From Field to Classroom: Bridging Maize Farming and Mechanical Energy Conservation

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By

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Declaration of Originality

I, Makgwedi Calendula Malemela (22M1328) declare that this thesis has not been submitted for a degree in any other university apart from Rhodes University and I declare that it is my work, written in my own original words. It has only been submitted for the master's degree at Rhodes University. Where I have cited the words or ideas of other researchers, these have been acknowledged using complete references according to the Departmental guidelines.

Signature: Date: June 2025

Dedication

I would like to dedicate the study to my mother, Mamaila Betty Malemela. Thank you for showing me what hard work and dedication are to an individual in academia.

To my siblings, Mpho Rachel Thwala (older sister) and brother-in-law Mthunzi Thwala, Maboke Quinton Malemela (1st youngest brother), Lebese Elvis Malemela (2nd youngest brother), Lesiba Malemela (3rd youngest brother), my niece Kokozi Dimpho Thwala and nephew Mthunzi Kgotsana Thwala, thank you for your support and inspiration.

To my grandmother Dikonketso Ramohlale and grandfather Lebese Ramohlale, *kea leboga le nkgoditsise baratiwa* (thank you, your granddaughter is all grown up now). To my late father Lesetja Molapo Petrus Malemela, *morwedi wa gago o kganya bjale ka tamane* (your daughter is shining bright like a diamond).

A special dedication to my loving husband Mpho Mosebo Magagane, you are a blessing in my life and thank you for your support and encouragement throughout this journey.

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In the same vein, I would like to give thanks to the Grade 10 learners at my school, my critical friend, and the four Indigenous Knowledge Custodians, for willingly participating in my research study. Special thanks to my grandparents for participating in this study despite their ill health.

To the school principals, Premiers Office and Ministry of Education officials, thank you for giving me the access I needed to conduct the research.

Furthermore, this thesis is written from a place of deep respect for the work of all my academic predecessors both locally and globally, I salute you all and your truly intellectual giants.

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Abstract

The current South African physical sciences curriculum for grades 10–12 encourages teachers to integrate Indigenous Knowledge (IK) into their teaching. By doing so, it is hoped that this would contextualise and make science relevant to learners. However, the contradiction is that IK is hardly discussed in the curriculum, and there are no clear guidelines on how to integrate it. It is against this background that in this study, I used traditional maize seed ploughing practices to support Grade 10 Physical Sciences learners from a rural school to argue and make sense of the conservation of mechanical energy.

This study is underpinned by the interpretivist and Indigenous research paradigms. Within the Indigenous research paradigm, I focused on the Ubuntu perspective. A qualitative case study research design was employed, and the study was conducted at Dimpe Secondary School (pseudonym) in the Waterberg District of the Limpopo Province. Fifteen Grade 10 Physical Sciences learners and four Indigenous Knowledge Custodians (IKCs) were participants in this study. In addition, a physical sciences teacher was a critical friend who offered insights and feedback throughout the research process. Data generation methods involved group activities, focus group interviews (sharing circles), observations (participatory and lesson observations), and learners' reflective journals. A thematic approach to data analysis was employed and concepts from Vygotsky's sociocultural theory were used.

The findings of the study revealed that during the IKCs' demonstrations, learners were able to identify science concepts related to the conservation of mechanical energy. Moreover, learners' argumentation and sense making of the conservation of mechanical energy and related concepts greatly improved. Based on these research findings, I thus recommend that teachers should tap into IKCs' cultural heritage to contextualise science to make it relevant and more meaningful to learners.

Keywords: conservation of mechanical energy; indigenous knowledge; physical sciences; sociocultural theory; Ubuntu

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Abbreviations and/or Acronyms

CAPS: Curriculum and Assessment Policy Statement

DAIM: Dialogical Argumentation Instructional Model

DBE: Department of Basic Education

FET: Further Education and Training

IK: Indigenous Knowledge

IKCs: Indigenous Knowledge Custodians

LJR: Learner Journal Reflections

LP: Learners' Prior knowledge

SCT: Sociocultural Theory

TIMSS: Trends in International Mathematics and Science Study

TMESD: Transformative Model of Education for Sustainable Development

WS: Westernised Science

ZPD: Zone of Proximal Development

CHAPTER ONE: SITUATING THE STUDY

1.1 Introduction

The study delineated a crucial inquiry into the integration of Indigenous Knowledge (IK) into the science curriculum, particularly focusing on the teaching of mechanical energy conservation through traditional maize planting to Grade 10 learners in a rural school setting in South Africa. Indigenous Knowledge (IK) is the knowledge passed down through generations among African communities (Kibirige & Van Rooyen, 2006), and encompasses their beliefs, practices, and stories (Taylor & Cameron, 2016). The study was conducted at a secondary school in the Waterberg District in the Limpopo Province, South Africa. This exploration emerged from the backdrop of my observation and experience of educational challenges faced by learners from socio-economically disadvantaged backgrounds in the rural secondary schools where I have been teaching for the past years. These challenges, as highlighted in the study, are linked to the practices of teaching science in non-Western contexts, a situation that becomes particularly common in the South African educational landscape.

In the quest for better pedagogical strategies that can be used to decolonise and transform the science curriculum (Mutanho, 2021), I explored teachers' perspectives on the integration of IK in science teaching and learning in my mini thesis for my Bachelor of Education (Science) Honours degree. The findings of the study revealed that teachers were interested in integrating local knowledge, with some indicating that they were already integrating IK into their science teaching and learning. This triggered my interest in finding practical strategies to integrate learners' IK in my science teaching.

In this chapter, therefore, I start by outlining the context of the study. Next, I describe my personal life experience in terms of IK and science, followed by my positionality and reflexivity. I further present a statement of the problem and the significance of the study. The research goal and questions that guided this study are elucidated, and I outline the theoretical frameworks that informed the study. The chapter ends with a thesis outline and the chapter summary.

1.2 Context of the Study

South Africa has been participating in the Trends in International Mathematics and Science Study (TIMSS) assessment since 1995. This assessment for Grade 4 and 8 learners in mathematics and science was developed by the International Association of Educational Achievement. Ever since South Africa started to participate, it has been one of the worst-performing countries among 39 participants, including other African countries, such as Egypt, Morocco and Botswana. For instance, in 2015, South Africa participated in TIMSS with Grade 9 learners and recorded the lowest performance among participating countries (Reddy et al., 2020). This inclusion allowed South Africa to assess its progress in mathematics and science achievement against international standards (Alex & Juan, 2017).

In 2019, the TIMSS was hosted in the Eastern Cape province of South Africa, and, again, South African schools performed poorly compared to those in other countries. The South African Grade 4 and 8 learners scored the lowest average scores, and only 36% of South African learners demonstrated basic science knowledge (Reddy et al., 2020). However, my criticism of the TIMSS is that it does not factor in learners' sociocultural backgrounds, as espoused by scholars such as Mavuru and Ramnarain (2020). Instead, its findings are generalised to all South African learners regardless of their sociocultural background.

Notably, in South Africa, the science curriculum is structured in such a way that Grade 4-6 intermediate-phase learners are introduced to and taught natural sciences and technology. In grades 7–9, senior-phase learners are taught the general knowledge of science and scientific concepts in natural sciences and technology. In Grade 10, the 'science stream' is introduced, which, in most rural schools, includes life sciences, physical sciences and agricultural sciences as the science subjects. This is because most schools in rural areas find it easier to teach these subjects rather than the more technical science subjects in Grade 10.

In Grade 10, science subjects offer foundational science knowledge for grades 11 and 12. That is, it is intended to build on the scientific knowledge that the learners acquire in the intermediate and senior phases in technology and natural sciences and offer them deeper meaning and understanding. This suggests that if learners lack a good foundation in Grade 10 Physical Sciences topics, their further understanding of the same topic in grades 11 and 12 might be affected. For instance, in my five years' experience as a physical sciences Grade 10–12 teacher at Dimpe Secondary School (pseudonym) (a quintile 2[1] school, Palala South Circuit), I have noticed that most Grade 12 learners seem to fail the topic of work, energy, and power (Mapfumo, 2024). It is notable that the scientific concepts taught in Grade 10 Physical Sciences on the conservation of mechanical energy are further explained in the work, energy and power section in Grade 12. Thus, as alluded to earlier, the basic concepts related to these topics are first introduced in Grade 10, but most of my learners seem to struggle to comprehend the concepts at the Grade 12 level. In the 2021 and 2023 National Senior Certificate (see Table 1 below), diagnostic reports expressed great concern about how most learners fail to answer question 5 adequately, which focuses on work, energy and power.

Table 1.1: The average performance of Grade 12 learners in the topic of work, energy and power over the last five years

Year	Number of learners who wrote	National Average performance (work, energy and power)
2019	164 478	56%
2020	174 310	37%
2021	196 968	45%
2022	209 004	52%
2023	206 399	54%
2024	200 715	54%

[1] Quintile 2 represents the second-poorest quintile, meaning it includes schools serving the next poorest 20% of learners. These schools, along with Quintile 1 and 3, are considered "no-fee schools" and receive more funding from the state to cover their non-personnel costs.

According to Table 1.1, there seems to be an improvement in learner performance between 2021 and 2024, based on the national average performance. Regarding this phenomenon, some scholars suggest that science teaching and learning in schools in South Africa seem to lack the adoption of relevant pedagogical approaches[2] (Nemadziva et al., 2023; Stott, 2018). Moreover, mastery of the science content in Grade 10 is important as it lays the knowledge foundation for grades 11 and 12. This study therefore sought to mobilise traditional maize seed planting techniques as a pedagogical approach to mediate learning concepts of energy conservation and transfer in Grade 10.

Traditional ploughing methods, used in many rural villages in South Africa, offer a tangible context for mediating topics in physics education (Nelson & Shilling, 2018). My grandparents and other community members tell the story of how, in the past, cow traction, as opposed to tractors, was used to plant maize seeds. This traditional method of ploughing involved harnessing a pair of cows to a specially designed plough. The cows pull the plough through the field, turning and loosening the soil to prepare it for planting. It also involved maize seed planters, who followed behind the cow traction while dropping the maize seeds inside furrows made by the ploughing disc. This practice was most common in our village then, since it was expensive to buy or hire a tractor.

However, nowadays, since the socio-economic statuses of most villagers have changed, traditional ploughing techniques involve a tractor-pulled ploughing disc followed by individuals who manually sow maize seeds into the formed furrows. The seeds are deposited at different depths, corresponding to the heights of the people planting them, as was the case when cow traction was used. The objective is to achieve an even distribution of seeds in a straight line, centred between the apex of the furrow and its base. During this process, maize seeds, initially held at rest, receive chemical energy from the hand or body that is converted into potential energy – the energy of position. When the seeds are released from the planters' hands, the potential energy is then converted into kinetic energy, the energy of motion. The interplay of gravitational forces and air

[2] Pedagogical approaches in education include a variety of methods adapted to different subjects and learners' needs. They are strategies that educators use to teach, ranging from subject design to material delivery

resistance creates a zigzag pattern as the seeds descend, demonstrating the interplay of energy in a real-world scenario.

Through relating these agricultural practices to scientific principles, the study seeks to create a tangible learning experience that can deepen learners' insights into energy dynamics. The value of integrating IK with science in teaching and learning has been demonstrated by numerous studies (Hewson & Ogunniyi, 2011; Nhalevilo & Ogunniyi, 2014). IK is the kind of knowledge that is unique to people living in the same area (Jones & Hunter, 2003; Kibirige & Van Rooyen, 2006). This simply implies that the IK that learners bring to the classroom and acquire from home or the community can serve as a bridge between home and school science (border crossing) (Aikenhead & Jegede, 2016). Concurring, Mavuru (2022) points out that, by basing their teaching on the local cultural background, teachers have the opportunity to use learners' practices, beliefs and knowledge in the science classroom to explain and deepen learners' understanding and application of science concepts.

The South African Curriculum and Assessment Policy Statement (CAPS) document urges teachers to integrate IK in their lessons. This should be done to expose learners to different IK from various cultures, as well as various worldviews and belief systems. The Grade 10–12 physical sciences CAPS document highlights the importance of valuing Indigenous Knowledge Systems (IKSs), acknowledging the rich history and heritage of South Africa as important contributors to nurturing the values contained in the Constitution (Department of Basic Education [DBE], 2011). Based on this aim, it appears that the curriculum anticipates learners to comprehend the significance of science in their daily lives by integrating sciences with IK (Gwekwerere, 2016).

