interest in solving problems connected with attracting the learners' attention, increasing their activity and independence, and awakening their interest in science.

### 2.12.2 Sense making

Sense making is the process of explaining observed phenomena through coordination of theory and evidence (Kuhn, 1989; Newman, Morrison, & Torzs, 1993). In order to gain insight into learners' sense making processes, learners were observed through video-recordings of their talking and how they constructed meanings out of the practical demonstrations. However, Ford (2012) proposed for learners to engage in sense making, they need to focus on attaining a 'grasp' of scientific practice, that is, an ability to participate in key forms of discourse and activity that form the epistemic basis of scientific claims. This is done through interactions between construction and critique of science phenomenon as suggested by Vygotsky (1978), by making connections to the real world or lived experiences of the learners.

Learners try to make meaning out of what they see and observe using mediational cultural tools. In the context of this study, a blast furnace was used as an epistemic tool for learners to construct knowledge or make meaning out of it. The practical demonstration was done in the local language as Msimanga and Lelliot (2014) and Mavuru and Ramnarain (2017) claim that reverting to the home language helps learners who lack confidence in English to construct understandings of scientific concepts. It is acknowledged that sense making can lead to motivation to learn science.

## 2.13 Theoretical Framework: Vygotsky's Socio-cultural Theory

A theory provides an overall orienting lens for the study and broad explanation for behaviour and attitudes that are complemented with variables, constructs, and hypotheses (Creswell, 2017). The study was informed by Vygotsky's (1978) socio-cultural theory. Vygotsky describes socio-cultural theory as a social process whereby people interact with each other and construct meaning through their social experiences using mediating agents like language. Moreover, the study used the term socio-cultural to refer to the general social and cultural circumstances in which individuals conduct their methods of acquiring knowledge, skills, and attitudes. Essentially, Vygotsky's reliance on meaning rather than action culminates in understanding language as central for understanding development for cultural psychologists (Leitch, 2011). Language learning is viewed by sociocultural perspective as influential upon individuals' strategic orientations to the classroom (Donato & MacCormick, 1994). Similarly, Vygotsky postulates that a child's mind develops by acquiring social experience in the form of

psychological tools, for example language, concepts and others. Language is a tool required by a child to make meaning.

The theory values the importance of social and personal aspects of learning (McRobbie & Tobin, 1997). In the classroom environment, for instance, learners should interact with their fellow learners and their teachers in order to make meaning that is relevant to what they want to learn. The sociocultural theory maintains that social interaction and cultural institutions, for example, classrooms among others, have a role to play in learners' cognitive growth and development (Donato & MacCormick, 1994). It should be noted that learners construct their meaning through interactions that exist between their peers and teachers in the classroom. Shabani (2016) postulates that social interaction is the basis of learning and development and believes that in order for social interaction to lead to development it had to be situated in activities that have a clear goal. In light of this, it was clear that social interaction helps learners to share their different insights and reasoning processes to adjust their understandings (Yu, 1996).

In contrast, Vygotsky's theory had been criticised for its model of internalisation in comparison with the participation model of cultural development (Lave & Wenger, 1991; Rogoff, 1990). The participation model represents development as the transformation of individual participation in sociocultural activity (Scott & Palincsar, 2013). Moreover, the guided participation indicates cognitive development occurs in a social context expanding beyond sociocultural theory. Similarly, Cobb and Yackel (1996) argued that the aspect of Vygotskian theory constitutes a transmission model in which "students inherit the cultural meanings that constitute their intellectual bequest from prior generations" (p. 186).

Vygotsky positions that agents such as social interaction, culture, and language affect how the individual learns knowledge. Within this theory, this study focused on the following key concepts: social interactions and zone of proximal development.

### 2.13.1 Mediation of learning

The notion of mediation refers to two interrelated ideas that are central for a socio-cultural understanding of human cognition and development (Vygotsky, 1978). Vygotsky proposes that in the learning process, experts use tools to mediate learning. Social environment plays an important role as Cole and Wertsch (2001) and John-Steiner and Mahn (1996) elaborate that

the impact of the social environment on learning can be seen in that the experts select and teach tool use, and this affects the way that the learners express their thinking.

This study viewed mediation of learning as a skill to draw on learning through social interaction. Vygotsky's theory stipulates that the development of the child's higher mental processes depends on the presence of mediating agents in their interactions with the environment (Kozulin, 2003). The use of the blast furnace in the study served as a tool for learners to interact with each other. The use of *Rukwangali* (local language), increased the learners' participation in the presentation, as they spoke freely since the presentation was done in their local language.

According to Vygotsky (1978), mediation involves leading learners to increased levels of complexity by providing assistance for them to reach the next level. This can be achieved with the support of the teachers and fellow learners. Mason (2000) described the role of teachers as leading the learner to higher levels of thinking by interpreting and giving significance to things and events. He claims that a critical orientation is significantly dependent on a thorough knowledge and understanding of the material. In order to achieve this, mediating tools should be aligned with learner needs and responsiveness during interaction in order to guide the learner toward new ways of thinking.

### 2.13.2 Social interactions

To Vygotsky (1978), learning is not just an individual matter but instead it develops within a social environment. That is, learning takes place in a social setting when people interact with each other. Social interaction is related to the learner-centred teaching that empowers learners with practical experience, meta-cognition, and self-evaluation through small group interaction (Brown, 1998). As Berg (2009) elaborates, learners engage in dialogues with more competent partners and adults, they internalise the language of the interactions, and use it to organise their individual endeavours in the same manner. The integration of IK in the science lessons facilitates the understanding of westernised science in the class, as IK will serve as a point of departure for learners. Social experience becomes a cornerstone of understanding and interpreting the world, as Jaramillo (1996) explains that to learn a concept, the learner must experience it and negotiate its meaning in the authentic context of a complex learning environment. The interaction of learners with indigenous people would create a platform where

learners could put to the test some indigenous knowledge or practices by having a critical discussion about them and finding the science embedded in the traditional knowledge or practices. The participation of the community member in the study is just like bringing the school to the community and the community to school which might help to improve the participants' zone of proximal development.

### 2.13.3 Zone of proximal development

The zone of proximal development was introduced as a part of a general analysis of child development (Chaitlan, 2003). Vygotsky (1978) introduced the concept of the zone of proximal development (ZPD) as a new approach that learning should be matched with the child's level of development. Zone of proximal development (ZPD) "is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). Mahn (1999, p. 347) states that the "ZPD is an important prerequisite for successful work with children who create unique paths of development based on their exceptionalities and who will have qualitatively distinct". Shabani, Khatib, and Ebadi (2010) echoed that individuals learn best when working together with others during joint collaboration, and it is through such collaborative endeavours with more skilled persons that learners learn and internalise new concepts, psychological tools, and skills. Vygotsky (1978) introduced the ZPD to establish the relationship between development and learning.

Vygotsky's thinking on the ZPD apparently began to crystallise as he confronted issues relating to IQ (Intelligent Quotient) and IQ testing (Fani & Ghaemi, 2011) and determined that in order for teaching to be effective, children had to reach a certain level of development to perform specific tasks independently. This was meant to encourage learners to take responsibility of their own learning. In relation to the testing, Vygotsky (1978) posits that one could not fully understand a child's developmental level without the determination of the desired level that measures the task the child performs with an expert.

Fani and Ghaemi (2011) pointed out that the introduction of ZPD by Vygotsky (1962) was meant to criticise the psychometric-based testing in Russian schools. Vygotsky believed that testing was not supposed to be based only on the current level of a child's development but

also on the child's potential development. In light of this, Verenikina (2003) argued that actual level of development does not adequately describe development, but it shows what is already achieved, it is a "yesterday of development", while the potential development level indicates what a person can achieve ahead, a "tomorrow of development". For example, it was difficult to determine learners' developmental level using IQ tests since two children can score the same marks in the test but their ZPD level (*higher or low*) might differ. To complement socio-cultural theory in this study, I used Ogunniyi's Contiguity Argumentative Theory (CAT).

### 2.14 Analytical Framework: Contiguity Argumentative Theory

According to Ogunniyi (2007a), the Contiguity Argumentative Theory (CAT) deals with the nature of interactions between distinctly different thought systems, for example, indigenous knowledge (IK) and Westernised Science (WS). Moreover, CAT is contextually based and asserts that science and IK tend to link with each other to make meaningful understanding (Ogunniyi & Hewson, 2008).

To Ogunniyi (2007a), CAT consists of five components or cognitive states that explain how conceptions move within a learner's mind. These are (1) dominant, (2) suppressed, (3) assimilated, (4) emergent, and (5) equipollent. Ogunniyi (2007a) explains that the dominant cognitive state exists when there is a powerful idea that explains and predicts facts and events effectively. In contrast, the suppressed cognitive state occurs when an idea is suppressed in the presence of a more dominant one. Similarly, an assimilated cognitive state is a less powerful idea in terms of the persuasiveness of the dominant idea in a given context.

On the other hand, an emergent cognitive state pertains to circumstances where no prior knowledge exists. For instance, science is not permanent knowledge, but changes as new experiments and theories develop (Govender, 2014). Likewise, an equipollent cognitive state occurs when two competing ideas have comparably equal intellectual power. That is, the ideas tend to co-exist without necessarily resulting in a conflict or dissonance (Le Grange, 2007). It seems that the equipollent state is akin to Jegede's (1995) notion of collateral learning. In the context of this study, collateral learning is the use of *mudukuto* as a supportive material to elaborate the science concepts from an indigenous perspective, concurring with Mhakure and Otulaja (2017) that the African indigenous knowledge system is the body of knowledge embedded in the African ways of knowing and social practices.

Mashoko (2018) contends that the CAT framework was developed to capture learners' experiences outside school environments. Indeed, this resonates with the study which focused on exploring how the traditional blast furnace enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability. This theory was relevant to the study as it involved some form of argumentation where it focused on the exploration of cognitive perceptual shifts in IK integration with school science (Mashoko, 2018).

In light of this, Siseho (2013) asserts that argumentation is a tool for resolving conflicting ideas and affords participants the opportunity to externalise their viewpoints and clear doubts. Agreeing, Govender (2014) envisages that where there is argumentative discourse that is culturally relevant (Mhakure & Otulaja, 2017), learners generate a fresh perspective of knowledge that might be useful in their classrooms.

Accordingly, the study sought to expose learners to these two worldviews, viz., the indigenous knowledge and westernised knowledge (Mukwambo, 2017; Taylor & Cameron, 2016). It could be argued therefore that the study thus adopted an integrationist model (Taylor & Cameron, 2016). To Taylor and Cameron (2016), an integrationist perspective regards IK and school science as complementing one another. That is, IK is used as a resource for learning (Keane, 2008) rather than being perceived as a barrier.

It is against this backdrop that Mhakure and Otulaja (2017) propose a *culturally responsive teaching* that embraces both IK and westernised science. Hence, it could be argued that teaching Western modern science (WMS) is enhanced when learners become aware of their personal and indigenous sciences (Ogawa, 1995). To this, Aikenhead and Jegede (1999) suggested that this helps learners acquire a culture of science. This is akin to Ogunniyi's (2007a) equipollent state, where the Indigenous Knowledge System (IKS) and Western Science Knowledge (WSK) are treated as co-existing.

It was the assumption of this study that the use of CAT would provide a dialogical framework for resolving the incongruities that might arise in the social interactions where IK and Western Science (WS) need to co-exist (Ogunniyi, 2007a). Socio-cultural theory is based on learning that is influenced by social interactions that exist among the participants (Vygotsky, 1978). Furthermore, CAT helped me as a researcher to observe the influence of IK in the teaching and

learning of the concept of malleability during the social interactions that occurred and helped to analyse the internal dialogues that happened due to conflicting ideas that occurred within interactions (Govender, 2014).

## 2.15 Chapter Summary

In the chapter, I discussed literature relevant to the study. I looked at the challenges of the science curriculum in the 21st century, malleability, blast furnace, prior knowledge, and practical activities. I discussed indigenous knowledge, role of community members, language, and teachers in integrating IK in a science curriculum to improve learners' conceptual understanding.

Secondly, I discussed Vygotsky's socio-cultural theory (1978) as a theoretical framework that informed the study, where I focused on the concept of social interactions and the zone of proximal development. Contiguity Argumentative Theory (CAT) was discussed as an analytical framework to analyse the data in the study.

In the next chapter, I discussed the research design and methodology used to generate data for the study.

# CHAPTER THREE: RESEARCH METHODOLOGY

## 3.1 Introduction

In the previous chapter, I explored the theory that informed the study. The research project was a Namibian case study which focused on a rural school in a rural village set-up. It was triggered and motivated by the need to make science relevant and accessible to learners, especially in a rural context.

In this chapter, I thus elaborated on the methodology adopted in the study. It gives insight about the research paradigm and qualitative case study approach that underpinned the study. I explain the research site, a profile of the research objectives, goal and questions, and the selection of participants as well as my role as the researcher and positionality. The data collection and methods of data analysis are explained in detail. Lastly, issues of validity and trustworthiness and ethical considerations were considered in this chapter.

## 3.2 Research Paradigm

The study was underpinned by an interpretive paradigm. Bertram and Christiansen (2016) explained that an interpretive paradigm tries to understand the social world. The interpretive paradigm was thus appropriate in the study as it afforded the learners and myself the opportunity to understand the lived world in a natural context. Cohen, Manion, and Morrison (2018) echoed that the context of an interpretive paradigm was to understand the subjective world of human experience.

However, the interpretive paradigm had been critiqued that it focuses on descriptions rather than explanations. To address this, I complemented the interpretive paradigm with the Ubuntu paradigm, whereby both learners and I had the opportunity to interact with community members, to interpret the science embedded in the traditional blast furnace practice. *Ubuntu* is the glue that holds African communities together (Hanks, 2008). Khupe and Keane (2017) assert that African research needs 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. Similarly, Vygotsky (1978) postulates 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 this social interaction, learners make meaning out of the activities they are exposed to.

It was in this context that the Ubuntu paradigm was adopted to complement the interpretive paradigm as it recognises the integral importance of our interactions (Hanks, 2008). Furthermore, Ubuntu not only honours our humanistic roots but also branches out and seeks to address the difficulties of a world far more diverse, complex, and fundamentally wounded (Hanks, 2008; Seehawer, 2018). Therefore, the study sought to take science education out of the confines of the classroom into a community to address the gap identified by Keane (2007). The Ubuntu paradigm was introduced to provide some explanations from a cultural point of view. As Keane (2008) postulates, by understanding key African worldviews, science educators can contribute to meaningful science education and community's well-being.

Within the interpretive and Ubuntu paradigms, a case study research design was adopted. A case study was deemed appropriate for the study as I wanted to understand and gain in-depth information about social concepts and promote understanding on how to integrate the knowledge gained in the science classroom to facilitate learners' understanding.