However, the absence of guidance on how to integrate IK may hinder implementation and potentially undermine the curriculum's goals. This is the gap that this study sought to close, since some of the science concepts taught in school are unfamiliar and difficult to apply in everyday situations (Gwekwerere, 2016). As a result, there is a conflict between the science learnt in the classroom and the learners' existing knowledge (Kibirige & Van Rooyen, 2006; Le Grange, 2007). Le Grange (2007) refers to this phenomenon as cognitive dissonance. This cognitive dissonance arises from differences between students' cultural worldviews and the mechanistic perspective of science (Adams, 2013). Constructivist approaches to science education emphasise that knowledge is actively built by learners through both individual and social processes, rather than simply transmitted (Driver et al., 1994). To address these conflicts, theories such as collateral learning and the contiguity hypothesis have been proposed to explain how students reconcile disparate worldviews (Adams, 2013; Jegede & Aikenhead, 1999). Effective science teaching requires teachers to act as cultural brokers, helping students navigate between their everyday experiences and scientific concepts (Jegede & Aikenhead, 1999). This approach aims to achieve a culturally sensitive curriculum and assessment while promoting scientific literacy and personalised learning experiences (Hodson, 1998).

For instance, the CAPS document requires learners to learn the definitions of gravitational potential energy and kinetic energy in addition to how to perform calculations to distinguish between the two concepts (Department of Basic Education [DBE], 2011). This study contends that these concepts can be explained in the context of rural learners by using the example of planting a maize seed, demonstrating the energy transformations that take place from the point the seed is dropped from a certain height until it hits the ground. This study rests on the idea that IK, which is part of the sociocultural background of learners, has the potential to foster an interest in learning and make science relevant (Gwekwerere, 2016; Mavuru & Ramnarain, 2020).

1.3 Situating Myself in the Study

My name is Makgwedi Calendula Malemela-Magagane. I grew up at Ga-Malahlela village being raised by my grandparents who are part of this study as Indigenous Knowledge Custodians. When I was growing up, my grandparents and the community as large, planted maize seeds annually, which they still do to this day. They often encouraged me to join in their practice so that they can teach me how maize seeds a planted traditionally, but I was more interested with playing my friends. I didn’t see the value in learning how maize seeds are planted traditionally as I saw that as an old people activity since I was young.

However, my grandparents were persistent, and they made it a point to invite all their children, grandchildren, great-grandchildren and close family friends to come and take part in ploughing the maize fields with them. I believe this is their way of spending time with us, and us spending time with each other, because we live far away from each other now as adults. After ploughing the maize fields, we often felt very tired and lacking in energy. Little did I know that we were converting the chemical energy in our muscles to the mechanical energy of movement as we were walking through the fields; the energy in our bodies was not created or destroyed but converted. I learnt about this at secondary school but could not relate the concepts to everyday life then, as recommended by the CAPS document. Moreover, as we were dropping or releasing the seeds from our hands, energy was being converted. This is the knowledge that I grew up knowing, but in secondary school, I could not fully make sense of how energy is converted in real-life situations; I had to memorise the concepts so that I would pass my grades. As I physical Sciences teacher now, I always try to integrate IK in my lessons in trying to relate scientific concepts that I am teaching in class with the knowledge that the learners have gained from home and community. I believe that this relation may help the learners to embody the scientific concepts better.

In addition, my grandparents would tell us stories during the ploughing and planting process and explain how and why we were planting the maize seeds the way we were doing it. They would also encourage us to take care of our environment. By doing this, my grandparents were and still are passing their knowledge on to us as the next generation.

1.4 My Positionality and Reflexivity in the Study

Holmes (2020) describes positionality as the researcher's worldview and the position they adopt about the research task at hand. I conducted the study in my classroom as a Grade 10 Physical Sciences teacher who has taught the subject for five years and as a researcher. I was aware that power dynamics might arise during the study because of my position as my learners' classroom teacher, and that learners might regard me as more knowledgeable (Vygotsky, 1978). However, coming from a different part of the Limpopo Province from that of my participants made me less knowledgeable about their Indigenous practices, particularly their traditional way of ploughing maize seeds. Therefore, I was mindful of not imposing my dialect on my participants. Instead, I positioned myself as a co-learner where we were all learning from each other's dialects. This created an environment of mutual benefit in which we showed respect for each other's culture, as emphasised by the Ubuntu perspective (Mdleleni & Ngcoza, 2025; Seehaer, 2023). Holmes (2020) posits that researchers need to acknowledge personal positions that have the potential to influence the study. Therefore, I made it clear to my participants that the intention of this interventionist study was to obtain an in-depth understanding of how best to integrate IK into my science lessons through using Indigenous practices in their surroundings.

My personal experience growing up participating in maize planting, although from a different region within the province, provided a foundation for understanding the process. However, my familiarity with maize cultivation also required me to be reflexive, carefully considering how my existing knowledge and assumptions might influence my interpretations of the learners' experiences. Throughout the study, I consciously reflected on my positionality and potential biases to ensure trustworthiness and maintain an open and receptive approach to learning from the learners' perspectives.

1.5 Statement of the Problem

According to the CAPS document, learners should apply the knowledge and skills they learn in class meaningfully in their daily lives (DBE, 2011). This calls for teachers to bridge the gap between science content learnt in the school classroom and the science accessible to learners in their homes and community environment (Mavuru & Ramnarain, 2020). This provision is intended to make science accessible to all learners regardless of their sociocultural backgrounds and, hence, advocates the integration of IK when teaching science (DBE, 2011). The South African education system faces significant challenges in effectively teaching science, particularly for learners from socio-economically disadvantaged backgrounds. Many of these learners struggle to grasp complex scientific concepts because of a disconnect between what they learn in school and their everyday experiences.

However, the absence of clear guidelines on how to integrate IK hinders its implementation and often results in students feeling alienated from the curriculum. Moreover, as a physical sciences teacher, I have observed that current secondary school pedagogical approaches and methods in physical sciences education do not adequately integrate IK, particularly in the context of teaching physics concepts like the conservation of mechanical energy in Grade 10. This gap in the curriculum likely disadvantages most learners in South Africa, whose experiential knowledge is deeply rooted in traditional practices, such as in the context of this study, ploughing maize seeds.

As observed by Aronson and Laughter (2016) and Rahmawati et al. (2023), learners' engagement and academic success are inextricably linked to the cultural relevance of education. Simialrly , Nikodemus (2017) emphasises that sense making is when meaning materialises, which is a crucial part of language, learner argumentation and communication.

As it currently stands, the CAPS curriculum often relies on Western scientific perspectives, neglecting the rich local knowledge that could enhance understanding and engagement. Learners encounter cognitive dissonance when they find that the science concepts taught in the classroom do not resonate with their home experiences or cultural practices (Kibirige & Van Rooyen, 2006; Le Grange, 2007). This situation is particularly evident in the context of teaching mechanical energy, where traditional practices, such as planting maize seeds, are relevant yet overlooked.

The assumption in this study is that without integrating IK into lessons, students struggle to see the relevance of science to their own lives. I observed that this discourages interest in the subject and negatively impacts their academic performance. Furthermore, many teachers are not trained in how to effectively bring IK into their teaching, leaving them solely reliant on the prescribed syllabus and textbooks without acknowledging the valuable contributions of local knowledge.

Against this backdrop, this study sought to address the gap in curricular relevance by exploring how the integration of IK, specifically traditional maize seed planting techniques, can or cannot mediate and enhance the learning of scientific principles in Grade 10, thereby contributing to a more effective, culturally responsive pedagogical approach and a deeper appreciation for both science and Indigenous practices.

1.6 Purpose and Significance of the Study

The purpose of this interventionist study was to use the traditional way of planting maize seeds to support a Grade 10 Physical Sciences class in a rural school to make sense of the conservation of mechanical energy. My personal experience of education was not in any way related to my home experience, despite all the IK I brought along to school. My teachers never linked my prior everyday knowledge (Kuhlane, 2011) to what was taught at school. However, I cannot blame them, because that is how they were taught. This is still the case in schools; hence, this research study.

It should be noted that, in my own experience of teaching science in a rural secondary school, I had also not acknowledged my learners' everyday home experiences as their prior knowledge. Instead, I had only taught what was prescribed in the syllabus and the textbooks. I could not see anything wrong with my teaching because I was never trained in how to integrate learners' home experiences. After enrolling for my Bachelor of Education Honours Degree at Rhodes University, I realised that integrating IK into science teaching could potentially make science relevant and meaningful to my learners.

Essentially, this study sought to make science accessible, clearer and more relevant to learners by integrating learners' existing knowledge into science learning. It was hoped that this might help learners cross the huge river that seems to stand in their way of moving from everyday life experience to school science (Godlo, 2024). This might, in turn, help them develop an interest in science and value and appreciate their IK.

Furthermore, the study might make science relevant and accessible to learners by using easily accessible cultural resources (Asheela et al., 2021; Shinana et al., 2021). Developing and using the exemplary lesson that integrates learners' IK in mediating learning about the conservation of energy might help improve my own teaching practice. In addition, the findings of the study might make other teachers appreciate the importance of involving Indigenous Knowledge Custodians (IKCs) in imparting their cultural knowledge, wisdom and skills, which could then be integrated into science lessons (Klein, 2011; Kudumo & Ngcoza, 2023; Lavallee, 2009; Mateus & Ngcoza, 2019). IKCs are the custodians, repositories and holders of cultural heritage which has been passed on from generation to generation. Involving them could contribute to an enriched mediation of learning.

1.7 Research Goal, Objectives, and Research Questions

The main goal of this interventionist study was to mediate Grade 10 learners' understanding of the conservation of mechanical energy using the traditional method of ploughing maize seeds.

To achieve this goal, the following research questions were addressed.

1. What enables and/or constrains Grade 10 rural school learners to argue and make sense of the different types of energies and their transfer before the intervention?
2. What do Grade 10 rural school learners know from their homes and community about the conservation of mechanical energy?
3. How do the presentations on traditional ploughing of maize seeds by the IKCs and consolidation thereof enable and/or constrain Grade 10 rural school learners to argue and make sense of energy conservation?
4. How do exemplar lessons that integrate the traditional ploughing of maize seeds enable and/or constrain Grade 10 Physical Sciences learners from a rural school to argue and make sense of the conservation of energy?

1.8 Theoretical Framework

A theoretical framework is used to frame an investigation broadly and offers a potential explanation for why things occur (Bertram & Christiansen, 2020). I selected Vygotsky's (1978) sociocultural theory (SCT) as the theoretical framework informing this study. The SCT, as a theoretical lens, emphasises the role of social, cultural and biological factors in cognitive development (Rahmatirad, 2020). The theory is underpinned by the concepts of culture and social interaction, mediation of learning, the use of tools to enhance learning and the zone of proximal development (ZPD). Vygotsky's (1978) theory strongly believes that social interactions underpin cognitive development, making it a strong theoretical foundation for this study.

1.9 Key Concepts

In this section, I discuss the key concepts used in the thesis.

Argumentation

Argumentation involves discussions where learners generate arguments through justifying several claims, explanations, and viewpoints. It promotes learners' critical thinking and understanding of science concepts through elaborating and exchanging each other's opinions (Sengul, 2020).

Attitudes

In this study, learners' attitudes refer to their feelings of pleasure or active interest in science learning and out-of-school learning (Agunbiade et al., 2017).

Cultural knowledge brokers

In this study, this refers to people who facilitate learners' movement from home or community culture to school culture (Wyatt et al., 2017).

Double stimulation

This is a Vygotskian perspective, which is described as a method of studying mental functions with the help of two stimuli (Engeström et al., 2020; Morselli, 2019; Sannino, 2015).

Indigenous knowledge

An existing body of knowledge commonly known within a community that covers technologies and practices that have been developed and are still used by local people (DBE, 2011).

Learner talk

Learner talk in education refers to students' verbal contributions in classroom interactions. It encompasses various forms, including responses to teacher questions and student-initiated discourse (Garton, 2012; Nurhasanah, 2013).

Out-of-school learning

Learning that takes place in the environment outside the school building but during school hours and within the scope of the curriculum (Kozaner, 2021)

Sense making

Odden et al. (2018) define sense making as a process of building an explanation to resolve an observed conflict of knowledge.

Social interactions

To Vygotsky (1978), social interactions refer to the way people act and relate with each other, and he believes that this is where learning and development occur.

Ubuntu

Ubuntu is a human quality that encompasses sharing, caring, respect and compassion, ensuring a happy and communal life in the spirit of family (Chilisa, 2012; Ogunniyi, 2021; Seehawer, 2023).

1.10 Thesis Outline

This study was conducted at Dimpe Secondary School (pseudonym) in the Waterberg District in the Limpopo Province. It consists of the following seven chapters:

Chapter One

This chapter outlines the background of the study and provides a description of my life experiences to situate the study. The problem statement is explained, and the purpose and significance of the study are also provided. This includes, among other aims, to develop better teachers who acknowledge the sociocultural background of learners by using easily accessible resources from the community to help them make sense of science concepts that may otherwise seem abstract. The research goal and research questions that guided the research study were also presented. The theoretical framework that informs the study is briefly discussed and key concepts are defined. The chapter concludes with an outline of the thesis chapters and a conclusion.

Chapter Two

In this chapter, I discuss literature related to the study. Firstly, I give a brief overview of the conservation of mechanical energy. Next, I discuss learners' prior knowledge in science classrooms, the nature of science and the nature of IK. Lastly, hands-on practical activities and visualisation in science teaching and learning is explored.

Chapter Three

In this chapter, I discuss Vygotsky's SCT, the theoretical framework informing this study. I provide details on the various components of the SCT that will be used as a framework to analyse the data from the study's focus group interviews.

Chapter Four

In this chapter, I discuss the research methodology used in conducting this study. I also outline the study's research goal and research questions. I assess the paradigms that informed the study and the qualitative research design used. Two research paradigms complemented each other in the study, namely the interpretive paradigm and the Indigenous research paradigm, focusing on an Ubuntu perspective. The research site, sampling and participants, researcher positionality, reflexivity, data gathering tools and the research process are discussed. Lastly, I review the study's data analysis, validation, trustworthiness and ethical considerations.

Chapter Five

In this chapter, I present, analyse and discuss data from learners' group activities and the four IKCs' presentations. The chapter aims to answer the first and second research questions of the study. The chapter also reviews how I used my observations during participatory observation to check whether learners' sense making of the conservation of mechanical energy shifted or not as they interacted with the IKCs.

Chapter Six

In this chapter I analyse, present and discuss the data generated from the lesson observation, sharing circle interviews and learners' journal reflections. The chapter discusses how this data was used to answer research question three.

Chapter Seven

Here, I present a summary of my findings and provide some recommendations. I also suggest areas for future research, the limitations of my study and my personal reflections. The chapter closes with an overall conclusion to the study.

1.11 Chapter Summary

The chapter started by outlining the background of the study and my personal experiences. The problem statement and significance of the study were also provided. Then, the research goal and research questions that guided the study were outlined. Finally, the theoretical framework that framed this study was briefly discussed.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

According to Creswell and Creswell (2018), a literature review shares with the reader the results of other studies that are closely related to the one being researched. Essentially, every piece of research relates to the larger ongoing dialogue in literature by filling the gaps and extending research that has been previously done (Bertram & Christiansen, 2020; Creswell & Creswell, 2018).

Literature is a foundational element of academic research, encompassing a broad body of written works that discuss and analyse various topics (Bertram & Christiansen, 2020). In this thesis, the literature includes a range of sources, such as books, academic journals, conference papers, theses and reports. Engaging with literature is essential, as it allows researchers to understand the context and background of their study areas, offering insights into previous research and established theories (Creswell & Creswell, 2018). This understanding helps inform research design and methodology by recognising successful approaches and potential pitfalls observed in earlier work. Moreover, a thorough literature review highlights unresolved questions and underexplored areas, thereby justifying the necessity of the current study (Bertram & Christiansen, 2020).

Conducting a literature review involves several key steps, including defining research questions, identifying keywords and searching for relevant literature in academic databases and libraries. Evaluating the credibility and relevance of each source, synthesising findings, and organising the literature in a coherent manner are also critical (Fink, 2014). This systematic process allows researchers to build a solid foundation for their studies and provide evidence to support their arguments. Therefore, this chapter aims to provide a comprehensive overview of both the theoretical and empirical foundations relevant to the integration of IK in science education, specifically focusing on the conservation of mechanical energy.

In this chapter, I thus discuss literature related to this study. Firstly, I will give a brief overview of the conservation of mechanical energy. Secondly, I will discuss learners' prior knowledge in science classrooms, the nature of science and the nature of IK and the relationship between the science and IK. Lastly, hands-on practical activities and visualisation in science teaching and learning will be discussed.

2.2 Conservation of Mechanical Energy

The CAPS document defines mechanical energy as the sum of gravitational potential and kinetic energy (Department of Basic Education [DBE], 2011). The conservation of mechanical energy states that energy cannot be created or destroyed but is transformed from one form to another. In addition, the conservation of mechanical energy is a fundamental concept in physics, with applications in various real-world scenarios. Understanding the conservation of mechanical energy, therefore, is crucial in daily life owing to its practical applications. The challenge lies in the difficulties learners face in grasping the concept.

Kassiavera (2020) and Gülçiçek (2004) highlight learners' difficulties in mastering this concept, emphasising the need for improved conceptual understanding. Bryan (2004) underscores the importance of technologies, such as video analysis, in investigating real-world problems related to mechanical energy conservation. Halilović (2021) further supports this, suggesting that a system-based approach to teaching can significantly enhance learners' understanding of this concept, particularly in Grade 10 Physical Sciences. These studies collectively underscore the importance of understanding the conservation of mechanical energy in daily life, highlighting both its practical applications and the pedagogical challenges that need to be addressed.

Notwithstanding, in South Africa, Grade 10 Physical Sciences textbooks generally seem to use Eurocentric examples, such as a person dropping an object from the edge of a hot air balloon (see Figure 2.1).

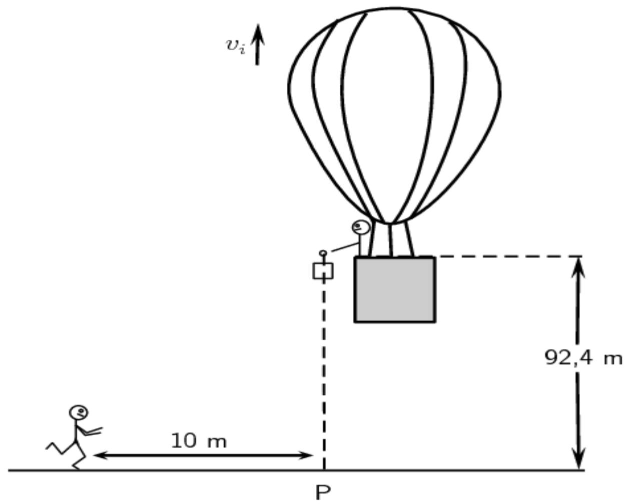


Figure 2.1: A man dropping an object from the edge of a hot air balloon 92.4m above the ground (adopted from: https://www.siyavula.com/read/za/physical-sciences/Grade-10/vertical-projectile-motion-in-one-dimension/03-vertical-projectile-motion-in-one-dimension-02)

Yet, most rural learners are unfamiliar with what a hot air balloon is and have most likely never seen one, which was my experience as a learner. This taught me that failure to relate scientific concepts to familiar examples when teaching might make it challenging for learners to understand those scientific concepts. However, using examples that are relatable and familiar, such as maize seed dropping (see Figure 2.2 below), could potentially reduce cognitive overload and overcome cognitive dissonance (Le Grange, 2007).

Figure 2.2: Practical demonstration of using a hoe to plant maize seeds in a field

In this regard, Druker-Ibáñez (2022) highlights the importance of epistemological justice in education, suggesting that integrating IK can potentially enhance learners' identity and ultimately learning outcomes. Furthermore, the conservation of mechanical energy taught in Grade 10 is a prerequisite for the topic of work, energy and power in Grade 12 (Mapfumo, 2016; 2024). This means that it is vital for learners to fully understand the topic in Grade 10, as it serves as prior knowledge for later use in Grade 12, as reiterated by Mavhunga and Rollnick (2013).

2.3 Learners' Prior Knowledge

Prior knowledge is the knowledge that learners have before learning new knowledge, and it can either help or hinder learning (Panggabean, 2020). According to Kramer et al. (2021), prior knowledge is the knowledge that learners have at the beginning of the learning process, and it is also embedded in their long-term memory. Constructivism, a key learning theory in education, emphasises learners' active participation in constructing their knowledge, with prior knowledge as the foundation for new learning (Chand, 2023). Prior knowledge could be in the form of learners' IK brought to school from home or the community. It could also refer to knowledge learnt in earlier grades.

According to Roschelle (1995), prior knowledge is not always practical because it can create some misconceptions. Taylor (1999), who expressed a similar viewpoint, emphasises that not all prior information is illuminating because it sometimes contains misconceptions (Mavhunga & Rollnick, 2013). In agreement with Taylor (1999), Hodson (2009) issues a warning against classifying anything in the curriculum as science. Nonetheless, it is understood that prior knowledge might take the form of IK, which I will cover below.

2.4 The Nature of Indigenous Knowledge and the Nature of Science

IK is knowledge that is unique to people living in the same place (Jones & Hunter, 2003; Kibirige & Van Rooyen, 2006). The IK in one area may differ from the IK in another area and from one clan and/or cultural belief to the next. According to Hatcher et al. (2009, p. 148), the "unification of physical and spiritual knowledge" gives IK its holistic nature. Mavuru (2022) also points out that, based on people's sociocultural backgrounds, teachers' practices and beliefs can be used to explain and deepen learners' understanding and applications of science concepts. IK is developed, changed and restructured with time and economic and technological changes.

Aikenhead and Jegede (1999) and Ogunniyi and Ogawa (2008) argue that the integration of IK into the school curriculum, particularly in science classrooms, could be advantageous in many ways. According to Aikenhead and Jegede (1999), for instance, IK can enable border crossing between home and school. Govender (2016) likewise states that integrating IK into scientific classrooms can stimulate learners to learn science.

Despite the benefits of IK integration, which some researchers promote, significant drawbacks have been reported. For example, Cobern and Loving (2001) believe that IK should not be viewed as a solution in science education because it may bring problems when integrated into science lessons. Le Grange (2007) speculates that learning while integrating IK may result in a conflict between scientific and everyday language. In contrast, Ogunniyi (2007) believes that these two systems should be merged, and that there is potential for dialogue between them (Seehawer & Breidlid, 2021). Scholars such as Ogunniyi (2007a), Keane et al. (2016), Afonso-Nhalevilo (2013), Mukwambo et al. (2014) and Mhakure and Otuluja (2017) caution against romanticising IK as the only way of teaching science. These scholars also propose that any misconceptions about IK be 'cleared out' before introducing new scientific knowledge. In this regard, it may be the knowledge about the nature of science.

Abd-El-Khalick et al. (1992) explain the nature of science as the theory of knowledge of science. In this regard, Taylor and Cameron (2016) argue that the inclusive perspective defines science as the "knowledge and understanding of nature" (p. 36), which opens the argument that there cannot be a single way to do or think about science. Indeed, science is broad and cannot be contained in a box. Ogunniyi (2017) similarly argues that the nature of science's focus is on the epistemology of science – that is, science as a way of knowing. Essentially, the term 'science' comes from the Latin word *scientia* (knowledge), and all types of knowledge can be termed science (Snively & Corsiglia, 2001). The nature of science must be understood since it is the central component of scientific literacy (American Association for the Advancement of Science, 1990, 1993; Klopfer, 1969; National Science Teachers Association, 1982).In South Africa, the science taught in schools seems to be mostly Eurocentric in nature. According to Mukwambo (2013), Eurocentric science is a body of knowledge based on a logical perspective of reality authorised by the British Association for the Advancement of Sciences. According to one scientific perspective, IKS and science are two different domains of knowledge that should be left separate (Cobern & Loving, 2000). Then there is the intersecting perspective between science and IK, in which both science and IKSs contribute to understanding the ‘know-how’ and ‘know-why’. South Africa’s DBE appears to promote the intersection perspective in science classrooms.