## 3.2 Research Design

This section provides a discussion about case study, and the research goal and questions of the study. I begin the section with the case study.

### 3.2.1 Case study

A qualitative case study provides a unique example of real people in real situations, enabling readers to understand ideas more clearly than by simply presenting them with abstract theories or principles (Cohen et al., 2018). In the context of the study, the community member explained how a traditional blast furnace works. Corroborating with the community member was hoped that learners might value this indigenous practice. The case study assisted me in generating thick descriptions of grade 9 learners and the community members' views and experiences about the usage of the traditional blast furnace. Complex social activities like exploring the use of a traditional blast furnace by learners can be understood better during a case study because it enriches the description of a case and offers another dimension of understanding an investigation. In the context of the study, the purpose was to investigate a case where learners

were exposed to IK practices as a means to provide a practical experiment to enhance their motivation to learn and make sense of science concepts. The participants of this case were bounded by the fact that they were all grade 9 Physical Science learners who had once been exposed to the practice of a traditional blast furnace or observed or heard about it in their upbringing. Thus, the case study was deemed appropriate for this study as it offered the participants the opportunity to get a deeper insight in the phenomenon that was investigated.

Equally, case study research allows exploration of the processes and dynamics of the practice (Merriam, 1998). In addition, the case study captures the learners' experiences in the science classroom that might include their interaction and engagement among themselves and with the community member during the lesson presentations. The case was grade 9 Physical Science learners and one community member. The unit of analysis was the motivation to learn science by the learners and their sense making.

Similarly, to Seehawer's (2018) study, a participatory approach was adopted in this case study. The participatory approach in the context of the study meant corroborating with elders or IK holders, where learners were taken to the places of IK holders to learn about or observe indigenous practices. Moreover, the study was also informed by Chikamori, Tanimura, and Ueno's (2019) Transformative Model of Education for Sustainable Development (TMESD) framework. The model was found appropriate for the study because it centred on designing and implementing IK integrated science lessons by inviting the community member as custodians of indigenous knowledge to add value to the science in the classrooms. Essentially, inviting community member resonates with the TMESD model as it focuses on transforming society, whereby parents become aware of what takes place in the classroom and how beneficial their knowledge is to the learners. This also helps learners to reflect on their own learning and come up with appropriate suggestions to improve it. This kind of study undertaken fits with the case study as it sought to understand a real-life situation that science learners are exposed to during out of school time with their parents.

According to Chikamori et al. (2019), the TMESD framework consists of three learning sub-processes: 'knowing the present', 'past-present relationships' (*focusing on the dependence of the present on the past*) and the 'future-present'. These scholars refer to the process of studying the past-present relationships as *retroduction* and on the other hand, future-present relationships as *retrodiction* (see Figure 3.1).

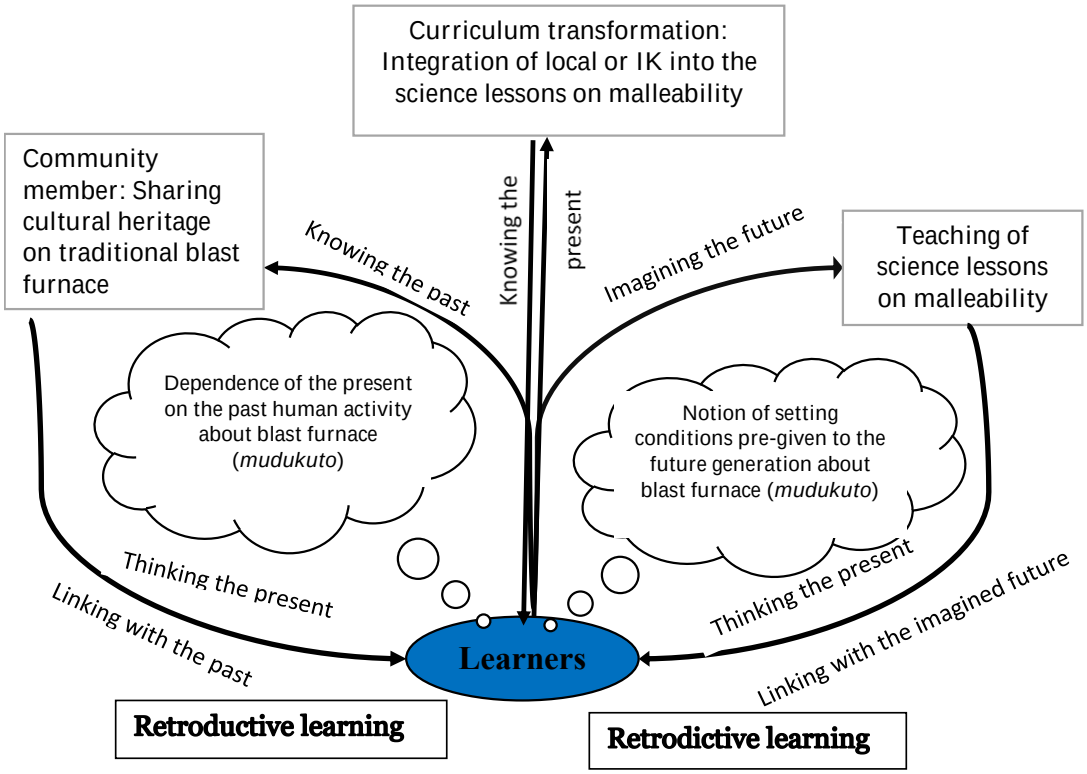


**Figure 3.1: Shows the IK-science integration process in this study (adapted from Chikamori et al., 2019, p. 9)**

In the context of the study, the past had to do with understanding the practice of the traditional blast furnace (*mudukuto*), while in the second stage, the presentation on cultural practices of the blast furnace relating to the concept of malleability which was made by a community member afforded learners an opportunity to learn about the blast furnace that is the past. The present had to do with integrating local or IK in lessons on the topic of malleability, with a view to making science relevant and accessible to the learners. This was achieved through reflections and stimulated recall interview about learners' experiences due to IK integration on the topic of properties of metal (malleability) (future).

### 3.2.2 Research goal and questions

The main goal of the study was to explore how a traditional blast furnace (*mudukuto*) enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability.

To achieve the goal, the research was guided by the following research questions:

1. What enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability?

2. In what ways do the grade 9 Physical Science learners interact, participate and learn (or not) during the practical demonstration on a traditional blast furnace (*mudukuto*) by expert community members?

3. How does the traditional blast furnace (*mudukuto*) enable and/or constrain grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability?

### 3.2.3 Research site, participants, and sampling

This section provides a discussion about the research site, participants, and sampling. I begin the section with the research site.

#### *3.2.3.1 Research site*

The study was conducted in Namibia in the Kavango West Region at the school where I teach. Martha Ghupwe Senior Secondary (pseudonym) School is a rural school in the Bunya Circuit. Although the school does not have a science laboratory, the performance of the learners in Physical Science was relatively satisfactory. Nevertheless, I wanted to improve their conceptual understanding as they might be learning by rote. This government school is situated along the Nkurenkuru road leading to Rundu town. It had an enrolment of 600 learners in classes from grades 4 to 11. The staff comprises of 20 teachers, nine males and 11 females who speak different languages namely, Rukwangali, Rumanyo, Oshikwanyama, and Subiya. However, the dominant language spoken by both teachers and learners is Rukwangali. The study was conducted at two different sites. Phases 1 and 3 of the study were carried out at school and Phase 2 was carried out at the community members' home. This was done with the reasoning to break the boundary that school was not an island as perceived by the community and to enhance the confidence of the presenter.

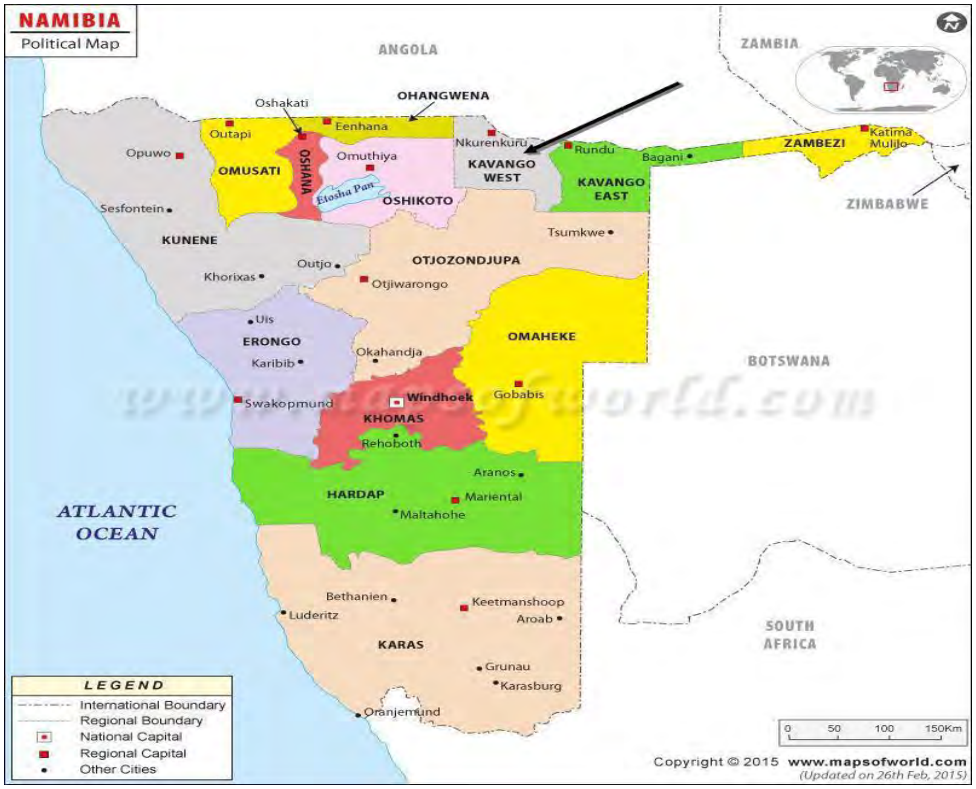


**Figure 3.2: The map shows the location of the school in the Namibian map**

### *3.2.3.2 Research participants and sampling*

Sampling refers to the process of defining the population on whom the research might focus (Cohen et al., 2018). Leavy (2017) pointed out that sampling addresses the questions, *who* or *what* is in the study? *What* is the data or content being obtained and *who* is in the study – the subjects, respondents, participants, or collaborators. In the case of this study, it was carried out with 36 grade 9 Physical Science learners consisting of 16 boys and 20 girls and [7]one expert community member selected based on his experience. The motive for the selection of learners was that I wanted to see if learners could apply their prior knowledge from grade 8. Purposive sampling was deemed appropriated for the study because it focused on the Grade 9 Physical Science learners and a community member who had a better knowledge about the usage of the traditional blast furnace. Both learners and a community member served as co-researchers in the study. According to Palys (2008), a purposive sample is a non-probability sample that is selected based on characteristics of a population and the objective of the study. The study

[7]The community member in this study is referred to as an 'expert' because he is the custodian of the traditional practice of blast furnace (*Mudukuto*).

sought to ascertain how the use of IK (traditional blast furnace) could be used to teach the grade 9 learners to understand the concept of malleability. A community member was requested to demonstrate the process of making a hoe or an axe using a traditional blast furnace.

The presentations by the community member helped learners to strengthen their knowledge in the integration of indigenous knowledge with classroom science, as Vygotsky believes that in social interactions with the community member, teacher, and more capable peers, learners learn more than they do on their own. The exercises enriched our knowledge along with the learners and helped improve our subject content knowledge.

### 3.2.4 Researcher positionality

Since I was teaching the subject, and at the same time conducting the study in my own classroom, it was acknowledged that power dynamics might be at play in the research study. As Thomas (2013) argued, interpretive researchers have an undeniable position in the research process and this position affects the nature of the observations and the interpretations that they make. This suggests that researchers (like me), should establish a good relationship and trust with the participants and clearly clarify their interest in the study. Herein lies the importance of the Ubuntu paradigm.

In doing the study, my keen interest was essentially to strengthen my academic understanding of how best to integrate IK in the science classrooms and broaden my understanding on the examples of IK in the surroundings that can be aligned to the teaching of Physical Science. Secondly, the issue of positionality and power might arise during the presentation of the community member with the learners and myself as a researcher. To address this, I positioned myself as a co-learner in the study, as the community member was the custodian of the cultural heritage. In light of this, Mateus and Ngcoza (2019) claim that some IK is derived from systematic observations and experimentation by the community member. The Community member was the more knowledgeable others as proposed by Vygotsky (1978). This suggested that I conducted the research *with* my learners rather than *on* them as they were involved in the construction of knowledge (Ngcoza & Southwood, 2015).

### 3.2.5 Data gathering methods

The study made use of the following as data gathering methods, namely, focus group interviews, participatory observation, learners' reflections, and stimulated recall interviews.

Additionally, I used document analysis to strengthen the context of the study. I now discuss each of the data gathering methods below.

#### *3.2.5.1 Focus group interview*

A focus group interview was used to find out learners' experiences, what motivates them to learn and how they make meaning out of what they learn in relation to malleability. A focus group interview resonated well with the study as I was working with learners. Cohen et al. (2018) echo the sentiments that a focus group interview is economical on researcher time, encourages interaction between the group and foresees less intimidation for children than individual interviews.

Learners were divided into two groups of six with gender taken into consideration, but the selection of the participants was done by each group's members, since they were already sitting in a group set up in the class. The focus group interview clarified the assumptions about what motivates learners to learn, as Khan and Manderson (1992) support focus group interview as they help understand a specific problem from the viewpoint of the participants of the research.

The natural setting in a focus group interview allows participants to express opinions/ideas freely, however a moderator (researcher) may unknowingly limit open, free expression of group members (Bernard, 2013). Consequently, it was my assumption that the use of English during focus group interviews was a lost opportunity. That is, participants gave short answers that could not be fully elaborated on, even though there was provision for the participants to answer in their vernacular language. This led to the interview lasting for a short period of time compared to the approximated time. From the observation, it was evident that science learning is enhanced when learners are afforded an opportunity to interact in their home language (Mavuru & Ramnarain, 2019). The weather condition was a challenge during recording as I experienced background noise due to wind when rewatching the video in some segments (see (Appendix G for the focus group interview responses).

#### *3.2.5.2 Participatory observation*

Participatory observation is a method an observer uses to participate in the life or doings of people under study, with a keen interest in seeing things that are happening, listening to what people are saying and questioning their doings over a certain period of time in order to gather data. In a qualitative observation a researcher takes field notes on the behaviour and activities

of individuals at the research site (Creswell, 2017). In the study I was a participant observer to gain insight on how learners learn in a social set-up. To this, Cohen et al. (2018) positions that participant observation is deemed appropriate when used in studying small groups, or for events and processes that only last for a short time.

Hence, the community member presented his knowledge about the cultural practices of *mudukuto* to the Physical Sciences Grade 9 learners at his homestead. Before our arrival at the homestead, the community member prepared all the necessary tools that were needed for the presentation. The community member was positioned in the study as the custodian of the cultural heritage regarded by Vygotsky (1978) as the more knowledgeable other (MKO). The purpose of observation was intended to afford me an opportunity to get first-hand experience of the participants, but my presence as a researcher might be seen as intrusive (Creswell, 2017).

The experience of the observation was also a challenging task. To this, I needed to split my time, so that I could both concentrate on observing and gathering data from the discussions. Participatory observation was deployed to observe the community member's everyday activities at his own convenient time and special attention was paid to identify the science concepts that were embedded in the traditional blast furnace demonstration. During the presentation, I observed how learners interacted with the community member. That is, the interaction existed in a form of a dialogue and arguments between the participants and the community member. The observation of the practical demonstration raised questions which were driven by our curiosity to find out more information. This finding validates Govender's (2016) view that argumentation helps learners engage with the social construction of scientific and indigenous knowledge ideas. Participatory observation provided me with a chance to learn things that participants were unwilling to discuss in the focus group interview. According to Bertram and Christiansen (2016), researchers should be aware whenever conducting an observation that human interactions are complex and based on relationships and previous experience between people. To augment data obtained from participatory observation, I used stimulated recall interviews.

#### *3.2.5.3 Learners' reflections*

At the beginning of the year, learners were asked to do reflections on all the lessons that were presented throughout the year in Physical Science, to hear their experiences and thoughts. I had to admit that at the start of the reflections, learners lacked confidence in sharing their

experiences. But with time, they begun building up their confidence and it improved their English writing skills and degree of concentration in the lessons. This supports the notion in the curriculum that English should be taught across the curriculum in each subject. I had asked learners to do reflections, as I had learnt about the importance of it at Rhodes University.

Thus, it gave me as a researcher an overview of how learners had conceptualised the learned knowledge from the presentation through their interactions, attitudes and sense making. For instance, after the presentations, learners reflected that the presentations by the community member had assisted them in understanding science and they did not know that their parents could also teach and understand science. Reflections helped learners understand and learn from their learning experiences by creating new relations between initial and acquired knowledge, making the learning process more effective (Mäeots, Siiman, Kori, Eelmets, Pedaste, & Anjewierden, 2016). However, since it was a research driven reflection, learners were given guidelines on how they should do their reflections. The impact of COVID-19 interrupted the reflections due to the sudden closure of schools (see Appendix H for learners' reflections).

#### *3.2.5.4 Stimulated recall interview*

Stimulated recall interviews involved watching the recorded videos to establish the interactions or behaviours that took place and trying to understand what was being conveyed. In this study, the video was rewatched with the selected learners who participated in the first focus group interview before the whole class. This was done to probe learners' understanding about what transpired in the presentation, for example, looking at the scientific concepts that emerged from the presentation, social interactions between participants, and attitudes towards the presentation. Learners extracted scientific concepts that emerged from the presentation.

Stimulated recall interviews offered me as a researcher an opportunity to make detailed inquiries about what had transpired in the video. This was done to check the accuracy of my observations with the participants and get an in-depth understanding of what had happened during the presentation. However, stimulated recall interviews are perceived to be very exhausting, because of having to really concentrate and struggle to remember, compared to other data gathering techniques (Busse & Ferri, 2003).

**Table 3.1: Shows a summary of the data gathering techniques used in the study**

| Technique | Purpose | Research question |
|---|---|---|
| Focus group interview | To establish the factors that influence/ or not, the learners to learn science. | 1 |
| Observation | How learners interact, participate, and learn during the presentation made by the community members. Scientific concepts emerged from the community members' presentations. | 2 |
| Journal reflections | Allow learners to express themselves and how they think about the presentations. Use local knowledge presented by the community member to develop a mind and concept map about the science concepts embedded in the presentation. | 1 |
| Simulated recall interview | To establish if the presentation has influenced or not, learners' ability to learn the concept of malleability. | 3 |

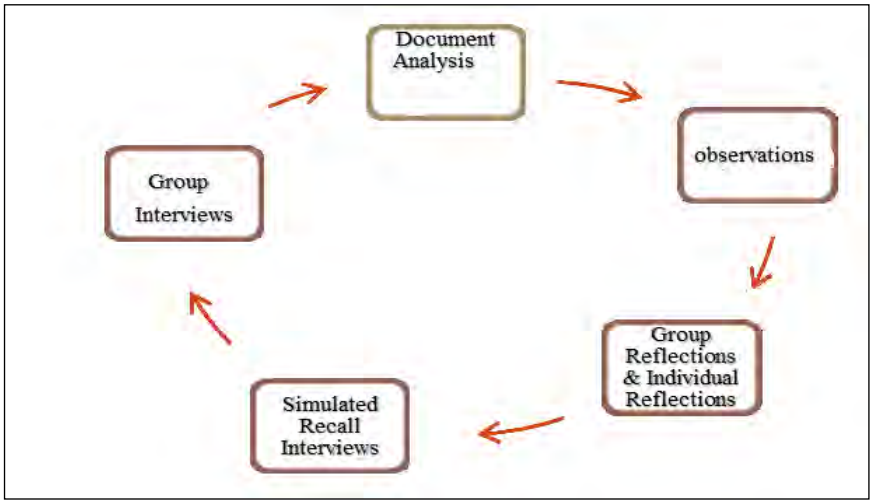


**Figure 3.3: A summary of the research process in this study**

### 3.2.6 Data analysis

Data analysis focuses on the meanings from in-depth, context-specific, rich, subjective data from participants in a certain situation, with the researchers themselves as principal research instruments (Cohen et al., 2018). In the study, qualitative data analysis was used where data from both the focus group interviews, participatory observation, learners' reflections and stimulated recall interviews were coded and compared/contrasted. A constant comparative method (Meriam, 1998) that is associated with grounded theory was used. The constant comparative method allows themes and patterns to emerge from the data collected. The data collected was coded using Saldana's (2009) manual coding, where emerging patterns or trends were identified. Coding involves taking text data gathered during data collection, segmenting sentences into categories, and labelling those categories with a term (Creswell, 2017).

In the context of the study, themes which emerged from the data were grouped together as sub-themes. Similar sub-themes were grouped further together and discussed in relation to the literature. Thus, in the analysis of data, a researcher needs to 'winnow the data' by focusing on some of the data and disregarding other parts of the data. Constructs from the socio-cultural theory – social interactions and the ZPD – were used to analyse data generated to see the influence of culture on science. The socio-cultural perspective helped me to analyse learners' and community members' experiences and interactions. With the help of the socio-cultural theory, ZPD was used to see if it had increased for both the learners, teacher, and community member through their social interactions and participations during and after the demonstrations. The knowledge that was gained might help teachers to integrate IK in their lessons and help move learners from the level of actual development to the level of potential development, as teachers have a great influence on the outcome of learners' progress.

In addition, the five cognitive states of CAT, namely, dominant, suppressed, assimilated, emergent and equipollent ideas (Ogunniyi, 2007b) were used as a lens to compliment the social cultural theory. Thus, the interactions that existed between the participants during and after the presentation were analysed according to the five cognitive states of CAT as proposed by Ogunniyi (2007b). This afforded me an opportunity to observe the influence of IK and see if there was a shift in the participants' understandings through the arguments and dialogues that occurred in the presentation. To validate data the following processes were used.

### 3.2.7 Validity, trustworthiness, and reliability

Validity refers to the extent to which the study findings reflect what it intended to measure. The collected data for this study was triangulated to strengthen my standpoint as a researcher from various aspects and capture different dimensions of the same phenomenon, as a qualitative approach attempts to understand the viewpoints of participants or a situation by looking at first-hand experience to provide meaningful data. The data interpretations were validated by checking the emergent themes with the participant learners.

The audio recording of the interview and video recording of the observation 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. A stimulated recall interview was used for the participants to recall their thoughts and experiences about the presentation by the community member. Maxwell (2012) describes this method as a way of checking the accuracy of observation. Learners' behaviours or attitudes observed in the video were probed for further clarification.

### 3.2.8 Ethical considerations

Ethical consideration is a significant issue in research because it is often intrusive (Bernard, 2013). It is centred on the involvement of putting participants in contrived social settings, engaging in specific activities. In light of this, I listened to what they said, observed their actions, and recorded their responses.

In the section, I discussed various aspects pertaining to ethical considerations in the study.

#### *3.2.8.1 Integrity, responsibility, and academic professionalism*

According to Cohen et al. (2018), ethical researchers have a duty of care to ensure that their research is of the highest quality. In the case of the study, it was carried out in accordance with the principles of the ethical policy and guidelines for Rhodes University's educational research. For this study, ethics involves informed consent, access, anonymity, and confidentiality. The rights of the participants, anonymity, and privacy were treated with a high degree of respect and confidentiality. Cohen et al. (2018) suggests that informed consent reinforces asymmetries of power between researchers and participants.

#### *3.2.8.2 Transparency and honesty*

Informed consent to carry out research at my school was obtained from the regional director in the region as well as the principal of the school for access and permission. Informed consents were also sought from the participants (parents of the learners, learners, and community member). With the community member, a personal relationship was established following local protocol. I visited the community member, at his own home. This was done not necessarily to gain access but to have a friendly exchange of greetings. In a second step, I invited the community member, to have a general discussion not related to the study but to establish trust with him. In a third step, I visited him, to discuss the purpose of the planned study and seek access and consent from the participant. To which the participant agreed without any hesitation as he knew me from the encounters, we had before. This was done, to show that I valued him and the knowledge he had. In terms of African ethics, it is not culturally appropriate to approach a community member to be a participant without first establishing a cordial relationship. If this is not done, it might lead to the person refusing or not disclosing all the necessary information and it might be seen as rudeness.

I stated openly in the letter to the participant that his participation in the study was voluntary thus he could withdraw from it at any time. The participants were informed beforehand that the engagements were to be recorded and their consent was needed – the motive for recording was thoroughly explained to all of them, to which they agreed. The schedules of the participants were respected as was agreed upon with the participants, and I was always considerate of their schedules. However, during the day of the presentation, the community member did not sign or give consent, as in his own words, it was not necessary as the relationship I built with him before the research was enough and it led him to trust me. This resonates with Smith's (2013) assertion that ethics in indigenous groups is framed in the western sense, where individuals had the right to give informed consent. To this, respect is an important pillar when conducting research in the community, as Smith (2013) posits that 'respect' is consistently used by indigenous peoples to underscore the significance of their relationships and humanity in general. In the context of this study, a cordial relationship was firstly established with the community member, where several visits were made to his homestead. This was done to create a relationship where he gets to trust me and see me as part of the community and to avoid what Smith (2013) highlights – that community and indigenous rights or views in research are generally not recognised and respected.

#### *3.2.8.3 Respect, accountability, and dignity*

Pseudonyms were used for the school and participants to address ethical issues of anonymity and confidentiality. However, O'Leary (2017) cautions that we should keep in mind those pseudonyms may not be enough to hide identity. In light of the above, the participants' faces were obscured to hide their identity. The data collected was kept safe, in hard copies and electronic data in an external hard drive, Google cloud account and memory stick with a secure password. Lastly, the study was my own work using my own ideas and where I used others' ideas, I correctly acknowledged and referenced it according to the referencing guidelines. All activities that I did concerning the study were done in consultation with my supervisors.

### 3.3 Chapter Summary

This chapter discussed the purpose of undertaking a qualitative case study situated within the interpretive paradigm on how a traditional blast furnace (*mudukuto*) enables and/or constrains Grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability. In addition, the research goal, objectives, and questions were discussed. Similarly, data gathering techniques such as group interviews, participatory observation, journal reflections, and stimulated recall interview were also discussed. I discussed the research site, participants, sampling, and explained how the data were gathered and analysed.

In the next chapter, I present, analyse, and discuss the data generated from the focus group interview.

# CHAPTER FOUR: FOCUS GROUP INTERVIEWS

## 4.1 Introduction

In the previous chapter, I discussed the research methodology I employed in this study. I explained how data were generated to answer the research questions for this study. In this chapter, I thus analysed, presented, and discussed data generated from the focus group interviews. This was aimed at addressing the first research question:

> What enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability?

The focus group interview was aimed at establishing and understanding what motivates learners to learn science.

## 4.2 Development of Themes

Six learners were interviewed as a group and the interview was recorded with their permission. They were given codes from L1 to L6 to ensure anonymity. FGI is the code for the Focus Group interview. Themes were developed from sub-themes and presented in the table below (see Section 4.1). Participants were coded as learner 1 focus group interview (L1FGI), learner 2 focus group interview (L2FGI), learner 3 focus group interview (L3FGI), learner 4 focus group interview (L4FGI), learner 5 focus group interview (L5FGI) and learner 6 focus group interview (L6FGI). This made it easier when presenting, interpreting, and discussing the data obtained from the FGIs. This chapter was therefore outlined according to the themes developed from the data from L1FGI to T6FGI. Data from the focus group interview were gathered and then analysed inductively. The following themes emerged from the colour coded data: participants' understanding of science; challenges of learning science; role of hands-on practical activities in learning science; and participants' perspectives of learning science. The data generated were summarised using literature and theory reviewed in this thesis (see Table 4.1 on the following page).

**Table 4.1: Shows the themes and sub-themes that emerged from the focus group interview.**

| Sub-themes | Themes | Literature /Theory |
|---|---|---|
| The like or dislike about science – views on integration of IK | Learners' understanding of science. | Mukwambo, Ngcoza & Chikunda (2014); Mavuru & Ramnarain (2020); Mhakure & Otulaja (2017); Agunbiade et al. (2017); Govender (2016) |
| Physical science syllabus<br>Lack of apparatus<br>Teachers approach | Challenges of learning science | Asheela et al. (2021); Olutusin (2007); Hashondili (2020); Oruntegbe & Ikpe (2011); Haimene (2018); Aikenhead (1997); Millar (2004); Rundgren & Yao (2014) |
| Links with outside world<br>Enhance participation.<br>Understanding of science concepts | Practical activities | Sedlacek and Sedova (2017); Asheela et al. (2021); Lyons (2006); Heeralal (2014); Uushona (2013); Gacheri & Ndege (2014) |
| Views on the teaching of science | Participants' perspectives of learning science | Oruntegbe & Ikpe (2011); Raved & Assaraf (2011); Agunbiade et al. (2017); Cook (2006); Gilbert (2008) |

The use of literature and/or theory assisted me in interpreting and discussing the findings in this chapter. For instance, the focus group interview was informed by Vygotsky's (1978) sociocultural perspective to understand how learners expressed their views and experiences about science.