The relationship between the nature of science and the nature of IK is complex and multifaceted. Bala (2007) argues that recognising the legitimacy of IK requires a rethinking of the relationship between science and other knowledge systems. Aikenhead (2011) further explores the similarities and differences between these two knowledge systems, emphasising the need for cultural bridges in science education. Ogunniyi (2000) provides evidence of the co-existence of Indigenous and scientific knowledge in the classroom, highlighting the challenge of ‘border crossing’ between the two (Aikenhead & Jegede, 1999). Wilujeng and Prasetyo (2018) propose a framework for integrating IK into the science curriculum, emphasising the potential for meaningful learning and cultural sustainability. It seems that these studies collectively underscore the importance of acknowledging and integrating IK in science education.

2.5 Hands-on Practical Activities and Visualisation

Active participation in learning activities is required for effective learning, as it develops links to real-life experiences through hands-on practical learning (Kozaner, 2021). Mavuru and Dudu (2021) define practical work as any teaching and learning activity in which learners observe and manipulate real objects. Asheela et al. (2021) agree that for learners to apply science to real-life situations at home, they must be exposed to purposeful hands-on and minds-on practical activities. Hands-on practical activities can effectively prevent cognitive overload (Harrelson & Leaver-Dunn, 2003; Sewell et al., 2020) in learning by reducing extraneous cognitive load and enhancing engagement (Le Grange, 2007). However, these scholars caution that hands-on practical activities are typically recipe-based. As a result, they recommend that when engaging in these activities, the emphasis should be on sense making and conceptual understanding (Asheela et al., 2021; Shinana et al., 2021).

Conceptual understanding encourages learners to predict, observe, explore and explain scientific concepts (Asheela et al., 2021). It allows them to make meaningful connections between topics and allows teachers and learners to make predictions before completing the activity (Asheela et al., 2021; Shinana et al., 2021). This approach is pertinent to this study because I believe that learners should be able to explore their existing local knowledge to strengthen their conceptual understanding, relate it to science, and construct new knowledge. Furthermore, research conducted in various parts of the world has shown that involving learners in hands-on, minds-on activities motivates learners (Kuhlane, 2011; Suarez et al., 2018), improves performance (Kuhlane, 2011) and makes learners more active and engaged in the science lessons (Correia & Harrison, 2020).

Furthermore, it should be recognised that hands-on practical activities are a form of visual representation. According to Bobek and Tvesky (2016), visual representation improves learners' understanding by illustrating and explaining concepts. However, Evagora et al. (2015) caution that when employing visual representations, the emphasis should be on conceptual understanding and knowledge production. Considering the aforementioned, I ensured that the IKCs' presentations included visual presentations to support learners in learning the concept of energy conservation while also allowing them to acquire new knowledge.

In search of ways to make learning effective and permanent, the IKCs' presentations took place in an out-of-school context (Godlo, 2024; Mayana, 2024; Nyamakuti, 2020). That is, learners were taken to a field outside the school environment to learn about the traditional methods of ploughing maize seeds. It was hoped that observing the traditional ways of ploughing maize seeds in this out-of-school context would enable the learners to argue and make sense of the conservation of mechanical energy.

2.6 Learner argumentation and sense making

Argumentation is a crucial aspect of science education, engaging learners in constructing and justifying knowledge claims (Berland & McNeill, 2010). Research suggests that learners' ability to argue effectively is closely linked to their prior knowledge and understanding of the subject matter (Aufschnaiter et al., 2008). A learning progression for argumentation encompasses instructional context, argumentative product and process, with simplified contexts potentially facilitating more complex engagement (Berland & McNeill, 2010). Teacher training in argumentation strategies can lead to improved classroom implementation, including group discussions and presentations (Erduran et al., 2006). Cognitive analysis reveals that argumentation competencies develop with age, with differences observed between elementary and secondary students (Garcia-Mila & Andersen, 2007). To support argumentation in science classrooms, educators should consider learners' content-specific experiences and knowledge before engaging them in argumentative tasks (Aufschnaiter et al., 2008). Overall, argumentation plays a vital role in scientific inquiry and knowledge acquisition across various learning contexts.

In the context of this study, through focus group interviews (sharing circles), learners were encouraged to communicate and argue about whether the integration of IK into science would help them make sense of the scientific concepts. Moreover, during the group activities and while making posters, learners engaged in arguments based on the guiding questions in the group activity, debating how best to represent them on their posters. During the arguments, the learners made claims and corrected and applauded each other for what they thought was correct or not. This type of interaction helps and encourages learners to make sense of the content that they are learning.

Sense making in science education involves engaging learners in constructing knowledge through active participation and critical thinking. Research suggests that professional development for teachers should focus on viewing science as a socially constituted sense-making practice, enabling informed decision making in teaching (Rosebery & Puttick, 1998). Novice teachers can create opportunities for equitable sense making by making space in classroom discussions, though they may need support in recognising and responding to these moments (Haverly et al., 2018). Effective sense making approaches employ instructional patterns that incorporate varied opportunities for student talk, investigation and reasoning (Avraamidou, 2019). These studies highlight the importance of sense making in fostering scientific understanding and promoting equitable participation in science education.

Vygotsky (1978) argues that language is the most important tool for creating knowledge. According to Nhase (2019), teaching science in the learners' native language empowers them since they can clearly and fluently express their ideas. For example, in my study, participants would converse with community members in their home languages. According to Mavuru and Ramnarain (2019), language enables learners to construct knowledge and make sense of science. According to Wieck et al. (2005), sense making of circumstances entails transforming them into a state that can be expressed explicitly in words and serve as a catalyst for action. Nikodemus (2017) emphasises that sense making, which is a critical component of language, discussion and communication, occurs when meaning materialises. In my study, I observed the learners' interactions to make sense of what they discovered from the IKCs. I also observed how the learners conceptualised the conservation of mechanical energy during the knowledgeable IKCs' presentations.

2.7 Chapter Summary

In this chapter, I discussed the literature relevant to the conservation of mechanical energy, emphasising both theoretical frameworks and practical applications within science education. The conservation of mechanical energy is a fundamental concept in physics that is often challenging for learners to grasp, particularly in rural contexts where access to resources and alternative pedagogical strategies may be limited. I reviewed the importance of learners' prior knowledge, highlighting how students' understanding of mechanical energy is frequently shaped by their experiences and backgrounds. This aspect is crucial, as it forms the basis for new learning and can either facilitate or obstruct the integration of scientific concepts in the classroom. Understanding students' existing knowledge enables educators to tailor their teaching methods to bridge any gaps.

The chapter also reviewed the nature of science and IK, positing that there is a vital interplay between them. It is essential for educators to recognise and value IKS, as they offer alternative perspectives and methodologies that can enrich the science curriculum. By integrating IK into lessons, teachers can foster a more inclusive educational environment that respects and acknowledges the cultural backgrounds of all students. Furthermore, I reviewed the benefits of hands-on practical activities and visualisation in science teaching. Engaging learners with interactive and experiential learning opportunities helps solidify abstract concepts and makes scientific learning more relevant and relatable. This approach is particularly beneficial in a rural

South African context, where students may have limited exposure to formal scientific environments and laboratory settings.

The chapter reinforced the idea that integrating IK into the teaching of mechanical energy conservation can create more meaningful learning experiences. It underscored the necessity of recognising and building on learners' existing knowledge, using culturally relevant pedagogical strategies that enhance engagement and comprehension.

CHAPTER THREE: THEORETICAL FRAMEWORKS

3.1 Introduction

A theoretical framework is used to frame the investigation broadly and offers a potential explanation for why things occur (Bertram & Christiansen, 2020). A well-developed theoretical framework ensures that the research is grounded in established theory and empirical facts, rather than personal instincts (Simon & Goes, 2012). It also helps limit the scope of the study by focusing on key variables and can be used to interpret new research data or respond to new problems (Yasmin & Islam, 2021). A theoretical framework is a structured plan that provides a foundation for research studies. It outlines the main ideas and concepts that guide the research, making it easier to understand and analyse the findings (Simon & Goes, 2012). In simple terms, it can be thought of as a lens through which a research question is viewed (Yasmin & Islam, 2021).

The purpose of a theoretical framework is to clarify the relationships between different variables in the study. It helps researchers connect their work to existing theories and knowledge, showing how their research fits into the wider academic context (Bertram & Christiansen, 2020). By using established theories, researchers can build on previous work, avoid reinventing the wheel and ensure their study is credible and relevant (Simon & Goes, 2012). In this study, a theoretical framework was crucial because it allowed me to explore the integration of IK into science education, particularly focusing on mechanical energy conservation. The study used Vygotsky's SCT to better understand how social interactions and cultural contexts influence students' learning experiences (Alkhudiry, 2022). This theoretical lens emphasises that learning is not just an individual process but is deeply rooted in social and cultural relationships (Pathan et al., 2018).

Moreover, the theoretical framework in this study helped to identify the key factors that affect how students learn about mechanical energy conservation when incorporating IK. It guided the development of the research questions and the interpretation of findings. It also provided a basis for discussing the significance of the study and how it contributes to the field of science education.

In this chapter, I discuss Vygotsky's SCT, the theoretical framework informing this study.

3.2 Vygotsky's Sociocultural Theory

Vygotsky's (1978) SCT emphasises the importance of social interaction in learning, particularly in second language acquisition (Pathan et al., 2018). The theory posits that cognitive development occurs through meaningful human interactions and engagement with cultural artefacts (Alkhudiry, 2022). The key concepts of SCT include cultural and social interaction, mediation of learning, the use of tools to enhance learning and the ZPD. SCT suggests that education should focus on making learning experiences relevant and meaningful to learners (Pathan et al., 2018). In language learning, SCT promotes collaborative activities, such as practical demonstrations in the case of this study, and interactions with sociocultural norms to enhance second language development (Alkhudiry, 2022). The theory also highlights the role of teachers' perceptions and expectations in fostering or discouraging learner interaction (Allahyar & Nazari, 2012). Implementing SCT in education can lead to more contextualised and significant learning experiences, potentially developing critical and creative individuals (Salas & Lupita, 2011).

The SCT views learning as a socially mediated process in which learners construct their own understanding of a phenomenon through interaction with their peers and the teacher. Vygotsky (1978, p. 163) reasoned that "any higher mental function first appears between people as an inter-psychological category before it is appropriated and internalized by the individual learners as an intra-psychological category". In other words, although, at first, knowledge is co-constructed through interaction with peers and the teacher, each individual learner builds their understanding as they internalise the learning process. In Hawkins' (2008) view, internalisation refers to the mechanism by which knowledge built during the social interpersonal interactions is appropriated and incorporated into the individual learner's understanding.

The role of the teacher is to give instructional support to the learner to stretch their understanding from what they already know to what they can potentially know or do with assistance. Vygotsky (1978) referred to this continuum – between what the learner already knows and can do independently and what they can potentially learn or accomplish with guidance – as the ZPD. Ismail et al. (2017) illustrated the ZPD diagrammatically as shown below:

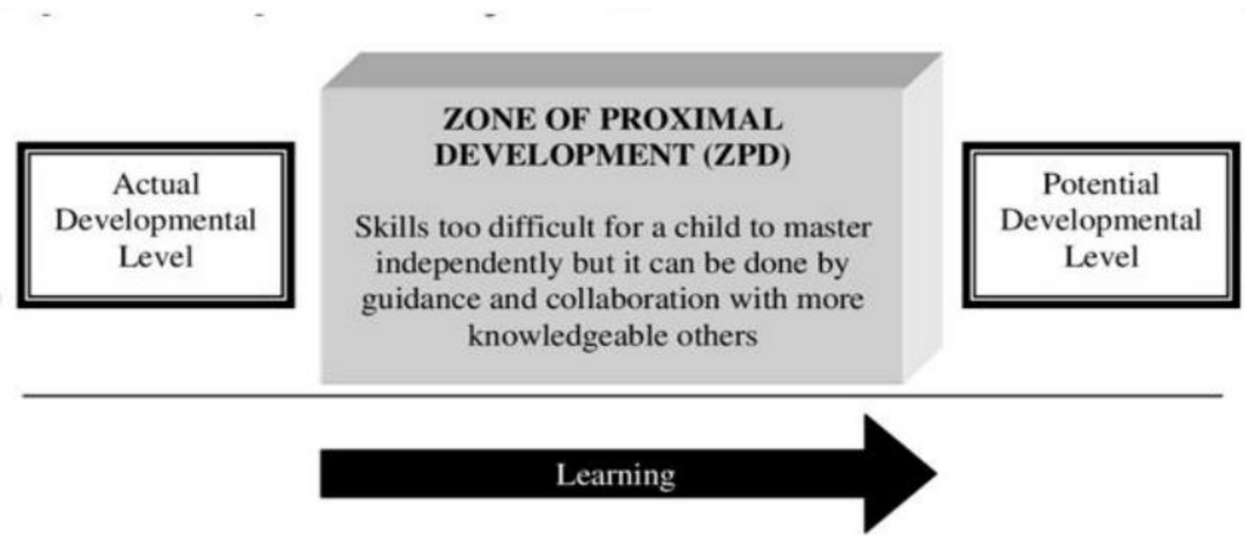


Figure 3.1: Illustration of the ZPD (Adopted from Ismail et al., 2017, p. 155)

Thus, the ZPD is a crucial concept in learning, representing the gap between what a learner can do independently and what they can achieve with guidance (Morgan & Skaggs, 2016). Learners develop their ZPD through scaffolding, a process of providing temporary support that is gradually reduced as the learner gains competence (Tinungki, 2019). Key factors in developing one's ZPD include assistance, mediation, cooperation, imitation, target-setting and facing challenges (Silalahi, 2019). In clinical education, preceptors use strategies such as differentiated instruction, instructional scaffolding and creating a positive learning environment to guide students through their ZPD (Kantar et al., 2020). By engaging in collaborative projects, connecting with mentors, and tackling rigorous tasks with minimal scaffolding, learners can expand their ZPD and achieve greater learning gains (Morgan & Skaggs, 2016). This approach is particularly effective in complex fields like nursing and statistics, where expert guidance is essential for optimal learning outcomes (Kantar et al., 2020; Tinungki, 2019).