### 4.3 Presentation and Discussion of Focus Group Interviews

In this section, I presented the themes that emerged from the data in relation to the theory and literature as alluded to earlier. This allowed me to combine the findings, theory and the literature during interpretations and discussions. Themes from focus group interview were assembled and coded according to the commonalities and differences in terms of the views or thoughts of the participants (see Appendix G). I now present each theme in detail, beginning with the first theme: participants' understanding of science.

### 4.3.1 Participants' understanding of science

During the focus group interviews learners were asked to share their views about what they like about science. Their responses indicated that they had an understanding of science. For instance, L1 indicated that, "*science is about investigations, observations, tests and studying things within the surroundings".* Furthermore, in agreement with L1, the participants (L2 & L3), posited that science is important as it is within their surroundings. This explanation resonated with Kuhlane's (2011) assertion that we are surrounded by science. It is against this backdrop that Mukwambo (2014) emphasised the need to use local materials to make science relevant to learners. Thus, the sentiments expressed by L2 and L3 indicated that the learners understood the importance of local knowledge in the science classroom.

According to L2, science teaches them about things that are related to real life. That is in affinity to Mavuru and Ramnarain's (2020) view that integrating learners' socio-cultural backgrounds in science teaching provides learners with a holistic view of science. Hence, this leads to learners making meaningful contribution of understanding scientific concepts better. In light of this, Mukwambo, Ngcoza and Chikunda (2014) posit that learning is understood to be dependent on the learners when they link their existing knowledge with the content of instruction. This coheres with Mavuru and Ramnarain's (2017) assertion that it is important to take learners' socio-cultural contexts into consideration. Similarly, Mhakure and Otulaja (2017) reiterate that there is a need for culturally responsive pedagogies. This seems to be consistent with the Physical Science Subject Policy (Namibia. MEAC, 2009), which states that the learning process of science may be amplified by linking science to real life situations.

Furthermore, L5 added that science allows her to do something that she learnt by using her hands. For example, the use of hands-on practical activities enriches the learning of science concepts. In addition, L3 commented that hands-on practical activities motivate her to learn science concurring with Agunbiade et al. (2017) that engaging in hands-on practical activities makes science more interesting and enjoyable.

In addition, according to L1, L2, L3 and L4, they were motivated to learn science because the discoveries in science help them to discover new things especially when they are carrying out an experiment to prove the outcome of a certain phenomenon. To this end, L4 reflected that "*Science can let you do things that you can see or observe with your own eyes".*

From these excerpts, it was evident that the use of visuals complemented learners' understanding of science. These participants (L1, L3, L5 & L6) emphasised that teachers have an important role to motivate learners to learn science. That is, according to L2, they should relate science to the outside world to understand the reality of how the phenomenon works in real life. Similarly, Govender (2016) postulates that indigenous knowledge is a valuable teaching resource to motivate learners to understand science.

### 4.3.2 Challenges of learning science

The six participants had to explain and give their perspectives on what makes them dislike or feel unmotivated to learn science. Science is perceived as a challenging subject to the participants (L1, L2 & L4). In their explanations, L3 noted that some topics in science were difficult to understand. In the follow-up on her explanation, she further narrated that she dislikes science because

> *Science has a lot of practical experiments while we don't have enough apparatus. The incorporation of mathematics in a form of calculation makes it tough for some of us who have a poor mathematic background.* (L3FG1)

From this excerpt, it could be argued that lack of hands-on practical activities deprives learners from broadening their existing knowledge. This finding corroborates with Oruntegbe 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. In agreement with L3, all the participants (L1, L2 & L4), believed the presence of mathematics in science makes it tough and tiring. Olutusin (2007) postulates that mathematics cannot be separated from science because of its application to Physical Science. I agree, for instance, that often a topic is difficult, not because of the chemistry concepts but because of the mathematics, for example, ratio and proportion in stoichiometry. This suggests that science teachers should consider mathematics in a particular topic as prior knowledge before a science topic is taught. Learning science is about seeing, handling and manipulating real objects and materials (Millar, 2004). For this reason, Haimene (2018) postulates that hands-on practical activities enable learners to develop positive attitudes towards science. Therefore, hand-on practical activities are essential for developing learners' scientific knowledge (Millar, 2004). In agreement with L3, L4 echoed that lack of resources to carry out hands-on practical activities in science hindered their love for science. This resonated with L1 that he learns many things in nature, but the knowledge is not incorporated in classroom science. Furthermore, L1 acknowledged that sometimes science

is just explained with the aid of diagrams in the classroom. From these discussions, learners recognised the importance of visualisation in science. In this regard, Rundgren and Yao (2014) posit that through visualisation, abstract knowledge and ideas can be expressed in simpler way that is understandable to the learners.

Consequently, L4 noted that carrying out experiments in the laboratory was a challenge. When probed for further elaboration, she stated that, "*some learners like tasting, since there are some chemicals that cannot be tasted"*. To support her explanation, she indicated that teachers should expose learners to easily accessible materials as the use of easily accessible materials makes learning relevant to the learners' immediate environment (Asheela et al., 2021; Kibirige & van Rooyen, 2006; Mukwambo, et al., 2014).

In light of this, the Junior Secondary Certificate (JSC) examiner's report (Namibia. MEAC, 2012) highlights the use of everyday practical examples. That is, it gives some relevance to the subject matter that arouses learners' interest and better understanding, as the relevance of science in everyday applications raises awareness among learners with multiple experiences (Oruntegbe & Ikpe, 2011). In this regard, Aikenhead (1997) affirms that classroom science would be more relevant to indigenous learners if it acknowledged their real-life experiences; 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 value learners' outside-classroom experiences to contextualise their lessons. In support, L3 indicated that science topics were easy to learn and understand if they were related to real life experiences, for example, learners experience of real life in their every day and that could broaden their existing knowledge in the classroom.

### 4.3.3 Role of hands-on practical activities in learning science

In this study, learners highlighted that carrying out hands-on practical activities was one way of understanding science (L1, L3, L5 & L6). This resonated with Asheela et al. (2021) that hands-on practical activities encourage active participation. Sedlacek and Sedova (2017) assert that effective teaching encourages learners' active participation in their learning. For instance, when asked about what motivated her to learn science, L5 explained that it was the conducting of *experiments* in the science laboratory – "*when learners are engaging in practical activities where necessary, they understand a bit clearly"*. Heeralal (2014) explains that practical

activities are essential components in science teaching. In addition, L1 highlighted the importance of hands-on practical activities and elaborated that they help him to understand science better as he can see and relate to it with his own eyes. For instance, he commented that:

> *Science should be taught physically because science is not about existing knowledge but also discovering new ideas and knowledge. People need to sit together and make up their mind and put their new ideas together in order to finalise the situations with correct answers.* (L3FG1)

This excerpt revealed that learners' valued hands-on practical activities as they enable their understanding and bring reality into the classroom. It could be hypothesised, therefore, that the incorporation of hands-on practical activities enables the development of a positive attitude towards science learning (Lyons, 2006). Similarly, Uushona (2013) asserts that hands-on practical activities in teaching and learning help learners to develop an understanding of abstract concepts. However, the participants agreed that lack of science apparatus hampers the doing of hands-on practical activities.

It was reported in the Junior Secondary Certificate (JSC) examiner's report (Namibia. MEAC, 2012) that lack of practical activities has proven to be the downfall of learners not being able to identify instruments correctly. The examiner's report emphasised that doing practical activities will always be to the benefit of the learners as it will help expose them to experimental techniques. In the context of this study, an attempt was made to explore the learning of the concept of malleability using a traditional blast furnace. This was done to help learners understand the properties of metals especially malleability so that they are able to observe how the particles of metals behave when they are heated and hammered into different shapes. For instance, when a metal is heated the particles re-arrange themselves because they have more energy, which makes them vibrate faster making the metal easier to hammer into different shapes without breaking.

In contrast, conducting practical activities in the science classroom is a challenge which denies learners the opportunity to verify scientific facts already taught (Gacheri & Ndege, 2014). Furthermore, L4 cautioned about the dangers of doing experiments as some science experiments were dangerous; for example, electricity does not go hand in hand with water, therefore knowledge is important before practical activities can be done. From the discussions, the participants valued the importance of practical activities as it broadens their knowledge of science and complements textbook explanations.

### 4.3.4 Participants' perspectives on how science should be taught

The participants were asked about their views on how they would like science to be taught in order to motivate and ignite passion in them. The six participants highlighted the need to relate science lessons to their daily life experiences and real situations. Furthermore, they emphasised the importance for teachers to focus on everyday real-life experiences since most of the science concepts are found in the community. For example, L2 pointed out that, *"It will help change their lifestyle, value one another (ubuntu) and solve problems in their surroundings"*. This suggested that teachers should bring real-life experiences into the science classroom for effective mediation of learning to take place (Rennie, 2011). For instance, building on learners' relevant experiences could heighten their motivation in science (Oruntegbe & Ikpe, 2011).

Learners' motivation to learn science is affected by their conceptual understanding of science concepts. Therefore, science taught in class should include familiar situations (Cetin-Dindar & Geban, 2017) and better understanding of science concepts could enhance their motivation to learn science. For instance, L3 said that, "*it will improve my knowledge and understanding of science"*. Regarding this expectation, L4 highlighted the important role teachers should play in the classroom and explained that *"teachers should motivate learners by being well prepared in their lessons and demonstrate the knowledge in their teaching*". In addition, L2 indicated that teachers should shorten the science notes and make them succinct.

Furthermore, L1 suggested that science should be taught using apparatus as some learners never saw the apparatus. This resonates with the Namibia Senior Secondary Certificate (NSSC) examiner's report's (Namibia. MEAC, 2015) findings that many learners could not label laboratory apparatus correctly or connect them procedurally. In support, L5 asserted that using apparatus would help learners visualise science. These findings have affinity to Cook (2006) and Gilbert (2008) that visualisation helps abstract science ideas become more easily comprehensible.

In light of this, it was emphasised in the Junior Secondary Certificate (JSC) examiner's report (Namibia. MEAC, 2015) that demonstrations and letting learners do experiments are proven to help learners achieve maximum performance. Moreover, L6 believed it would help them to know how the processes happen and confirm what the results of the experiments are compared to the results in the textbook. Lastly, the participants saw a need for science to be taught in the morning and that the hands-on practical activities to be done in the afternoons, based on what

was taught in the morning, as learners would be able to recall or relate to it. However, the findings take cognisance that learners' attitude towards science studies were influenced by many factors which include interaction between learners and teachers, relevance of the topics taught and diversity of the teaching methods (Raved & Assaraf, 2011). As Agunbiade et al. (2017) posit, learners' attitude towards science encompasses some constructs such as interest in science, enjoyment of science, value of science, motivation, and other affective variables.

### 4.4 Chapter Summary

In this chapter I presented data on what enables and/or constrains grade 9 Physical Science learners' motivation to learn science. The data were generated using focus group interview. The findings revealed that learners understand what science is. In addition, the learners seemed to demonstrate understanding of the importance of hands-on practical activities in science lessons. For instance, they indicated that carrying out hands-on practical activities helps to visualise science concepts in the classroom. Similarly, learners recommended the use of hands-on practical activities in science lessons to help them understand the science concepts. In the next chapter I analysed, presented and discussed the data generated from participatory observation, learners' reflections and stimulated recall interviews.

# CHAPTER FIVE: PARTICIPATORY OBSERVATION, REFLECTIONS AND STIMULATED RECALL INTERVIEWS

## 5.1 Introduction

The main goal of the study was to explore how a traditional blast furnace (*mudukuto*) enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability. In the previous chapter, I presented, analysed and discussed the data from focus group interview which was aimed at answering the first research question of this study. In this chapter, I thus analysed, presented and discussed data generated from participatory observations, reflections and stimulated recall interviews (see Table 5.1). Data generated from these data gathering techniques was aimed at addressing the research questions one, two and three:

- What enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability?
- In what ways do the grade 9 Physical Science learners interact, participate and learn (or not) during the practical demonstration on a traditional blast furnace (*mudukuto*) by an expert community member?
- How does the traditional blast furnace (*mudukuto*) enable and/or constrain grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability?

The presentation was aimed at allowing the expert community member to share the cultural way of using a blast furnace and his indigenous knowledge with learners. In the discussions of data, I interweaved the literature and theory as well as participants' supporting statements. Furthermore, I presented and discussed the findings in relation to the community elder's views on the indigenous practice of the blast furnace.

## 5.2 The Practical Demonstration of How the Traditional Blast Furnace Works

In this section, the process of how *mudukuto* works was used as a mediating tool for learning of scientific concepts. A community member as a more knowledgeable other (MKO) in *mudukuto* was invited to present his knowledge and skills on how *mudukuto* works as espoused by Vygotsky (1978). The demonstration was done in the local language *Rukwangali* spoken both by the learners and the community member. This was intended to enable the community member to speak freely in a language he was comfortable in. In light of this, Keane et al. (2017) posit that speaking to community elders in a language other than their own could be viewed as disrespectful. Moreover, *Rukwangal*i was considered as a mediating cultural tool for promoting social interactions and active participation amongst learners (Sedlacek & Sedova, 2017; Vygotsky, 1978).

### 5.2.1 Practical demonstration by a community member

*Mudukuto*[8] is an indigenous technological knowledge used by men to make tools for cultivating purposes, for example, the making of a hoe (*etemo*), axe (*nzimbu*), panga (*ekatana*) and so forth. In this study, it was my assumption that learners' conceptual understanding of the concept of malleability could not be realised if they just wrote down a list of the properties of metals. It was for this reason that *mudukuto* was used as it was familiar to learners' lived experiences. This concurs with Mavuru and Ramnarian's (2017) assertion that when learners learn science in unfamiliar contexts, misconceptions arise.

Firstly, the community member made sure that all the necessary tools that were needed were prepared before our arrival at his place. Before his presentation, as customary, he welcomed us in his homestead and gave an introduction of what *mudukuto* was by identifying the parts of it. Firstly, he said, "*ogu yigo mudukuto nye mwazuva*" (this is *mudukuto* that you heard of) (see Figure 5.1).

[8] Mudukuto is a traditional blast furnace.

**Figure 5.1: Shows the modified traditional blast furnace**

This was meant to make sure that participants were aware of the apparatus before them. He also cautioned the participants at the beginning to listen attentively during the whole process of the presentation. He started by explaining that wind gets in the big hole of the *mudukuto* when someone rotates its pedal. The community member explained that *mudukuto* consists of two types: the modified one (see Figure 5.1) and the original or common one (see Figure 5.2).

**Figure 5.2: Shows the original traditional blast furnace (left)**

He started by asking a question, "*kwaku si mona esi sivera?"* (Are you seeing the metal?). We all responded: yes. "*To damuna sivera esi, to si tura po makara to tameke kudukuta dogoro sivera sa gehe"* (you take this metal and put it on charcoal then you start pumping air until the metal becomes red). "*Nsene sa gehe sivera tosi gusa po, makara toruganesa kaveragona kokupora otetese ko sivera sa gehe"* (once the metal becomes red, you take it out and get a small piece of metal to cut the heated metal). "*Pokumana kusiteta sivera, to gusa tjange yipo*

*o kwatese ko sivera soupyu*" (when you are done cutting the metal, you take a plier to hold it properly as the metal is hot).

He explained further that he pumps air onto the charcoal so that the metal becomes light and easy to use. He elaborated further that, "*nsene sivera esi kapi sapi nawa nokulitjindja ugeha, kuka ninkisa si dire kuka wapa nawa apa no si hamara"* (if the metal does not turn red then it will be rough when you hammer it). For instance, you put a piece of metal on the fire until it becomes red. When the metal turns red, it means it is ready to be taken out of the fire or charcoal. Once it is taken out, immediately it has to be put on a stone and another metal that is not heated must be used to cut the heated metal by using a hammer to hit on the top of it. From the explanation, it seemed the community member knew the work very well as it was succinct, and the participants were listening attentively while taking notes. This coheres with Shizha's (2007) assertion that learners' participation takes a special dimension when indigenous knowledge is made visible in science education.

The community member demonstrated confidence as manifested in the depth of his explanations. For example, he explained that when looking for the sharpness of the metal, "*wa kona kutura nzimbu pomundiro siruwo oso ove kwakudukuta dogoro nzimbu ozo zili tjindje ugeha. Hepero kuka ruganesa sikehe o kwatese sivera sa kara noupyu"* (you put the axe on fire while pumping air until the axe becomes red then you take a material that is not metal, to take it out of the fire because you are afraid to be burnt). Thus, the community member's reasoning could imply that if one takes the axe with a metal while it is still hot, then heat will be transferred through the metal since a metal is a good conductor of heat (see Figure 5.3).

**Figure 5.3: Shows a community member demonstrating how to pick an axe from the fire**

From the observation, it was evident that the practice of *mudukuto* was used to elaborate on the scientific concepts from an indigenous perspective. Once again, this gave us an opportunity to

link the cultural practice of *mudukuto* and the scientific concepts embedded in the practice – for example, the properties of metal in relation to heat. The community member further explained that once the axe is taken out of the fire, it is immediately put on a stone and hammered so that it becomes sharp. "*Nsene o mana kuzi hamara nzimbu wa kona kuzi tengwidira pomundiro morwa nonzimbu dimwe kuvhura kubomoka"* (once you are done hammering the axe, you take it back on the fire as some axes break easily). "*Nsene nzimbu pomundiro zina kara, wa kona kuzindindira zigehe komeho oka tomweseko mupini gwazo"* (once the axe is on the fire, you pump air until the metal becomes red, then you make a hole where you immediately put the axe once it is removed from the fire and pour water on it). The reason for this was, according to his explanation, in order for the metal not to bend and afterwards allow the axe to dry.

Furthermore*, "Apa na zi rerupa nzimbu wa kona kuzi tura momema gomungwa nokuka zi ndindira zi pore"* (if the axe is soft, you take the axe and put it in a container of a mixture of salt and water and you let it dry after). From the explanation, it could be deduced that the community member wanted to improve the strength of the metal (alloy). Alloys improve the properties of metals making them more suitable for the desired purpose. For example, in the case of this study, the intention was to make the metal harder and stronger so that it was suitable for making an axe or hoe. He continued further that, "*Nzimbu nsene momupini gwazo zina kara wa kona kuzi rora ko komaruha gazo nagenye"* (you put the axe in the wood and look for a file to sharpen the edge of the axe on both sides). The participants began to link what they observed to what they knew.

As the community member was explaining about *mudukuto*, one learner asked about some traditional blast furnaces that have a stick-on top of them (see Figure 5.2): "*morwa sinke eyi wa hambwira nzimbu zoge morupe naropeke?"* (Why did you design yours differently from the common ones?). With a smile on his face, the community member elaborated in detail the differences between the two blast furnaces. He explained that the bad part of the old ones (see Figure 5.2) is the wood that is always at the edge and should be fitted with pipes to prevent heat reaching the wood, especially when the charcoal becomes hot. He continued that the other challenge is "*kuroroka usimbu"* (you get tired easily) – this is because the person has to pump air to the charcoal for a long time and after the activity, will feel pain in their muscles. The expert community member valued the importance of visuals as he brought axes and a panga to show the participants the tools he normally makes.

The exchange of ideas among the participants to complete the presentation was a demonstration that learning took place. *Mudukuto* is a locally available material that stimulated learners' interest. Thus, to make local or IK visible in the science classroom. Learners were eager to know more about the practice. Learners were excited about the presentation. For instance, some learners managed to feel the *mudukuto* by pumping air (see Figure 5.4 below).

**Figure 5.4: Shows the picture of a participant pumping air using *mudukuto***

In the next section, I presented sub-themes and themes that emerged from the participatory observations I did during community member's presentation and reflections written by the learners. Themes and sub-themes are showed in Table 5.1 below.

**Table 5.1: Shows themes that emerged from the data and supporting theory or literature.**

| **Themes** | **Literature/Theory** |
|---|---|
| **Theme 1: Learning opportunities**<br>Link to science, inclusion of IK, learning during presentations | Mawere (2015); Jegede (1995); Ogunniyi (2007a); Keane et al. (2016); Ngcoza (2019); Vygotsky (1978). |
| **Theme 2: Shifts in learning**<br>Visualisation of science<br>Supporting learners and drawing from everyday life experience | Klein (2011); Ngcoza (2019); Erinosho (2013); Asheela et al. (2021); Haimene (2018); Msimanga & Lelliot (2014); Mavuru & Ramnarain (2019); |

The CAT is rooted in the Aristotelian Contiguity notion of creating a meaningful understanding from learners' experiences to resolve conflicting ideas (Ogunniyi, 2007a). From these, Ogunniyi's (2007a) Continuity Argumentative Theory's (CAT) five cognitive states were used to further explain how conceptions move within the learners' mind which are the dominant, suppressed, assimilated, emergent and equipollent (see Section 2.13). During the presentation, there were arguments before and during the presentations among learners questioning what was being observed. Some learners saw it as an ordinary presentation that they were exposed to in the community, and others were associating what they observed to what they knew. Hence, learners' minds kept shifting along the five cognitive states during the practical demonstration of *mudukuto*.

Some participants viewed the presentation of *mudukuto* as an ordinary presentation and not as a presentation where they could learn about science in the classroom. This related to the dominant state. For instance, during the explanations of the community member, one learner said that she did not know that their parents knew science. This was a suppressed idea. Consequently, all the participants were surprised to see the science concepts that emerged from the presentation as most of them viewed it as an ordinary presentation. This was the emergent state as learners begun to realise the importance of the practice. This concurs with Dei (2010), that indigenous knowledge continues to suffer due to the game of dominant western ideological power. The presentation led to the participants suggesting that they should invite the community member to a science classroom to teach science (emergent). I now discuss each of the themes below.

## 5.3 Themes

In the following section, the themes that emerged from the data were discussed in relation to literature and theory.

### 5.3.1 Learning opportunities

The practical demonstration assisted learners to ask questions about what they observed. For example, L2 asked the community member why he was taking the metal with wood from the fire. The community member replied with a smile that *"Sivera sa pyapyara, nomusi hena no vhura kuruganesa sivera sikwawo osi guse po"* (The metal is hot so there is no way you can use a metal again to take it out. But wood does not become hot and you do not feel the hotness when using it). This meant that wood is a poor conductor of heat while a metal is a good

conductor of heat. From the response, it could be surmised that local knowledge is rich with science that should be embraced to transit from home to classroom science. This validates Mawere's (2015) view that use of local or 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.

Learners were able to relate to what was being taught in the classroom. This was an indication 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 perspectives of *mudukuto* to classroom science. For instance, L6 said that, *"the presentation did something that is related to what we learn in science like when a metal is heated, it expands due to heat"*. This stage is called *equipollent*. According to Govender (2016), at this stage a learner begins 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. Learners acknowledged that local knowledge was also at school and this thinking was for someone at an *emergent* stage. Thus, at this stage according to Ogunniyi (2007a) learners begin to develop new knowledge. In this case, learners had realised that what they learnt at home was also found at school. For example, L6 pointed out that some things learnt in Physical Science, for example, temperature and expansion could be observed during the process of *mudukuto.* From this thought, it could be deduced that the learner was at an *equipollent* stage, where they appreciate two competing ideas as one (IK and western science) (Ogunniyi, 2007a).

From these foregoing discussions, L1 suggested that *mudukuto* can also be used during the topic of expansion in solids in Physical Science and Physics. It was evident from the comment that L1 was at an *emergent* stage as the learner began to link the practice of *mudukuto* to possible topics where it can be used as a learning support material, for example, to explain what happens when particles in solids are heated. From the excerpt above it could be hypothesised that the learners began to link the presentation to other science concepts observed and this demonstrated that the transition from their local or indigenous knowledge to scientific concepts was smooth. Thus, it can be concluded that there was a shift from the indigenous knowledge practice to scientific concepts. It could be suggested that hopefully the shift might had resulted from the dialogue and arguments among learners. It was evident that arguments existed among the participants to help them broaden their knowledge through the exchange of

ideas that arose from the presentation. The knowledge, which was acquired during their social interactions, contributed to a shift in their ZPD (Vygotsky, 1978).

When the community was asked where he acquired the skills of *mudukuto*, he laughed and said that he learnt it from his parents, observing while they were doing it. Thus, the response concurs with Keane et al. (2016) that IK is living, evolving and travels with our stories. Stories are a powerful way to disseminate knowledge by indigenous people. Similarly, many indigenous knowledge practices continue to be dynamic and responsive in changing times (Ngcoza, 2019). From the observation, there were interactions and participation among learners.

### 5.3.2 Shifts in learning

The presentation by the community member afforded learners an opportunity to relate to their learning in the science class. 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. It was evident in the questions asked to assist the participants to make sense of the scientific knowledge that emerged from the practical demonstration. The identification of scientific concepts was an indication that learners made sense of the presentations. This was evident from the development of a mind map (see Figure 5.5).

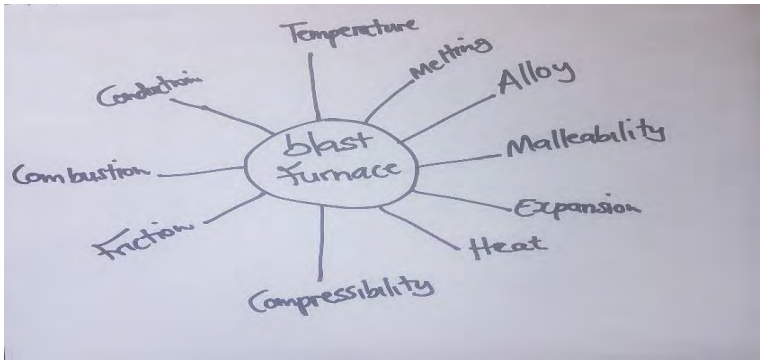


**Figure 5.5: Shows a mind map of the scientific concepts that emerged from the practice of *mudukuto***

During the presentations, I observed that the community member emphasised to the participants to listen attentively and ask questions. For instance, he tried to capture the learners' attention by telling them "*purakeni nawa*" (meaning listen attentively) whenever he was emphasising an important point. This was done to make sure that the participants were taking note of the right information. This indicated that interaction existed during the presentation and this resonates with Vygotsky (1978), that learning takes place through social interactions with

peers or with the more knowledgeable other (MKO). The participants enjoyed the teaching and the process of hammering the metal into an axe. For instance, L2 said that, *"listening to how axe is done made me feel proud by looking at our culture".* This is so profound that learners were beginning to show appreciation of their culture and local knowledge. In light of this, Ngcoza (2019) emphasised the importance of giving value to local or IK.

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 classroom and community members as the inclusion of local or IK ensures that schools were 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 were an island as often perceived by the community. It was against this backdrop, that the study added value to the natural context by going to the place of the community member.

Thus, the presentation enriched learners' interest as they were able to link the community members' explanations to science [Emergent]. This evidence came from the reflection of learners L1 after the presentations: *"The explanations of our teacher in class and the community member about mudukuto is the same. We were taught that if you put the metal on fire, the metal will become big".*

From this except, it can be concluded that indigenous knowledge is science since science starts at home. For instance, L1 commented that he had learnt some concepts of science from the presentation. Thus, it can be concluded that the learner was at an *emergent* stage as there was a shift in his learning (new knowledge acquired) after the presentation. L1 continued that it contributed better to his science understanding by showing him how some science processes worked. The learner appreciated the two knowledge systems as they complement each other, which transited the learner to an *equipollent* stage (Ogunniyi, 2007a). In addition, L1 said that it helped him to get a better understanding in the class because he already knows it. This resonates well with Erinosho's (2013) assertion that IK is a part of learners' prior experiences that they bring to school learning. This comment indicated that there was a shift in learning. For example, L6 said that local knowledge contributed a lot to the knowledge of science because most of the things that are done at home was science.

This indicated that learners appreciated the inclusion of local or IK in science lessons. For instance, L3 said that, *"It contributed a lot to my understanding of science that if we have nothing to use for our experiments in science then we can also use mudukuto so that work can be easy".*

From this excerpt, it was evident that learners acknowledged the use of easily accessible materials to teach science (Asheela et al., 2021). This collaborates with Haimene's (2018) findings that the use of easily accessible resources enabled learners to develop positive attitudes toward science. It was against this background that the study corroborated with the community member as another way of valuing the importance of community in education, apart from sending their children to school. IK was used to understand the context that was taking place in the classroom and by using local or IK, we were not moving away from conventional science, but we were moving from context to content.

The expert community member who was the custodian of this cultural heritage was involved to provide practical examples of how home language can be used as a resource rather than being seen as a barrier (Mavuru & Ramnarain, 2019; Msimanga & Lelliot, 2014). The discussion was conducted in Rukwangali since it was spoken by all participants. Thus, the use of the local language increased participation of participants in the presentation (Sedlacek & Sedova, 2017). This indicated that local language was a mediating cultural tool that enhanced social interactions among participants and learning (Vygotsky, 1978). Additionally, the use of home language influenced the degree of concentration and understanding among participants.