The SCT, while influential in understanding human cognitive development and language acquisition, has faced several criticisms. Ameri (2020) and Rahmatirad (2020) highlight the theory's strengths but also note its limitations in explaining individual differences and cognitive processes. Critics argue that the theory may oversimplify the complex nature of learning and development by focusing primarily on social interactions (Ameri, 2020). However, in this study, the following elements from SCT will be adopted:

3.2.1 Mediation of learning

Vygotsky (1978) posits that human activities occur in cultural contexts, mediated by language and other symbol systems to achieve the goal of learning. He argued that learning is a social process that gets individualised through language contact between the child and more experienced members of society, such as parents, teachers and peers (Stott, 2016). Kakambi (2020) concurs, stating that the process of mediating learning involves interactions between the teacher, subject content and the learner to facilitate knowledge construction. This study focuses on how learners' everyday knowledge can be used to explain Grade 10 Physical Sciences concepts related to the topic of conservation of mechanical energy. According to Vygotsky (1978), language and culture play a central part in learning; he argued that children's development is driven by social interaction rather than predetermined stages.

3.2.2 Culture and language

Culture is a social environment and a system of social standards (Vygotsky, 1986). Language helps to internalise culture and change the way we think. Vygotsky (1978) argues that language is fundamental in educational research and building relationships. Language is the tool that mediates cultural learning through storytelling; it allows individuals to voice their thoughts. Chilisa (2012) suggests that culture is not only a way of life for people but also a way in which we make meaning of the environment around us and initiate change. In this study, I look at how learners integrate IK when learning science and how IK is influenced by culture. Language and culture are still important for an individual's cognitive and mental development. In a cultural context, the child learns from adults and peers, gradually developing the ability to do things on their own, without adult supervision. Against this backdrop, in the study, learners observed IKCs as they demonstrated the traditional way of ploughing maize seeds using their native language, Sepedi.

During social interactions, the IKCs shared their wisdom and materials from their culture. In addition, the IKCs presented a practical demonstration using Sepedi, the native language of both the IKCs and the learners.

3.2.3 Social interactions

To Vygotsky (1978), social interaction is the basis of learning and development. He argued that knowledge is constructed in dynamic interactions between people and their social environment. Shabani (2016) avers that, according to the SCT, the origin of knowledge should not be sought in the mind but constructed through social interactions. Considering the above argument, the study sought to explore how learners participated, interacted, argued and learnt during the practical demonstration of the traditional methods of planting maize seeds. The study was not only interested in what the IKCs, who are repositories of IK, bring to the interaction, but also in what learners will bring and how the interactions will shift (or not) the learners' sense making of the concept of conservation of mechanical energy. Social interactions also play a role in a learner's ZPD, which is discussed next.

3.2.4 Zone of proximal development

According to Vygotsky (1978), the ZPD is defined as the distance between a learner's actual development level, as determined through independent problem solving, and their potential level of development. The ZPD forms part of cognitive development and highlights the gap between what a child can do on their own and what they can achieve with the help of an adult, peer, technology or a more knowledgeable other until they reach their full potential. Scott (2016) concurs that Vygotsky's theory sees the ZPD as the area in which a child needs more guidance to achieve higher mental functions. For example, in the context of this study, learners engaged in activities within their ZPDs by participating in the presentation by the IKCs, who demonstrated traditional ways of planting maize seeds. The practical demonstration was used to explore learners' independent problem-solving skills.

3.3 Chapter Summary

In this chapter, I presented the theoretical framework that guides the study. A theoretical framework is a vital structure that supports and defines a research project, helping researchers explain why a study is necessary while providing a foundation for analysing and interpreting data. It clarifies key concepts, guiding research design by outlining important factors to consider, ensuring that the study remains focused and relevant. Moreover, it connects existing theories to real-world situations, illustrating how theoretical ideas can be applied to educational practices, particularly in integrating IK into teaching. For my research, I specifically used Vygotsky's SCT as a framework. This theory emphasises how social interactions and cultural contexts influence learning. This was essential for understanding how Grade 10 learners from rural backgrounds can connect their traditional knowledge to scientific concepts, especially in energy conservation. Through applying the SCT, I acknowledged learners' cultural heritage while enhancing their engagement and understanding of science, leading to a more inclusive and effective educational experience. The theoretical framework is crucial in this study, as it ensured my research was grounded in established principles, supported my investigation of integrating IK into the curriculum, and helped me draw meaningful conclusions from the data collected.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

Research methodology refers to the systematic approach that researchers employ to conduct their studies, encompassing the methods, procedures, and techniques used for gathering and analysing data (Mishra & Alok, 2022). Understanding research methodology is crucial because it ensures that a study is conducted in a structured manner, which contributes to the reliability and validity of the results (Mishra & Alok, 2022). The main goal of this interventionist study was to mediate Grade 10 learners' understanding of the conservation of mechanical energy using the traditional method of ploughing maize seeds. The research methodology helps clarify important questions, such as what the study aims to achieve, how the research will be conducted, and why this approach is suitable. The goal was to better understand the impact of integrating IK on learners' understanding and engagement in science education (Mavuru & Ramnarain, 2020).

To achieve this, a qualitative approach was employed, including methods such as interviews, lesson observations, and discussions with IKCs. These methods allowed for in-depth insights from participants and helped capture their lived experiences of IK in the classroom. This qualitative approach was particularly effective as it aligned with the study's aim to explore personal and cultural perspectives on learning (Betram & Christiansen, 2020). In addition, this methodology promoted a respectful and ethical way of working with communities, recognising the valuable knowledge that local communities possess (Chilisa, 2012). In the context of this rural South African secondary school, where learners struggle with conventional science teaching methods, engaging with IK enriches the curriculum and makes science more relatable and meaningful to them (DBE, 2011). The research methodology is integral to any study, providing a clear plan for data collection and analysis (Betram & Christiansen, 2020). In this study, the chosen methodology ensured that the integration of IK was explored effectively, leading to findings that could improve science education and better support the unique cultural backgrounds of learners.

4.2 Research Paradigms

A research paradigm is a conceptual lens through which a researcher examines the methodological aspects of their research project to determine the research methods that will be used and how the data will be analysed (Betram & Christiansen, 2020; Chilisa, 2021; Kivunja & Kuyini, 2017). These scholars further argue that a research paradigm tells us how meaning will be constructed from the data collected based on individual experiences. It is against this background that an interpretivist paradigm underpinned the study (Cohen et al., 2018; Creswell & Creswell, 2018) complemented by an Indigenous research paradigm (Chilisa, 2012). This suggests that this study was guided by the assumptions, beliefs, norms, and values of these chosen paradigms (Kivunja & Kuyini, 2017).

In the context of this study, the two research paradigms complemented each other in trying to support this investigation of how learners argue and make sense of the concept of conservation of mechanical energy during the presentation of the traditional method of maize seed dropping during the maize ploughing by the two IKCs. Based on the Indigenous belief that knowledge is relational, both the learners and I had an opportunity to interact with the IKCs to understand and interpret the science concepts that emerged as they shared their wisdom and knowledge on maize seed ploughing. I discuss these paradigms below.

4.2.1 Interpretivist paradigm

The interpretivist paradigm enables a researcher to gain a deeper understanding of the experience and perceptions of a particular social context (Alharahsheh & Pius, 2020). This paradigm was significant for this study, in that it supports the need to understand things in their real contexts. Cohen et al. (2018) assert that interpretive researchers see the world through the eyes of the participants rather than as outsiders. Concurring, Creswell and Creswell (2018) state that researchers immerse themselves in the context to try make sense of it from the participants' point of view. The emphasis in the interpretive paradigm is on understanding individuals and their interpretation of the world around them (Cohen et al., 2018; Kivunja & Kuyini, 2017). Similar views are shared by Bertram and Christiansen (2020), who argue that the purpose of the interpretive paradigm is to develop a greater understanding of how people make sense of the contexts in which they live and work. These scholars posit that data in the interpretive paradigm is generated in real situations that ultimately lead to descriptions of behaviour, perceptions, and experiences. Tracy (2013) adds that another strength of the interpretive paradigm is that the researcher works with the participants as co-researchers rather than as subjects being researched.

Considering the above, in the context of my study, learners observed IKCs dropping maize seeds, demonstrating how gravitational potential energy at a certain point at a certain height is converted to kinetic energy, how mechanical energy is conserved and other related scientific concepts in the school yard. In the process, the researchers, learners, IKCs, and my critical friend were co-researchers because we all explored how mobilising the intervention strategy of traditional maize seeds could support the learners in making sense of the conservation of mechanical energy. This was a new knowledge construction strategy for all of us, aligning with Tracy's (2013) claim that this paradigm is a way of seeing both reality and knowledge as constructed and reproduced through arguments, interactions, and practice.

However, one of the limitations of the interpretivist paradigm is that it focuses on description at the expense of explanation (Nuntsu, 2020). It is also silent on relational dynamics between the researcher and the participants, and it focuses on individuals. In trying to address this, the interpretive paradigm was complemented with the Indigenous research paradigm to enhance explanations. In the Indigenous research paradigm (Chilisa, 2012), knowledge is relational: it goes beyond individual knowledge and is shared among others. As a result, the researcher is answerable to all the participants.

4.2.2 Indigenous research paradigm

The Indigenous research paradigm entails including perspectives and methods that draw from IK, languages, metaphors, worldviews, experiences, and philosophies of the former colonised, historically oppressed, and marginalised social groups (Chilisa, 2012). Hart et al. (2010) argue that an Indigenous research paradigm is structured within an epistemology that includes a subjectivity-based process for knowledge development and a reliance on community elders and individuals as custodians of our culture. Indigenous research methodologies prioritise storytelling, relationships, and the researcher's personal experiences as integral to the research process (Keane et al., 2016).

The paradigm is built on a framework comprising ontology, epistemology, methodology, and axiology, all rooted in Indigenous perspectives (Hart et al., 2010). Researchers are increasingly recognising the need to integrate Indigenous methodologies into their work, particularly in fields like science education (Keane et al., 2016).

Based on this perspective, the paradigm was deemed relevant in the study's context in that IKCs shared their knowledge on the Indigenous method of maize seed dropping when ploughing and, in turn, helping the learners make sense of the conservation of mechanical energy. My interest in employing this paradigm as one of the paradigms underpinning my study was triggered by the fact that the Indigenous research paradigm allows researchers to be who they are while they are actively involved as participants, and knowledge is relational and is shared with all (Hart et al., 2010).

Moreover, Hart et al. (2010) assert that with this paradigm, there is a sense of commitment to the people that you work with as the researcher, and there is an understanding of reciprocity and accountability to one another. In the study, I was answerable to all my participants, both the IKCs and learners. Also, we all benefited from the study in the sense that I managed to support learners to make sense of the topic by integrating the lesson with IK from the IKCs, while learners made sense of the topic from the demonstration. Moreover, the IKCs became part of their children's education. This speaks to cultural revitalisation. Research suggests that cultural revitalisation can have positive impacts on community well-being, including improved academic attainment, a stronger sense of belonging, and increased cultural engagement (Shea et al., 2019).