### 5.4 Chapter Summary

In this chapter, I analysed and discussed the data generated from participatory observation, reflections and stimulated recall interviews. The data presented was aimed at addressing all three research questions of the study. From the discussions, the data generated showed that learners held dominant and suppressed views and a few assimilated views of science and local or IK. After the presentation, learners began to shift their state of mind along the five cognitive states of the continuity argumentative theory (Ogunniyi, 2007b). That is, learners extracted the science concepts that emerged from the presentation by the expert community member. Thus, the use of easily accessible materials (*mudukuto*) in the study created a steppingstone for the learners to scientific discovery. In the next chapter, I presented the summary of the findings, recommendations, and conclusion.

# CHAPTER SIX: SUMMARY OF FINDINGS, RECOMMENDATIONS, AND CONCLUSION

## 6.1 Introduction

The main goal of the study was to explore how a traditional blast furnace (*mudukuto*) enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability. In order to achieve this goal, I employed a qualitative research design to generate data using a variety of methods. I used focus group interview, participatory observations, stimulated recall interviews, and learners' reflections. Data in this study 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:

- What enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability?
- In what ways do the grade 9 Physical Science learners interact, participate, and learn (or not) during the practical demonstration on a traditional blast furnace (*mudukuto*) by expert community members?
- How does the traditional blast furnace (*mudukuto*) enable and/or constrain grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability?

In the preceding chapter, I presented, analysed, and discussed data generated from the participatory observations, learners' reflections as well as stimulated recall interviews. Thus, in this chapter, I thus present a summary of findings, recommendations, suggested areas for future research, limitations to the study and reflections. This chapter ends with a conclusion.

## 6.2 Summary of Findings

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

### 6.2.1 Research question 1

> What enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability?

The findings from this study revealed that there is a need to relate science to learners' daily life experiences. For instance, L6 commented that the use of hands-on practical activities motivated her to learn science. These findings support literature that suggest that the inclusion of familiar situations motivates learners to learn science (Cetin-Dindar & Geban, 2017). For instance, Shizha (2007) asserts that learners' lived experiences are important as they assist and enhance their understanding of science. To achieve this, 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 foundation to build on for classroom science. That means, 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). Hands-on practical activities enhance learners understanding of science. For instance, L3 indicated that science topics were very easy to learn and understand if they were related to real life experience. Similarly, hands-on practical activities promote active participation among learners (Sedlacek & Sedova, 2017). This leads to learners developing positive attitudes towards science (Haimene, 2018).

However, learners acknowledged that a lack of hands-on practical activities deprives them from broadening their existing knowledge. For example, L4 postulated that lack of resources to carry out hands-on practical activities in science hinders their love for science. Thus, the findings revealed that learners shared a strong positive view on the use of easily accessible materials to teach science.

### 6.2.2 Research question 2

> In what ways do grade 9 Physical Science learners interact, participate and learn (or not) during the practical demonstration on a traditional blast furnace (*mudukuto*) by an expert community member?

It was observed during the presentation of the expert community member that social interactions and participation of learners increased. This finding was in line with the findings of Erinosho (2013) where a similar case study was conducted using easily accessible materials. The Erinosho study revealed that learners were excited to be with the community member and found relevance with what they learnt with classroom science. For instance, the practical demonstration enabled the learners involved in the study to raise questions, as they were curious to find out about what was happening. This manifested in the social interactions (Vygotsky, 1978) and arguments (Ogunniyi, 2007a) during the presentation by the expert community member. Thus, the findings from this study revealed that the presentation raised learners' awareness of the value of indigenous practices.

This was enabled using easily accessible materials and home language. To this, Asheela et al. (2021) posit that easily accessible materials reinforce social interactions that enhance meaningful learning. Hence, 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 member. This finding resonates with Mavuru and Ramnarian (2019) that when learners are afforded the opportunities to interact in their home language, science learning is enhanced. It was precisely for this reason that Shizha (2007) postulates that indigenous learners find it easier to grasp scientific principles and skills when the language of instruction makes sense to them. Furthermore, he extended that it facilitates their border crossing from home science to classroom science.

The use of materials from their local environment changed their perspective on how they learn science and the perception they had about local people that they do not know science. L3 indicated that science topics become easier to learn and understand when they are related to real life. For example, one learner further commented that she did not know that her parents knew science. It was my assumption that indigenous knowledge was not static as the change in the structure of the *mudukuto* (see Figure 5.2) and (Figure 5.3) demonstrate that the knowledge evolves with time. This concurs with Mhakure and Otulaja (2017) that local or IK

exists in different forms that include indigenous technologies that had evolved in the community.

The use of *mudukuto* as traditional practice according to L6 contributed to her better understanding of science as she was able to visualise how some science processes worked physically. In addition, L1 supported that the integration of local or indigenous knowledge made understanding the science lessons easier since the materials used were found in their locality. It is for this reason that Mukwambo (2017) emphasised the need for teachers to contextualise science concepts in order to relate to learners' daily life experiences. The presentation by the expert community members afforded learners the opportunity to relate science to their daily life experiences.

For instance, one learner asked the community member why his *mudukuto* was different from the *mudukuto* he knows. With a smile on his face, the community member explained that the bad part of the old ones (see Figure 5.2) is wood and should always be fitted at the edge with pipes to prevent heat reaching them especially when the charcoal becomes hot. It was evident from the learner's question that their prior knowledge can be enhanced when they are actively engaged through hands-on practical activities (Asheela et al., 2021). This indicated that learners knew the indigenous practice, therefore, it is up to the teachers to tap into this wealth of knowledge that learners bring to school. Therefore, it is precisely for this reason that Le Grange (2007) postulates that the implementation of the two worldviews depends largely on the teachers' knowledge.

The community member was happy to be invited to be with the learners. For instance, he commented that he was happy to share his knowledge and wisdom about *mudukuto* so that learners can teach others. The sentiment expressed by the community member concurred with Klein's (2011) assertion that local or IK can be integrated in schools by drawing on the skills and knowledge of elders. For example, L4 said that he enjoyed the way the community member presented how *mudukuto* works and his explanations. Similarly, L3 supported the integration of local or indigenous knowledge as it makes it easier for learners to understand science since some materials, such as *mudukuto*, they know from their grandparents. This coheres with Kibirige and Van Rooyen (2006) that IK is a legacy of knowledge that has been developed and passed on over generations.

### 6.2.3 Research question 3

> How does the traditional blast furnace (*mudukuto*) enable and/or constrain grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability?

The findings from this study revealed that the presentation complimented the learners understanding. For example, L6 commented that he used to struggle to comprehend what the teacher taught during lessons when explaining the heating of a metal resulting in expansion. It could be surmised that the learner appreciated the importance of visualisation in science lessons. This resonates with Hashondili (2020), that the community member's presentations assisted the participants to make sense of the scientific concepts in the practice and viewed indigenous knowledge as visualisation. This was evident in the mind map that the learners developed (see Figure 5.5). The knowledge learners obtained from the community member contributed to their subject content knowledge of the concept of malleability. Thus, this indicated the importance of community as their traditions and culture are mostly accessible and fruitful educational resources for school education. For instance, L6 commented that local knowledge contributed a lot to his knowledge of science since most of the things he does at home was science. For example, writing and balancing of chemical equations. When Mama Nolingo made [9]*Umqombothi* for us she had used the correct amounts of ingredients that is ratio and proportion which is important in stoichiometry (chemistry) and Mathematics. To this, Stears, Malcom, and Kowlas (2003) posit that the construction of science concepts is strongly influenced by cultural knowledge.

The social interactions and arguments that took place in the presentation helped learners to clarify the myth about local or indigenous practices that they were not science. For instance, one learner said that she did not know that their parents knew science until she was exposed to the presentation of the community member. From the presentation, learners extracted science concepts that were embedded within the local or indigenous practices. Therefore, the use of Ogunniyi's Continuity Argumentative Theory was helpful in providing insights into how learners framed their arguments when they were exposed to IK practices in school science. L6

[9] *Umqombothi* is a traditional alcoholic beverage made by many families in South Africa and its alcohol content is about 3%.

said that if you heat a metal, it will expand and when a metal is heated it should always be removed with something that is not a metal (see Figure 5.3) because a metal is a good conductor of heat. This demonstrates that there was shift in the learning and the learner's zone proximal development as espoused by Vygotsky (1978). Similarly, learner's reflections showed that there were a lot of science 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, *mudukuto* was a supportive material that learners were familiar with and could relate to. In light of this, L1 suggested that *mudukuto* can also be used during the topic of expansion in solids in Physical Science and Physics to teach the arrangement of particles when they are heated. It can be concluded that IK and western knowledge complement each other (Shizha, 2005).

The presentation helped learners to appreciate their daily life experiences. For example, L4 said that if a teacher asked him a question about expansion of metals in an examination, he would be able to use the knowledge about *mudukuto* to explain. This concurs with Erinosho (2013) that knowledge of indigenous science can be viewed as a steppingstone, thus, learners find it easier to make the connection between their experiences and science taught at school if their socio-cultural context is considered (Fleming & Regmi, 2011). When the expert community member was asked where he learnt the skills of *mudukuto*, he responded that he learnt it through observing his parents. This resonates with Mukwambo (2017) that local or indigenous knowledge (IK) is constructed using observations and passed on verbally.

### 6.3 Recommendations

The study recommends that the traditional practice of *mudukuto* should be integrated during teaching of science in schools. That is, teachers should endeavour to use local or IK practices to make science accessible and relevant to the learners. As evidenced in this study, the traditional practice of *mudukuto* could be extended to topics such as thermal expansion, and transfer of thermal energy and alloys. It should, therefore, be acknowledged that learners come to school with a wealth or fount of knowledge that can be utilised as a steppingstone to the learning of science concepts. This concurs with Liveve's (2017) assertion 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 is utilised to enhance their understanding (Mavuru & Ramnarain, 2020).

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

### 6.4 Areas for Future Research

A research on the same topic could be extended to grade 10 chemistry since they deal with the properties of metals (malleability) in-depth. In addition, a further research could be done on the same topic, whereby the community member demonstrates to teachers how a traditional blast furnace (*mudukuto*) enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability. Furthermore, the research could be extended to more schools and grade 9 learners in the region. Lastly, it could be really interesting to see how learners would go about analysing curriculum documents, for example syllabus, textbook on how the concept of malleability is presented and to hear their voices after doing the exercise.

### 6.5 Limitations of the Study

The focus of the study was to explore how a traditional blast furnace enables and/or constrains grade 9 Physical Science learners' motivation to learn science and make sense of the concept of malleability. The participants were grade 9 Physical Science learners in the Kavango West region. The study was carried out with only one class of grade 9 learners and so the findings cannot be generalised to represent all Physical Science learners in the Kavango West region. Nonetheless, it provided insights into how *mudukuto* influences or does not influence learners' sense making.

In addition, learners did not analyse the curriculum documents before the presentation with the expert community member and I feel that this was a lost opportunity. However, the translation from vernacular language (Rukwangali) to English meant some statements or explanations lost value compared to being written the way the expert community member said them in the local language.

### 6.6 Personal Reflections

The journey of my study started in 2017 when I was admitted into the BEd Honours programme. Notably, I had tried in 2014 and I was not accepted but I never gave up. As a result, when an opportunity arose in 2017, I grabbed it with both hands; I told myself not to look backward but to keep on moving forward. In the second year of the BEd Honours programme, I was introduced to local or indigenous knowledge as one of three components of our study of science education. Admittedly, at that time, little did I know how important local or indigenous knowledge in science is since no reference to it was made at school and at tertiary institution.

Such exposure triggered me to do research on local or indigenous knowledge. However, I initially struggled to come up with a research topic along these lines. In my first year as a master's scholar, I had an opportunity to attend a Research Design Course at Rhodes University in Makhanda (Grahamstown), South Africa – it was the tenth time that I had visited South Africa. I had the privilege to be one of the participants during the presentation by Mama Nolingo on making *Umqombothi*. Umama being the custodian of local or indigenous knowledge demonstrated that she had knowledge of making *Umqombothi* as manifested in her confidence of explaining all the steps of making it. The pace of Mama's explanation was worth emulating for the professional growth of a teacher, for example, her sense of humour and passion about her work of making *Umqombothi.* Her facial expression was welcoming and that contributed to our engagement with her and we were free to ask questions and clarifications on some cultural beliefs and 'myths' associated with the traditional practice. This provoked many discussions and arguments (Ogunniyi, 2007a). Furthermore, the presentation contributed to our zone of proximal development (ZPD) as espoused by Vygotsky, in terms of identifying science concepts embedded in the traditional practice of making *Umqombothi.* This was done to gradually transit from home science to science in the class which Aikenhead and Jegede (1999) refer to as border crossing.

From the presentation, I came to realise that there was a lot of science in the community that seems to be under - utilised. I therefore came to conclude that I was one of those teachers who did not value learners' socio-cultural background in my science lessons (Mavuru & Ramnarain, 2020). The introduction of local or indigenous knowledge in science education contributed to a better understanding of the knowledge to the point that I did a research study in it in my MEd studies.

Since I started integrating learners' lived experiences in my science lessons, they had developed interest in finding out more about local or indigenous knowledge, although at first, they found it hard to believe. 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 carbon dioxide – the textbook identifies that it is through respiration and combustion, but do not include any indigenous practices. To this, I told the learners to include the process of making *Sikundu* which is a homemade non-alcoholic beverage that learners are familiar with.

From this study, the presentation with the community member was a revelation to myself on the importance of indigenous practices that were neglected unknowingly by myself in my teaching. For instance, I came to learn that the process of making the traditional blast furnace can indeed be used to teach the concept of malleability. Furthermore, the 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 presentation (Sedláček & Sedova, 2017). However, I had missed an opportunity, when I rewatched the videos with the learners, I did not invite the community member and he would have been able to observe himself on the video that was recorded and clarify some parts in the presentation that needed elaboration. This could have contributed to further broader knowledge in this study. The invitation of the community member taught me to appreciate the knowledge our parents possess and how can it be integrated in science classrooms. Thus, the exposure and experiences from this study contributed to my academic and professional growth as a scholar and science teacher.

Lastly, writing a thesis in the COVID-19 era was not an easy exercise. For instance, the data gathering process had to be shifted three times due to the changes in the programme of the Ministry of Education, Arts and Culture. The only modes of communication that I could use to contact my participants were via cell phones, WhatsApp, or on Zoom. However, the situation of the learners in the different localities was not the same due to the economic inequalities in society. All the participants in the study did not or could not afford smartphones or data to make sure the data collection took place.

In hindsight, COVID-19 has taught us to value the importance of technology that should have been given more priority in the 21$^{st}$ century in order for online classes to take place without disturbance. Albert Einstein once said that, the only source of knowledge is experience, yet

with COVID19, 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.