In the context of this study, the IKCs demonstrated how maize seeds are dropped when ploughing them traditionally, showing how gravitational potential energy is converted to kinetic energy and how mechanical energy is conserved. Hence, Mertens (2016) states that with the Indigenous research paradigm, research is done by, with and for the Indigenous people and informs decolonisation. For instance, the demonstration was done by the IKCs interacting with the learners and the researcher, and in turn, the IKCs were involved in the education of their children and a new strategy of teaching and learning was developed. Similar views are shared by Triyanto et al. (2020), who argued that integrating IK into science is a way for IKCs to be part of the school curriculum. Therefore, within the Indigenous research paradigm, the focus was on the Ubuntu perspective.

Hanks (2008) refers to Ubuntu as the glue that holds African communities together. Also, the need to combine the interpretive and Ubuntu paradigms was partly influenced by Khupe and Keane (2017), who stressed that African researchers need to develop methods that align with participants' lived experiences and cultural values that recognise the place of local culture in shaping the identities of communities. This philosophy has become crucial in reviewing African education systems. For example, Mkabela (2015) portrayed that the Ubuntu paradigm suits the African research activities as it focuses on African IK and their behaviours. Similarly, Goduka (2005) argued that African research must be done respectfully, rooted in the Indigenous way of knowing. In this regard, Le Grange (2012) posited that the use of Ubuntu is not about wanting to live in the past but rather a way of harnessing togetherness and living in harmony. Concurring, Seehawer (2018b) accentuated that there should be mutual respect between the researchers and participants. That suggests that researchers should respect the Indigenous people and the communities where they carry out their research.

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

Seehawer (2018b) posited that in an Ubuntu paradigm, the knowledge is generated and validated through discussions with the concerned community. In other words, the views and opinions of community members are equally valued and considered important to the validation of different knowledge emerging from the communal discussion. In this study, we adhered to Ubuntu principles by using clan names instead of pseudonyms, which helped establish strong, respectful relationships with participants and facilitated more relational interactions. This approach respected the cultural norms of the participants and allowed for more authentic engagement. Focus group interviews also reflected Ubuntu, fostering unity, belonging, and a safe space for open discussions. This methodology was integral to the research process, ensuring that the study remained true to the principles of the Indigenous research paradigm and effectively captured the rich, diverse perspectives of the participants. It is for these reasons that I married the Ubuntu paradigm with the interpretive paradigm, as it would recognise the integral importance of the participant's interactions.

In the context of my study, using an interpretive paradigm coupled with the lens of Ubuntu allowed me to explore, observe, and understand learners' conceptions and dispositions when the traditional practice of maize seed ploughing was integrated into my science lesson. Chilisa (2012) referred to this as the restoration and development of cultural practices, central to decolonisation.

Indeed, Chilisa's understanding and conceptualisation of decolonisation agrees with calls for the indigenisation or Africanisation of science curricula and the education system (Mbembe, 2021; Mukwambo et al., 2014; Seehawer, 2021). This suggests a need for constructive co-existence and dialogue of different epistemologies and worldviews. Therefore, it was hoped that these paradigms would enable me to understand the situation and interpret meanings within the study's social and cultural contexts. This study employed a case study research design within the interpretive and Indigenous paradigms.

4.3 Research Design

Maree (2015) describes a research design as a strategy that moves from the underlying philosophical assumptions to specifying the selection of respondents, the data gathering techniques to be used, and the data analysis to be done. Bertram and Christiansen (2015) describe the research design as a plan for conducting the study and analysing the data gathered to address the research question(s). Bertram and Christiansen (2015) also point out that a research plan should explicitly describe what will be done with the data once it has been collected. Similarly, a research design is a plan or strategy developed for organising the research and making it feasible so that the research questions may be addressed with evidence (Cohen et al., 2018). In this study, I employed a case study methodology.

4.3.1 Qualitative case study research design

A case study is a systematic and in-depth study of individuals or groups in their real-life settings for an extended period using several data collection methods (Bertram & Christiansen, 2020; McChester et al., 2014; Nayak & Singh, 2015). In a case study, the researcher aims to get a deeper understanding of the participants' points of view (Cohen et al., 2018; MacChester et al., 2014). However, one of the limitations of using a case study design is that results cannot be generalised.

In this study, I employed a case study design to get an in-depth understanding of how to integrate the information gained from the traditional way of maize seed dropping when maize ploughing by the IKCs, to help learners make sense of the concept of the conservation of mechanical energy. Also, I employed a case study design to help me better understand the learners' points of view as they interacted with each other, the IKCs and the researcher during the IKCs' presentation. At the same time, I better understood the IKCs' experiences of traditional maize seed dropping when ploughing maize crops, in relation to conserving mechanical energy. In the case of my study, the units of analysis were the learners' argumentations during group discussions, their interactions with one another and the IKCs during the practical demonstration of traditional maize seed ploughing and how they used the IK of maize seed dropping when planting maize seeds to make sense of the conservation of mechanical energy.

Therefore, the case study sought a deeper understanding of how Indigenous maize seed ploughing could support learners in a rural school to make sense of the conservation of mechanical energy. This teaching strategy was adopted to make the topic relevant to learners by making them active participants in negotiating their learning (Mashoko, 2022). Hence, the study employed a participatory observation approach where all the participants participated fully, including me as a co-researcher.

4.3.2 A participatory approach

Birhane et al. (2022) postulate that a participatory approach provides a distinct learning opportunity. This includes knowledge that is created by people who are directly affected by the existing or new project, leading to individual and collective empowerment. Furthermore, Hall et al. (2021) argue that the participatory approach establishes trust and rapport between the researcher and the participants and actively involves participants in the research problem.

Therefore, within the context of this study, I believe that a learner-centred, culturally relevant strategy and a participatory approach helped me achieve the study's goal. This is in line with one of the principles that underpin the South African CAPS, which suggests active learning as a way of moving away from rote and uncritical thinking to allow learners to work effectively as individuals and with others in groups (DBE, 2011).

In support of this, scholars such as Hernandez-de-Menendez et al. (2019) and Jesionkowska et al. (2020) contend that active learning is a learner-centred approach which directly involves learners in the learning process. To these scholars, active learning allows learners to be active participants in the learning process and motivates them to take ownership of their learning by doing meaningful activities and critically thinking about what they are doing.

4.4 Research Goal and Research Questions

The research goals of a study include the motives, desires, and purpose of doing the study or anything that the researchers want to accomplish, and each study has its own purpose (McChester, 2014). Therefore, the decision about what theories and knowledge are relevant for the study depends on the research goals and questions. Hence, the research questions need to have a clear relationship with the research goal. The main goal of this interventionist study was to mediate Grade 10 learners' understanding of the conservation of mechanical energy using the traditional method of ploughing maize seeds. To achieve this, the following research questions will be addressed:

1. What enables and/or constrains Grade 10 rural school learners to argue and make sense of the conservation of mechanical energy before the intervention?
2. What do Grade 10 rural school learners know from their homes and community about the conservation of mechanical energy?

3. How do the Indigenous Knowledge Custodians' presentations on the traditional ploughing of maize seeds and the consolidation thereof enable and/or constrain Grade 10 rural school learners to argue and make sense of the conservation of mechanical energy?
4. How do exemplar lessons that integrate the traditional ploughing of maize seeds enable and/or constrain Grade 10 Physical Sciences learners from a rural school to argue and make sense of the conservation of mechanical energy?

4.5 Methodological Frameworks

In the following section, I elaborate on the two methodological frameworks that informed this study. The first one is the dialogical argumentation instructional model (DAIM), followed by the transformative model of education for sustainable development (TMESD).

4.5.1 Dialogical argumentation instructional model

Langenhoven et al. (2012) argue that the DAIM is a teaching model that enables learners to argue about their opinions and express their understandings and beliefs to make sense of science concepts. The DAIM has also shown promising results in enhancing learners' understanding and argumentation skills across various subjects. Studies have demonstrated its effectiveness in improving comprehension and argumentation abilities in high school physics (Nuryandi, 2015) as well as pre-service teachers' capacity to solve conceptual mathematics problems in physics (Iwuanyanwu & Ogunniyi, 2020). The DAIM has also been found to increase scientific argumentation skills in high school learners (Muslim, 2015). When combined with explicit instruction or procedural guidelines, deliberative dialogues can further enhance argumentative synthesis writing, with explicit instruction particularly beneficial for improving integration levels and procedural guidelines contributing to argument coverage (Casado-Ledesma et al., n.d.). These studies suggest that DAIM and related dialogical approaches can effectively promote critical thinking, scientific communication, and argumentation skills across different educational levels and subject areas. Langenhoven et al. (2012) further explain that DAIM is one way of creating teaching and learning spaces where learners' views are appreciated, giving them a chance to make meaning of science concepts. Through using DAIM as a teaching method, teachers provide learners with the skill of argumentation.

The DAIM views the two worldviews, that is, IK and Westernised science (WS), as complementing each other instead of competing, and it aims to reach cognitive harmonisation regarding conflicting or controversial views (Langenhoven & Stones, 2013). They argue that as learners try to negotiate IK and WS in their cognitive processes, the two worldviews attempt to align themselves with each other by seeking the thought systems, ideas or concepts that share common elements to accommodate, adapt and reconcile them so they make sense. In other words, these scholars believe that using DAIM as a teaching strategy for scientific argumentation and integrating IK into science classrooms enhances teaching and learning of scientific concepts.

In the context of this study, the learners thrived during argumentation while code-switching between English and their mother tongue, Sepedi (Modipa & Davel, 2022). By so doing, they were able to express their views freely and communicate their ideas more easily (Raymunde, 2024; Vela Gámez, 2023) during their group discussions and interactions with the IKCs during the practical demonstrations. The DAIM created an environment conducive to learners' discussion among themselves, with the IKCs, my critical friend and me during the presentation by the IKCs using their mother tongue, as they tried to reconcile the two worldviews to make sense of the topic under consideration.

Langenhoven and Stones (2013) also believe that DAIM is a learner-centred approach that promotes discussions in science. These scholars believe that teachers should be able to design teaching strategies that create non-threatening environments for learners to be able to negotiate IK and WS so that they appreciate the relevance of science in real-life settings. To achieve the aim of navigating between IK and WS, these authors suggested a DAIM model that follows a series of stages as shown in Figure 4.1.

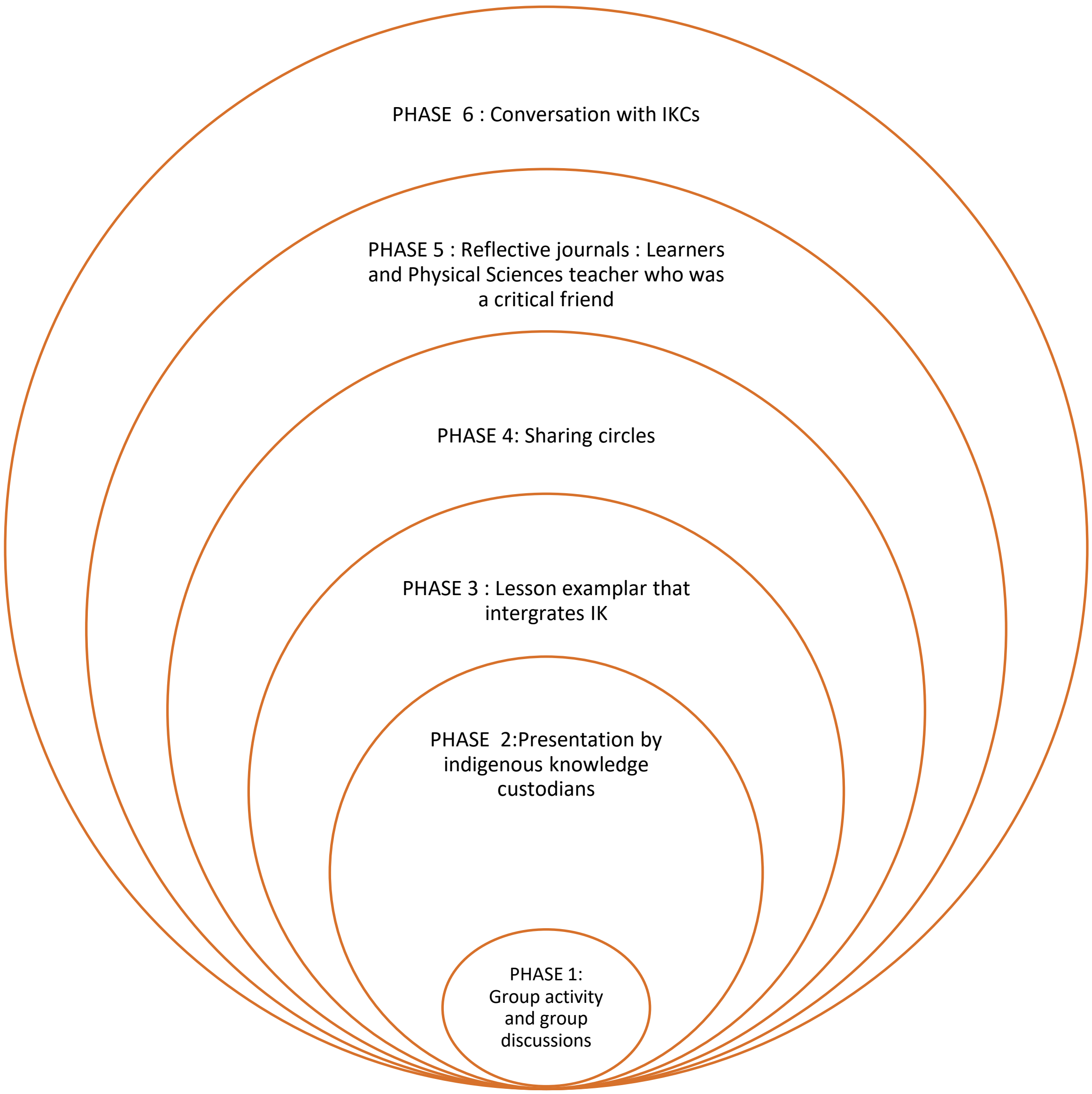


Figure 4.1: The DAIM for integrating IK into science (adapted from Langenhoven & Stone, 2013, p. 6 and Langenhoven & Ogunniyi, 2018, p. 76)

In contrast to Langenhoven and Stone's (2013) DAIM model, in phase 1 (group activity and discussions) in this study, learners worked in groups and shared views on how they plant maize seeds at home and stories they were told at home around the fire and then identified scientific principles related to these stories. For phase 2 (presentation by IKCs and participatory observation), the IKCs came to the school, and we went to the school garden with the learners and my critical friend to observe the practical demonstration of planting maize seeds traditionally to find out if this could help learners make sense of the topic. In phase 3 (lesson exemplar), I consolidated the lesson by presenting a lesson exemplar that integrated IK into the topic, focusing on the concepts that emerged during the practical demonstration by the IKCs. Phase 4 (sharing circles interviews) took the form of focus group interviews (sharing circles) (Lavallee, 2009) where we sat in a circle with the learners (this a traditional way of sitting when sharing stories) in trying to create a non-threatening atmosphere where learners freely expressed their views, respecting the opinions of others (Fakudze, 2021).

The aim of the focus group interviews (sharing circle) was to find out if learners 'sense-making of the topic had shifted or not after the intervention. Phase 5 (reflective journals) took the form of reflective journals of learners and the science teacher, who was my critical friend. These were also intended to find out if the learners 'sense-making had shifted or not after the presentation and the use of the lesson exemplar. This was so because not all learners were part of the focus group interview. Also, I was mindful of the fact that some learners were shy to speak, so reflective journals allowed all learners to reflect on what transpired during the practical demonstrations by the IKCs. They also helped me see if there was a shift or not in their sense-making of the topic.

In phase 6 (conversation with the IKCs), after the whole process, I went back to the IKCs who presented the traditional way of planting maize seeds to ask how they felt about presenting to the learners. They felt so privileged to be allowed to showcase their knowledge and skills to learners. They were proud of the fact that their culture was being appreciated at school. The IKCs were extremely happy to show me how to plant the maize seeds. The other IKC made a remark that she felt so happy that she knew something that I, as the teacher, did not. She felt that they were more knowledgeable than I was.

In this regard, Langenhoven and Stone (2013) assert that DAIM is an effective strategy for teaching science by connecting it with IK. These scholars believe that argumentation clarifies the science in IK and the IK in science. Within the context of the study, this was evident as learners identified science concepts that emerged from the practical demonstration of maize seed planting. For example, when the IKCs dropped the seeds from a certain height onto the ground, the learners identified the potential energy from the top, where the maize seeds were dropped, to the kinetic energy at the bottom (on the ground). They also identified that the seeds fell because of the gravitational force once they had been released from the hands of the IKCs. In all, the use of DAIM in the study through social interactions (Vygotsky, 1978) among learners and the IKCs necessitated argumentation, leading them to reach a collaborative consensus, hence making sense of the conservation of mechanical energy. Concurring, Riffel (2020) states that DAIM occurs when two worldviews, such as IK and WS, are expressed with the hope of reaching a collaborative consensus in the end.

4.5.2 Transformative model of education for sustainable development

Education for Sustainable Development (ESD) in science teaching aims to equip learners with knowledge and skills to promote sustainable development. Studies have shown that integrating ESD into science education can enhance students' cognitive organisation, attitudes, and classroom practices related to sustainability (El-Deghaidy, 2012). Approaches to implementing ESD in science education include action research projects (El-Deghaidy, 2012), experiential learning (Jegstad et al., 2018), and socio-scientific issues-based teaching (Eilks, 2015). These methods can help develop critical scientific literacy and general educational skills while providing a balanced view of science in societal contexts (Eilks, 2015; Hogan & O'Flaherty, 2021). However, challenges remain, such as the need for explicit teaching of ESD concepts and overcoming discipline-specific barriers to adopting discursive pedagogical approaches (Hogan & O'Flaherty, 2021; Jegstad et al., 2018). Successful implementation of ESD in science education requires a focus on both content knowledge and critical exploration of sustainability issues.

Within the context of this study, the research process was informed by the TMESD (Chikamori et al., 2019). The TMESD model socialises learners to be informed agents who can transform their society into a sustainable society by thinking about how the past has brought them to the present actions and what actions at the present can take them forward towards a sustainable future. This resonates with the main goal of this interventionist study, which was to mediate Grade 10 learners' understanding of the conservation of mechanical energy using the traditional method of ploughing maize seeds. It was hoped that if the strategy worked, it would mean some form of curriculum transformation with new teaching strategies that integrate IK into future science lessons (sustainable future).

Chikamori et al. (2019) accentuate that the TMESD model consists of three sub-processes, that is 'knowing the present', 'past-present relationships' and the 'future-present'. To these scholars, the "past-present relationships" are known as 'retroductive learning' and the "future-present relationships" as 'retrodictive learning' (see Figure 4.1 below). They claim that the present depends on the past, and it gives pre-conditions that enable or constrain the future in relation to 'knowing the present'.

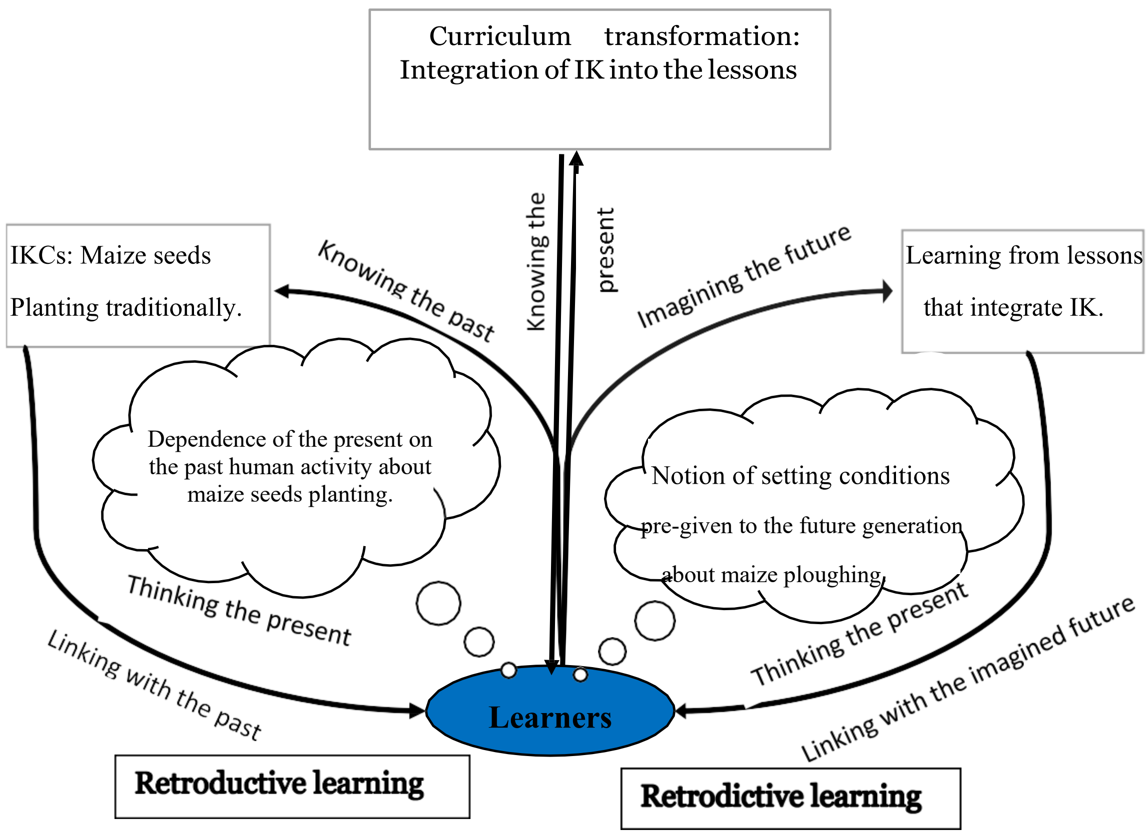


Figure 4.2: Shows the process of IK integration into science in this study (adapted from Chikamori et al., 2019, p. 9)

4.6 Research Site and Participants

The study took place at Dimpe Secondary School (pseudonym) in Limpopo Province, Waterberg District. The learners and teachers in this school are of the Black race, and their home languages ranged from Sepedi to isiXhosa, isiZulu, and Tshivenda. However, most of the learners and teachers at the school were Sepedi home-language speakers. The learners came from different social and cultural backgrounds – most of them from families with low incomes who depended on social grants. A small number were from families with middle incomes. The school was a convenient research site because it was where I was teaching physical sciences grades 10-12, Natural Sciences Grade 8, and Mathematics Grade 9 at the time of the study. This made interacting with participants easier as I had already worked with them. A Grade 10 class was purposively selected in this study as I taught them, and the conservation of mechanical energy is part of their syllabus. The class had 15 learners, 10 girls and five boys. I also invited two community members, who were IKCs, to tell stories about their cultural beliefs and practices on maize seed planting to come to school and share this knowledge with my learners. A teacher for physical sciences, Grades 10–12, was also invited from the nearest school in the Palala South Circuit as a critical friend, so that we could reflect together throughout the research process. Figure 4.3 below shows the five districts in the Limpopo Province with their different circuits.