### 6.7 Conclusion

This study contributes to the current decolonisation or decoloniality debates meant to shift ontological and epistemological orientation to enable integration of local or IK in science teaching. This was done by tapping into the cultural heritage or fount of knowledge of the community member who was positioned as the more knowledge other (MKO) (Vygotsky, 1978). Thus, integrating learners' lived experiences of local or IK from home and the local community helps the transition to the learning of scientific concepts. Aikenhead and Jegede (1999) refer to this phenomenon as border crossing. Through the presentation by the community member, learners acknowledged the use of easily accessible resources in conducting hands-on practical activities (Asheela et al., 2021). As a result, learners were able to link the science to their out-of-school environment. For instance, L2 realised that the explanations of the teacher in the class and the community member about the concept of malleability were similar. This finding validates Taylor and Cameron's (2016) advice that local or indigenous knowledge complement westernised knowledge rather than these knowledges being seen as mutually exclusive. 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 local or IK (Khupe, 2017). In addition, Vygotsky believes that the use of language helps learners to learn science. Learners' exposure to the traditional practice of the blast furnace (*mudukuto*) was intended to assist them to think of local or indigenous processes they could bring into the class to facilitate their conceptual understanding. The study therefore contributed to the possibilities of how learners' socio-cultural background can be utilised in the science classroom as reiterated by Mavuru and Ramnarain (2020). Thus, the science embedded in the cultural practice of *mudukuto* could be optimally used by teachers in their science classrooms to contextualise science lessons.

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# Appendices

## Appendix A: Ethical Clearance


**Human Ethics subcommittee**
**Rhodes University Ethical Standards Committee**
PO Box 94, Grahamstown, 6140, South Africa
t: +27 (0) 46 603 8055
f: +27 (0) 46 603 8822
e: ethics-committee@ru.ac.za

www.ru.ac.za/research/research/ethics
**NHREC Registration no. REC-241114-045**

16 July 2020

Mr. Peter Kudumo

Education

Email: g17k8168@campus.ru.ac.za

Review Reference: 2020-1150-3508

Dear Prof Ngcoza

**Title:** Exploring how the traditional blast furnace as an approach enables and/or constrains grade 9 Physical Science learners' motivation to learn and hence make sense of the concept of malleability

Principal Investigator: Prof Kenneth Ngcoza

Collaborators: Mr. Peter Kudumo,

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Ethical Standards Committee (RUESC) – Human Ethics (HE) sub-committee.

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

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on the completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloging number allocated.

Sincerely,

**Prof Arthur Webb**

**Chair: Human Ethics Sub-Committee, RUESC- HE**

**Appendix B: Directorate Letter of Consent**


**KAVANGO WEST REGIONAL COUNCIL**
**DIRECTORATE EDUCATION, ARTS AND CULTURE**

Tel No: (066) 264976
Email: kavangowesteac@yahoo.com
Enquiries: Ms. F. Sikongo
Ref: 26 / 1 / 16

Private Bag 6193, Nkurenkuru
Namibia

Mr. Peter W. Kudumo
P O Box 1792
Rundu

02 July 2020

**RE: PERMISSION TO CONDUCT EDUCATIONAL RESEARCH WITH GRADE 9 PHYSICAL SCIENCE LEARNERS AT RUPARA SECONDARY SCHOOL**

1. The Ministry of Education, Arts and Culture wishes to acknowledge receipt of your letter dated 30 June 2020, seeking permission to conduct an academic research for your Master Degree in Science Education, on the topic: ***Exploring how the Traditional blast furnace enables and / or constraints Grade 9 Physical Science Learners motivation to learn and make sense of the concept of malleability.***

2. Permission is hereby granted to you provided, you seek for further clearance from the Circuit Inspector of Education where you wish to conduct your research to ensure that:

   - permission is sought from the school Principal;
   - teaching and Learning is not interrupted and
   - all participation is voluntary.

3. Furthermore, you are kindly requested to share your research findings with the Ministry of Education, Arts and Culture after completion of your study. You may contact the Deputy Director: Programme and Quality Assurance (PQA) for submission of a summary of your research findings.

4. We wish you all the best in conducting your research.

Sincerely,

KAVANGO WEST REGIONAL COUNCIL
Office of the Director
Directorate of Education, Arts & Culture
2020 -07- 03
Tel: 066-264976 - Private Bag 6193
Nkurenkuru

**TEOPOLINA HAMUTUMUA**
**REGIONAL DIRECTOR OF EDUCATION, ARTS AND CULTURE**
**KAVANGO WEST**

03/07/2020
**DATE**

*cc: Inspector of Education*
*Bunya Circuit*

All official correspondences must be forwarded to the office of the Chief Regional Officer

**Appendix C: Principal Letter of Consent**

**Rupara Combined School**

*Tel: (066)-257607*
*Private Bag 2108*
*Rundu*

Enquiries: Ms Ausiku
Email: ausikup@yahoo.com
Cell no: 0813501458

14 July 2020

Mr. Peter W. Kudumo

P.O. Box 1792

Rundu

**Re: Permission to conduct Educational research with grade 9 Physical science learners at Rupara Combined School**

Rupara Senior Secondary school wishes to acknowledge receipt of your letter dated 08 July 2020 seeking permission to conduct an academic research for your Master's Degree in Science Education.

Permission is hereby granted by the principal.

We wish you well in your study.

Yours Sincerely

Ausiku Patricia

Principal

MINISTRY OF EDUCATION
THE PRINCIPAL
RUPARA COMBINED SCHOOL
14 JUL 2020
P/BAG 2108
RUNDU
REPUBLIC OF NAMIBIA

**Appendix D: Learners' Consent Letter**

P O Box 1792

Rundu Namibia

11 July 2020

**Dear Participant**

**Re: Participation in research on the integration of Indigenous knowledge in science**

I, Peter Wilfred Kudumo, a part time student doing Master's in Science Education at Rhodes University. I am hereby kindly requesting you to be a participant in my study.

The study will focus on *mudukuto* `*blast furnace*` as an approach to enable science learners improve their understanding and application of science to their immediate environment. The study will be conducted in three phases. The first phase, a lesson will be presented. The second phase involves an intervention in a form of a blast furnace "*mudukuto*" to be demonstrated by a community member. In the last phase, a lesson will be developed that integrates the knowledge shared by the community member.

Kindly be informed that your participation in the research is completely voluntary and you can withdraw at any time you wish to do so. The data collected will be used for academic purpose. I ask for your permission to take videos during the demonstrations. Your views or contributions will be treated with a high degree of confidentiality and anonymity.

If you have any questions about the research, please feel free to contact me at 081 4915445.

I henceforth request you to indicate your choice by ticking **(✓)** in the box below if you have agreed to my request and cross **(×)** in the box if you disagree. ☐

Signature _____

Your cooperation will be highly appreciated

Yours Sincerely

Peter W Kudumo

**DECLARATION BY PARTICIPANT**

I agree to participate in the research, and I understand that I am free to withdraw at any time.

Name: _____

Signature: _____

Contact number: _____

**Appendix E: Letter to the Participant`s Parent [English]**

P O Box 1792

Rundu Namibia

11 July 2020

**Dear Parent Participant**

**Re: Participation in research on the integration of Indigenous knowledge in science**

I, Peter Wilfred Kudumo, a part time student doing Master's in Science Education at Rhodes University. I am hereby kindly requesting for your permission to allow your child to be a participant in my study.

The purpose of the study is to explore how African Indigenous knowledge can be integrated in the lessons to improve teaching, students understanding and application of science to their immediate environment. The study will involve a demonstration from the community member as knowledgeable person.

Kindly be informed that the participation of your child in the research is completely voluntary and she or he can withdraw at any time he or she wish to do so. The data collected will be used for academic purpose. The views or contributions and identity of the child will be treated with a high degree of confidentiality and anonymity.

If you have any questions about the research, please feel free to contact me at 081 4915445. I henceforth request you to indicate your choice by ticking **(✓)** in the box below if you have

agreed to my request and cross **(×)** in the box if you disagree. ☐

Signature _____

Your co-operation is this regard is highly appreciated.

Yours Sincerely

Peter Wilfred Kudumo

**DECLARATION BY PARTICIPANT**

I agree for my child to participate in the research, and I understand that he or she is free to withdraw at any time.

Name: _____

Signature: _____

Contact number: _____

**Letter to the Participants` Parents [Rukwangali]**

Komureti hamenimo

**Siparatjangwa: Elihameseromo momakonakono keturomo maunongo gopampo mosirongwa sounongo**

Ame Peter Wilfred Kudumo murongwa gokaruwokwatelimo nina kurugana / lironga masta mosirongo sounongo konkurusure za Rhodes. Ame apa kuna ku mu hundira nelinunupiko mu pulisire murerwa gweni nga kare muhameni momalirongo gange.

Sitambo setulisopo malirongo gangesi yipo tu gwane mauzera omu maunongo gopampo moAfrica na va vhura kuga hamesera moyirongwa yipo yi ka retesepo erunduruko mondongeso, ezuvhoko movarongwa, ntani neturo mosirugana maunongo ogo monkarapamwe zawo. Malirongo simpe nga ga hamesera mo elikido lyokutunda kwa gumwe gomomukunda omu nga vhura kulikida udivi wendi.

Kareni muna sidiva asi ehameseromo lyomurerwa gweni momalirongokonakono ogo ngasikara selizambero yimo hena asi muntu kuvhura kutunda mo nkenye apa. Mauzera pongaiko ngava ga ruganesa kositambo somalirongo. Magano ndi makwatesoko geni nenongonono nga yi gwana ehoramo lyenene.

Mauzera nkenye kuhamena makonakono aga, gwanekereni name kongodi ozo: 081 4915445. Tani mu hundire mu likide etamburo lyeni po kukoreka ndi mu disure mokafano oko konhi nsene kapi muna yitambura.

Esaino:_____

Epakero mbili lyeni tani lipanda unene.

Gweni

Peter Wilfred Kudumo

**Etamburo lyomuhameni**

Nina tambura ni hamene momakonakono ntani nina zuvhu as kuvhura kutunda mo nkenye apa.

Edina: _____

Esaino: _____

Ngodi zokomawoko: _____

**Appendix F: Letter to the Community Member [English]**

P O Box 1792

Rundu Namibia

11 July 2020

Dear Sir/Madam

**Re: Participation in research on the integration of Indigenous knowledge in science**

I, Peter Wilfred Kudumo, a part time student at Rhodes University. I am hereby kindly requesting you to be a participant in my study. I am doing a research on Exploring *mudukuto* "blast furnace" as an approach to enable grade 9 Physical Science learners to understand the concept of malleability.

The purpose of the study is to explore how African Indigenous knowledge can be integrated in the lessons to improve teaching, students understanding and application of science to their immediate environment. The study will involve a demonstration from the community member of which you are going to present how a blast furnace "*mudukuto*" works. Being a knowledgeable person about the practice of blast furnace, I trust you on facilitating the demonstration as my belief that within our communities, our cultural practices and cultural artefacts are embedded with science concepts.

Your participation in the research study will be highly appreciated and it is a voluntary exercise that means you can withdraw anytime if you wish to do so. The data collected will be used for academic purpose. I ask for your permission to take videos of the demonstrations so that I can be able to analyse the data later. Your views or contributions and identity will be treated with a high degree of confidentiality and anonymity.

For more information, you may contact my supervisors Prof Kenneth Mlungisi Ngcoza at

(K.Ngcoza@ru.ac.az) and Dr Zukiswa Kuhlane at (z.kuhlane@ru.ac.za)

Lastly, I would like you tick **(✓)** in the box below if you have agreed to my request and cross **(×)** in the box if you disagree. ☐

Signature _____

Your Sincerely

Peter W Kudumo

**DECLARATION BY PARTICIPANT**

I agree to participate in the research, and I understand that I am free to withdraw at any time.

Name: _____

Signature: _____

Contact number: _____

**Letter to the Community Members [*Rukwangali* translation]**

Komunekuto / mugolikadi gefumano

**Siparatjangwa: Elihameseromo momakonakono keturomo maunongo gopampo mosirongwa sounongo.**

Ame Peter Wilfred Kudumo, murongwa gokaruwokwatelimo konkurusure za Rhodes. Ame apa kuna kumuhundira nelinunupiko mu kare muhameni momalirongo gange. Ame kuna kurugana makonakono gange ku hamena "*Exploring mudukuduku "blast furnace" as an approach to enable grade 9 Physical Science learners to understand the concept of malleability*".

Sitambo setulisopo malirongo gangesi yipo tu gwane mauzera omu maunongo gopampo moAfrica na va vhura kuga hamesera moyirongwa yipo yi ka retesepo erunduruko mondongeso, ezuvhoko movarongwa, ntani neturo mosirugana maunongo ogo monkarapamwe zawo. Malirongo simpe nga ga hamesera mo elikido lyokutunda kwa gumwe gomomukunda omu nga vhura kulikida omu mudukuduku a gurugana.

Ngokukara gumwe goudivi kuhamena sirugana oso somudukuduku nina kara nehugavaro mweni mokurerupika elikidoturopo olyo ngetamburo ko asi monomukunda detu; yirugana noyiruganeso yopampo; kwayigwanekedesa monondaka domaunongo.

Elihameseromo lyeni momalirongokonakono ngatu ga panda unene ntani esi sirugana selizambero oyo yina kutanta asi muntu kuvhura kutunda mo nkenye apa. Mauzera pongaiko ngava ga ruganesa kositambo somalirongo. Tani hundire epulisiro lyeni ngani ya faneke no videos damalikido yipo ngani vhure ku ka tarurura mauzera ogo knonyima. Magano ndi makwatesoko geni nenongonono nga yi gwana ehoramo lyenene.

Mauzera gomanzi kugwanekera nomunomeni / tareli gwange: Prof Kenneth Mlungisi Ngcoza ko (K.ngcoza@ru.ac.za) ndi Dr Zukiswa Kuhlane ko (Z.kuhlane@ru.ac.za). Hulilira, nina hara mu koreke mokafano oko konhi nsene muna tambura ehundiro lyange ndi mu disure mokafano nsene kapi muna yi tambura.

Esaino: _____

Gweni

Peter Wilfred Kudumo

**Etamburo lyomuhameni**

Nina tambura ni hamene momakonakono ntani nina zuvhu as kuvhura kutunda mo nkenye apa.

Edina: _____

Esaino: _____

Ngodi zokomawoko: _____

**Appendix G: Focus Group Interview Responses**

Explain code: **T1-T6**

BLUE: LEARNERS' UNDERSTANDING OF SCIENCE

RED: CHALLENGES OF LEARNING SCIENCE

GREEN: ROLE OF HANDS-ON PRACTICAL ACTIVITIES IN LEARNING SCIENCE

YELLOW: PARTICIPANTS` PERSPECTIVES ON HOW SCIENCE SHOULD BE TAUGHT

## INDUCTIVE-DEDUCTIVE ANALYSIS/THEMATIC APPROACH

| Questions | Answers |
|---|---|
| 1. What do you like about science? | **L1FGI**: L**ikes investigations, observations, test and studying things within the surroundings. Importance of investigations discovers the truth about a phenomenon being studied.**<br><br>**L2FGI**: I**t relates to real life (knowing the right things about life).** It t**eaches me about modern things that are in the surroundings by doing it.**<br><br>**L3FGI**: Topics in science are very easy to learn and understand when related our real-life experiences. In science experiment is used to prove things and it can be **done by hands.**<br><br>L4FGI: **New development in science & technology. Especially, the laws of science and advance of modern science.**<br><br>L5FGI: B**eing able to do something that I have learnt by hands.**<br><br>L6FGI: There's a lot of calculations that improves the mathematically skills and more good ideas that improves someone's knowledge. |
| 2. What do you not like about science? | L1FGI: **I don't like it when the syllabus of sciences changes to mathematics, especially mathematics whereby they teach us a lot of calculations in science & it's tough for me.**<br><br>**L2FGI: Topic in mathematics "lack of practical".**<br><br>**L3FGI: Some topics are difficult. Not being able to catch up its things easily if I'm not doing its activities/exercising it. Science has a lot of practical experiments while we don't have enough apparatus. Science has a lot of practical** |

| | |
|---|---|
| | **experiments while we don`t have enough apparatus. The incorporation of mathematics in a form of calculation makes it tough for some of us who have a poor mathematic background.**<br><br>**L4FGI:** Research **"doing research. Lack of resources to carry out research." The incorporation of mathematics, there's no way you can do science subject, if you are not good in mathematics**<br><br>**L5FGI: Doing an experiment on your own. Science is dangerous when you do not know how work with some experiment. Some experiments might burn you when working with them not properly handled. E.g. electricity does not go hand in hand with water, it might create a shock.**<br><br>**L6FGI: Science has a lot of summaries notes which makes me not to complete reading it. Lots of experiments that are involved in science.** |
| 3. What motivates you to learn science? | **L1FGI: Summary is short s it becomes easier, clear to understand. I enjoy it is the one that teaches us about the world around us. It opens up "unlocks" the brain because all of its chapters/topics are exciting. Opens my mind, to think divergent when I'm doing science.**<br><br>**L2FGI: The discovery in science makes me to discover something that is important like careers in science/opportunity of employment**<br><br>**L3FGI: Science have short summary notes. Leads to careers in science like being a nurse/doctor as they are my favorite careers to be. P**ractica**l** activities motivate me to study science as it will assist me to improve my knowledge and understanding of science.<br><br>**L4FGI**: Experiments in the science laboratory. You can do things that you can see or observe with own eyes.<br><br>**L5FGI:** Science allows me to do something that I have learnt by hands, like carrying out an experiment to confirm the result of something.<br><br>**L6FGI:** Some topic which I learn about the danger of electricity and some instrument which are useful to people. Helps with the skills of measurement when using measuring instruments. Study more about things which is in nature improves my knowledge understand. Science has to do with the use of experiments. |

| | |
|---|---|
| 4. What does not motivate you to learn science? | **L1FGI: There's a lot of mathematics in it that makes it tough sometimes and tiring.** Sometimes, s**cience lessons are explained with use of diagrams in the classroom**<br><br>**L2FGI: Peer pressure from friends as some of the things learnt can make someone sad.** Teachers should simplify their notes so that it becomes easier to read and understand not long.<br><br>**L3FGI: Teachers explain too much that sometimes confuse a leaner and makes the topic look difficult.**<br><br>**L4FGI: Carrying out experiment in the laboratory because some learners like tasting since they are some chemicals that cannot be tasted.**<br><br>**L5FGI:** Science consist of a lot of calculations and formulas<br><br>**L6FGI:** There's a lack of apparatus that can be used to conduct our experiment. When learners do a practical activity, they understand it a bit clearly. |
| 5. How do you like science to be taught? Explain why? | **L1FGI:** Be taught in such a way that a learner can understand by engaging in practical activities where necessary**. Practical activities simplify leaners understanding as they can see & relate it with their own eyes. Teachers should visualize science as same learners don't know how or have not seen the apparatus or touched them.**<br><br>**L2FGI: Relate to daily experience, real situations that incorporate Ubuntu (value one another) solving problems.**<br><br>**L3FGI: Science should be taught physically because science is not about existing knowledge but also discovering new ideas and knowledge. People need to sit together and make up their mind and put their new ideas together in order to finalise the situations with correct answers.**<br><br>**L4FGI: To be taught all experiments in the laboratory "being practical". Explain in detail, show some examples/demonstrate how to do it. This helps learners to understand the reality of how it works and almost things learnt in science is happening in the community.**<br><br>L5FGI: **Allows learners to carry out an experiment at the same time as the teacher is teaching. Science to be taught morning time and do the experiment in the afternoon on what was taught in the morning.**<br><br>L6FGI: **Science to be taught using apparatus when doing experiments as some learners never saw the apparatus. In order for us to know how it happened and to confirm what could be the result of the experiment compared to the result in the notebook.** |

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| | | THEORY |
| Categories | Themes | LITERATURE:<br><br>CONCEPTUAL/THEORETICAL<br><br>FRAMEWORK |
| **L1FGI**: **Likes investigations, observations, test and studying things within the surroundings. Importance of investigations discovers the truth about a phenomenon being studied.**<br><br>**L2FGI**: **It relates to real life (knowing the right things about life).** It teaches me about **modern things that are in the surroundings by doing it.**<br><br>L5FGI: **Science allows me to do something that I have learnt by hands, like carrying out an experiment to confirm the result of something.**<br><br>**L1FGI: Summary is short s it becomes easier, clear to understand. I enjoy it is the one that teaches us about the world around us. It opens up "unlocks" the brain because all of its chapters/topics are exciting. Opens my mind, to think divergent when I'm doing science.**<br><br>L4FGI: **Experiments in the science laboratory. You can do things that you can see or observe with own eyes.** | **Participants' understanding of Science** | Mukwambo, Ngcoza and Chikunda's (2014)<br><br>Mavuru and Ramnarain (2020) Mhakure and Otulaja (2017) Agunbiade, Ngcoza, Jawahar and Sewry (2017)<br><br>Govender (2016) |
| **L3FGI: Some topics are difficult. Not being able to catch up its things easily if I'm not doing its activities/exercising it. Science has a lot of practical experiments while we don't have enough apparatus. Science has a lot of practical experiments while we don`t have enough apparatus. The incorporation of mathematics in a form of calculation makes it tough for some of us who have a poor mathematic background.**<br><br>**L1FGI: There's a lot of mathematics in it that makes it tough sometimes and tiring.** Sometimes, **science lessons are explained with use of diagrams in the classroom** | **Challenges of learning science** | Asheela, Ngcoza & Sewry, 2021<br><br>Olutusin (2007)<br><br>Hashondili, 2020<br><br>Oruntegbe and Ikpe (2011)<br><br>Haimene (2018)<br><br>Aikenhead (1997)<br><br>Millar (2004) |

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| **L6FGI:** There's a lack of apparatus that can be used to conduct our experiment. When learners do a practical activity, they understand it a bit clearly.<br><br>**L5FGI:** Science consist of a lot of calculations and formulas<br><br>L1FGI: **I don't like it when the syllabus of sciences changes to mathematics, especially mathematics whereby they teach us a lot of calculations in science & it's tough for me.**<br><br>**L4FGI: Research "doing research. Lack of resources to carry out research." The incorporation of mathematics, there's no way you can do science subject, if you are not good in mathematics**<br><br>**L5FGI: Doing an experiment on your own. Science is dangerous when you do not know how work with some experiment. Some experiments might burn you when working with them not properly handled. E.g. electricity does not go hand in hand with water, it might create a shock.** | | Rundgren & Yao (2014) |
| **L2FGI: The discovery in science makes me to discover something that is important like careers in science/opportunity of employment**<br><br>**L3FGI: Science have short summary notes. Leads to careers in science like being a nurse/doctor as they are my favorite careers to be.** Practical activities motivate me to study science as it will assist me to improve my knowledge and understanding of science.<br><br>**L4FGI**: Experiments in the science laboratory. You can do things that you can see or observe with own eyes. | **Role of hands-on practical activities in learning science** | Sedlacek and Sedova (2017)<br><br>Asheela, Ngcoza & Sewry, (2021)<br><br>Lyons (2006)<br><br>Heeralal (2014)<br><br>Uushona (2013)<br><br>Gacheri & Ndege (2014) |
| L6FGI: **Science to be taught using apparatus when doing experiments as some learners never saw the apparatus. In order for us to know how it happened and to confirm what could be the result of the experiment compared to the result in the notebook.**<br><br>L5FGI: **Allows learners to carry out an experiment at the same time as the teacher is teaching. Science to be taught morning time and do the experiment in the afternoon on what was taught in the morning.** | **Participants' perspectives on how science should be taught** | Oruntegbe & Ikpe (2011) Raved & Assaraf (2011) Agunbiade, Ngcoza, Jawahar and Sewry (2017)<br><br>Cook (2006) Gilbert (2008) |

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| **L2FGI:** **Relate to daily experience, real situations that incorporate Ubuntu (value one another) solving problems.**<br><br>**L1FGI:** Be taught in such a way that a learner can understand by engaging in practical activities where necessary**. Practical activities simplify leaners understanding as they can see & relate it with their own eyes. Teachers should visualize science as same learners don't know how or have not seen the apparatus or touched them.** | | |

**Appendix H: Reflection by Learners**

| Questions | Answers |
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| 1. What did you enjoy or not about in the presentations? | **L1:** I enjoyed the teaching and the process of hammering the metal (axe). I felt good seeing how the mudukuto was pumping air to put the fire on for the metal to burnt nicely so that they hammer it and cut it nicely. I enjoyed the way the community member explained the whole process of the presentation so that we know, how it works.<br><br>**L2:** I enjoyed the process of showing how axe is prepared. Listening to how axe and hoe is prepared and felt proud by looking at things of our culture. Putting the metal on fire so that it becomes red and put it in cold water mixture with salt.<br><br>**L3:** I enjoy how mudukuto is used to hammer metals e.g. to make axe & hoe. The process of metal melting completely while the mudukuto is ongoing on.<br><br>**L4:** I enjoyed more about it because I learnt and understand many things from the presentation which is about some concepts that we learn in science.<br><br>**L5:** I was surprised to see how Mudukuto pumps air so that the charcoal becomes red so that the metal in order for it to be light.<br><br>**L6:** I enjoyed asking questions on the certain thing that I was confused about and how we all gathered to observe the process. But I didn't enjoy it when it came to heat and removing the metal from fire because its hot it can burn you. |
| 2. what have you learnt/not from the community presentations | **L1:** I learnt how the community member present his knowledge towards the learners. It helps us to get better understanding. We learnt a lot how to make axes from the community member and some concepts of science from the presentations. |

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| | **L2:** I have learnt how they prepare the axes/hoes so that tomorrow I have knowledge about it so that I go teach my children. It becomes easier to explain something related to the presentations in case a person asks you questions.<br><br>**L3:** I have learnt that if someone wants tools for weeding/cultivating, it can be done by ourselves according to the community members.<br><br>**L4:** I have leant that during the process of mudukuto a metal can be soften & make tools like hoes, panga and knife. I have learnt important thing that I haven't seen especially how they sharpened the axes, how to hammer a metal. Type of things to use so that the axes becomes strong.<br><br>**L5:** I leant how a metal is cut so that they can make a knife out of it.<br><br>**L6:** I have learnt that if you heat a metal, it will expand, and a heated metal should be removed an insulator like wood because wood is a poor conductor of heat. |
| 3. How did the presentations changed/contributed to your understanding of science | **L1:** It assisted in understanding the process of science like temperature. It has contributed better to my science understanding by showing me how some science processes work physically.<br><br>**L2:** The explanation of the teacher in the class and the community member about the mudukuto is the same, we were taught that if you put the metal on fire, the metal will become big.<br><br>**L3:** It contributed a lot to my understanding of science that if we don`t have apparatus to use in some experiments in science then we can use materials like mudukuto, easier to relate to.<br><br>**L4:** I understand it that when a metal is heated it can increase in size/expand and in the presentation a wood |

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| | was used to hold a metal instead of another metal. In science we learn that wood is a poor conductor of heat so that is why he uses wood instead of a metal. Even if the teacher asks a question in the examination about metals, I will be able to explain using the process of mudukuto.<br><br>**L5:** According to what the community member presented there's a similarity with what the teacher taught us. For example, when you put a metal on fire, it expands.<br><br>**L6:** The presentation did something that is related to what we learn in science like heating a metal when a metal is heated it expands due to heat. It is expansion. It changed a lot of things because when the teacher taught us I failed to understand what he explained like if you heat a metal it expands so i was waiting to see it physicals. |
| 4. what do you think about including local knowledge in the science lessons, is it a good idea/not explain. | **L1:** It is a good idea because what we learned in local knowledge is also there at school and it creates a better understanding in the class because you already know it from local knowledge.<br><br>**L2:** Good idea because it's our culture otherwise no one will know it. Including local knowledge in science lessons will help learners learn to understand it well because they already know what the teacher is talking about because it's what is being done in their community.<br><br>**L3:** Good idea, easy to understand and contribute more in the science lessons, because most of local things are the one which are used in science lessons.<br><br>**L4:** Good idea, gives a good example to leaners to understand it well because most of them know local things. |

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| | **L5:** Good idea. Because it will be easier for us to understand so that we can be able to remember it even in the test.<br><br>**L6:** Good idea because learners understand better when they see how science lessons work and what happens when something is done but only after school or when there's no school. It will delay the time if it done during school hours. Local knowledge contributes a lot to our knowledge of science because most of the thing we do at home is science so it's better. |
| Do you think there`s a need to include local materials in science lessons | **L1:** Yes. To know well about local knowledge so that you can do it at home. The teacher can teach you with local materials so that you have a better understanding. It is easier for learners to understand it quickly because they know and have seen the material before or already. Mudukuto can also be used during topics of expansion in solids.<br><br>**L2:** Yes. The materials are the same used in the teaching and learning. Because some the things we learn in physical science, for example, temperature, expansion, heat energy, compressibility, you get it during the process of mudukuto.<br><br>**L3:** Yes. Because it will make learners easy to understand it and some they know some materials like mudukuto which was used by their parents.<br><br>**L4:** Yes. Because it will include some skills in the science lessons, which makes things go well.<br><br>**L5:** Yes. because some of the local knowledge are important in science like mudukuto. It helps someone to see the whole process that is taking place.<br><br>**L6:** Yes. because when we are taught some science lessons some of us wonder how it happens and what can you do to observe it. There's a need to include |

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| | local materials in science lessons to improve learners understanding. with local materials we know them. |