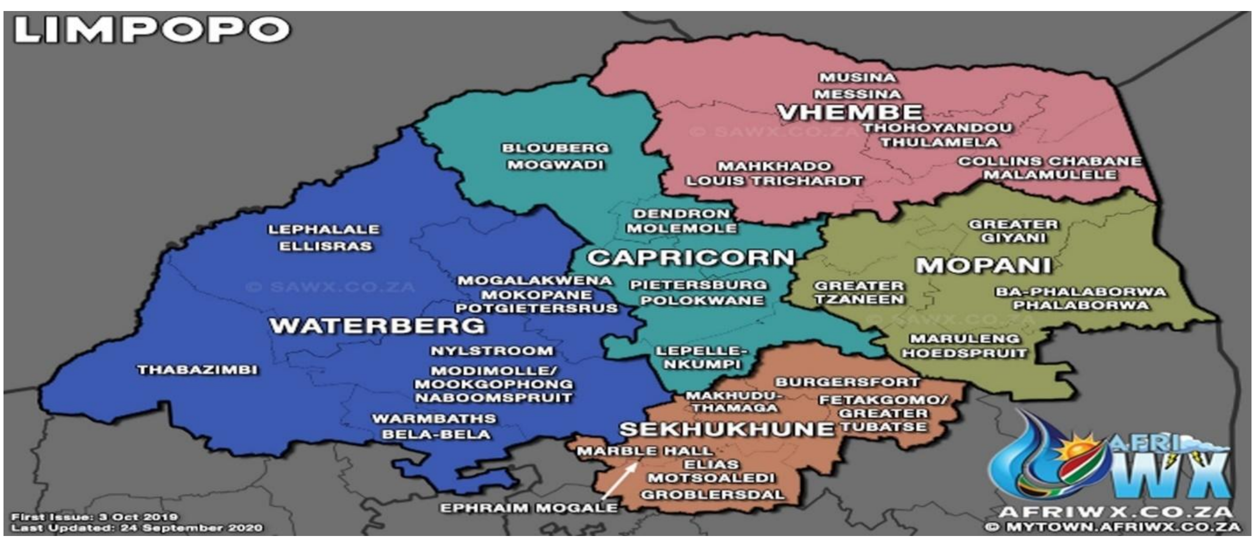


Figure 4.3: Map of the Limpopo Province showing the Waterberg District where the study occurred (https://images.app.goo.gl/N8w5EMSoc3Yjfzwn6)

4.7 Data Gathering Methods

The following data gathering methods were used in this study: group activities, focus group interviews (sharing circles), lesson observations (participatory and lesson observations), and learners' journal reflections. Different data gathering methods allow for data triangulation, enabling rich data to be collected. I will now discuss each of these data-gathering techniques below.

4.7.1 Group activity

Group activities in science education have been shown to enhance student learning outcomes and engagement. These activities can include collaborative work on common themes, information gathering, role-playing, and games (Lock, 1997). Group work aligns with Vygotsky's ZPD, emphasising cooperation and imitation for developing new skills (Martins, 2002). Redesigning individual tasks into group activities can improve problem solving, critical thinking, and communication skills (Hettiarachchilage & Haldolaarachchige, 2024), which was observed in this study. Moreover, learners in this study were grouped by me into three mixed groups of five (boys and girls) by to work together to draw mind maps and concept maps based on the practical demonstrations of the IKCs to help them make sense of the conservation of mechanical energy.

Based on their concept maps of the conservation of mechanical energy through the group activity, learners seemed to achieve cognitive growth. This concurs with Fung and Lui (2016), who argue that learners achieve greater cognitive growth when engaged in cooperative learning activities, particularly in science education. Furthermore, teacher-supported group work is especially effective, with educators playing a crucial role in guiding learners through the joint construction of conceptual knowledge (Fung & Lui, 2016). Overall, group activities in science education foster a more interactive and multi-sided argumentative learning environment, benefiting learners across various levels of understanding (Fung & Lui, 2016; Hettiarachchilage & Haldolaarachchige, 2024).

In addition, research has shown that group activities and argumentation can enhance science education. Small group discussions and problem-solving activities can promote quality argumentation, especially when learners are familiar with this approach and take on positive roles (Simon & Maloney, 2007). In the context of this study, learners were given guiding questions that were meant to help them draw their concept and mind maps. During the activity, positive learner arguments broke out in their small groups about how they should present their ideas. They argued about which definitions they should use when presenting, which spoke more in-depth to the scientific concepts. Agreeing with Cross et al. (2008), in this study, when the learners were engaging in scientific argumentation, it was linked to improved learning gains and achievement and the development of scientific identities. In addition, studies have found that learners draw on prior knowledge when arguing, which helps consolidate existing understanding and elaborates on scientific concepts (Aufschnaiter et al., 2008). The quality of argumentation is influenced by learners' familiarity with the content, suggesting the need to consider their prior experiences before engaging in such activities (Aufschnaiter et al., 2008). In the context of this study, the learners' group activities were based on the knowledge they gained from the practical demonstrations, which served as prior knowledge. Research has also demonstrated that teachers can develop their skills in implementing argumentation-based lessons over time, leading to improvements in learners' argumentation capabilities (Osborne et al., 2004). These findings highlight the potential of argumentation as a valuable strategy in science education.

4.7.2 Participatory observations and lesson observations

Participatory observation and lesson observation methods have gained prominence in educational research and professional development. Observation means that the researcher goes to the research site of the study and observes what is taking place there, which means engaging in the very activities set to be observed (Bertram & Christiansen, 2020; Cohen et al., 2018). Participant observation is a research methodology where the researcher is immersed in the day-to-day activities of the participants (Nabhan-Warren, 2022). Muller (1995) additionally urges that participant observation is a qualitative research method involving sustained contact with a group in their natural setting, allowing researchers to observe and participate in activities while recording observations. This concurs with the context of this study, where participatory observations and videotaping were crucial methodologies employed, particularly during the practical demonstration of the IKCs and the sharing circles (semi-structured interviews). This approach is widely used in various disciplines, including healthcare and ageing research (Muller, 1995; Vitorelli Diniz, 2014). While participant observation offers valuable insights into social and cultural spaces, it also raises ethical considerations and questions about researcher positionality (Walsh, 2020). Despite its challenges, this method remains valuable for understanding complex social phenomena and group dynamics (da Costa et al., 2024; Vitorelli Diniz, 2014).

At the other end of the spectrum, lesson observations play a significant role in teacher assessment and development across educational sectors. In schools and further education institutions, observations have become increasingly linked to performance management, often using simplified rating scales (O'Leary, 2012). However, this approach can create emotional tensions between authentic teaching and performance requirements (Edgington, 2016). Teachers' perceptions of lesson observations by school heads are often negative, as they tend to follow dominant supervisory models rather than collaborative approaches (Sibanda et al., 2011).

However, in this study, lesson observation was done by allowing learners to come up with their own mind and concept maps with guided questions. The lesson observation was not dominant but gave learners the freedom to share their ideas and creativity while making sense of the conservation of mechanical energy. The effectiveness of observations can be limited by the risk of shame and self-perceptions, discouraging playfulness in teaching (Edgington, 2016). To address these issues, alternative methods like 'lesson study' in schools and peer-directed models in higher education offer more autonomy and opportunities for critical reflection (O'Leary, 2012). Overall, lesson observations remain a complex and pivotal aspect of teacher training and development, requiring careful consideration of their implementation and impact (O'Leary, 2020).

4.7.3 Focus group interviews (sharing circles)

Bertram and Christiansen (2020) define interviewing as the conversation between the researcher and the respondent, whereby the researcher asks the respondent questions and gets answers. In this study, I used focus group interviews (sharing circles), including in-depth interviews where participants were purposively selected. The focus group interviews afforded me an opportunity to make my questions clear and thus gain in-depth and quality data.

Since I had direct contact with participants, the sharing allowed me to explore more specific responses, repeat a question if necessary, and discover new developing avenues for gathering in-depth information (Bertram & Christiansen, 2020; Maree, 2012). In this manner, I interacted with Grade 10 learners using an Indigenous methodology called the sharing circle (Lavallee, 2009). Also, the sharing circles were aligned with the traditional or Indigenous approach, where learners were seated in a circle during the interviews; this is called sharing circles (Afonso-Nhelevilo, 2013; Chilisa, 2012; Lavallee, 2009; Mucina, 2011).

I believed that this would create a non-threatening and relaxed environment for my learners, and it did just that along the way. At the beginning of the sharing circle sessions, I must admit that the learners were not entirely comfortable since they still viewed me as their physical sciences teacher (see Section 1.4) and expected that I wanted them to give me the right answers, even though I explained to them that there were no right or wrong answers. However, as the sessions continued, they felt more comfortable expressing their views because we were sitting in a circle and there was no one standing in front who was viewed as more knowledgeable. We used our clan names to interact, and the learners were excited to call me by my clan's name, MaTau. This helped in levelling the power dynamics and allowed them to express themselves fully. In addition, using clan names is consistent with the Ubuntu perspective; to show them I was on their level and create a relaxed, non-threatening environment. However, the sharing circles were time-consuming, as reiterated by Maree (2012). The interviews took place at my school in Lephalale, Limpopo Province. Participants were given letters of consent outlining the purpose of the study before conducting the study.

4.7.4 Learners' reflective journals

Reflective journals are notes that learners prepare to reflect on what they understand. Reflective journals are written documents that learners create as they think about various concepts, events, or interactions over a period to gain insights into self-awareness and learning (Khan, 2019). Concurring, Alt et al. (2022) argue that reflective journal writing is an effective pedagogical tool for nurturing learners' lifelong learning skills. A reflective journal is an active learning method designed to promote higher-order thinking skills. Wallin and Adawi (2018) suggest that a reflective journal aims to express the self-observation of the learning process and evidence of reflection (Khan, 2019). Encouraging learners to engage in reflective journal writing has been acknowledged as an essential goal in education.

As in Mayana's (2020) study, at the beginning of 2024, I introduced my learners to writing journal reflections and encouraged them to reflect after every lesson taught. From the beginning, my learners preferred to express themselves and reflect in English, and Sepedi here and there, where they did not know the word in English. Muwanga-Zake (2010) acknowledges that most people appreciate and communicate more effectively in their home language.

Initially, this technique was meant to prepare learners for the context of the study so that when the data collection process began, they would be used to doing this. However, I found this helpful as it gave me some insights into learners' understanding of the lessons and how to improve my teaching practice. This also improved learners' language proficiency. In the context of this study, learners were encouraged to reflect using the notebooks provided. They reflected on their observations, thoughts, and actions during and after the research study.

Hence, in this study, participants were encouraged to record learning-related incidents during the learning process and mostly after they occurred. They reflected on how they found the lessons, what areas of the lessons they did not understand, which sections they understood, and which sections they felt they needed help from the teacher and the IKCs. That is, journal reflections allowed learners to express their attitudes and critically reflect on the activities they were engaged in.

All learners answered the guided questions provided for reflective journals. Those learners who were too shy to talk were able to reflect when given a chance to write. To avoid being biased when I analysed data from the learners' journal reflections, I requested that they anonymise their journals. I did this so I would not just select the journals of learners whom I regarded as the best in class. Therefore, this gave me a genuine insight into the learners' shift in sense making of the topic and allowed me to treat them equally. The purpose of using reflective journals was to establish from all the learners, including those unable to express themselves during the focus group interviews, how they found the experience of having IKCs presenting to them and the lesson that integrated IK into learning the conservation of mechanical energy. The reflective space also helped my critical friend and me to reflect on what transpired during the practical demonstration by the IKCs and on how to integrate the information gained from the presentation in science learning, particularly the concept of the conservation of mechanical energy.

Table 4.1: Summary of data-gathering methods used in this study

Stage	Method to be used to gather data	Purpose	Research question
Stage 1	Lesson observation Focus group interview (Sharing circles)	**To find out** What enables and/or constrains Grade 10 rural school learners to interact and make sense of the conservation of mechanical energy before the intervention?	1
Stage 2	Group Activities	**To find out** What do Grade 10 rural school learners know from their homes and community about the conservation of mechanical energy?	2
Stage 3	Presentations of IKCs	**To find out** How do the Indigenous Knowledge Custodians' presentations on the traditional ploughing of maize seeds and the consolidation thereof enable and/or constrain Grade 10 rural school learners to argue and make sense of the conservation of mechanical energy?	3
Stage 4	Lesson Observation Reflective Journals	**To find out** How do exemplar lessons that integrate the traditional ploughing of maize seeds enable and/or constrain Grade 10 Physical Sciences learners from a rural school to argue and make sense of the conservation of mechanical energy?	4

4.8 Data Analysis

Bertram and Christiansen (2020) define data analysis as the process of organising and reducing large amounts of data and analysing it to make sense of it (Graziano & Rauln, 2010). In this study, thematic analysis was used to analyse data. This is a method of identifying, analysing, and reporting themes in data (Braun & Clarke, 2006). This method is suitable for analysing qualitative data. During the process of data analysis, I read through the collected data, developed categories and codes and created sub-themes. Common sub-themes were combined to form themes, which were linked to relevant literature. First, I analysed the focus group interviews and commenced with the data analysis process by writing them as a narrative story (Nhase, 2019; Nuntsu, 2020). From those narratives, as in Nuntsu's (2020) study, I then identified some episodes and colour-coded them (see Appendix D1). Within the narratives, I identified themes and categories. Concepts from Vygotsky's (1978) sociocultural theory and Langenhoven and Stone's (2013) DAIM six stages were used as lenses to analyse emerging data from group discussions among learners, IKCs and me, focus group interviews and learners' reflective journals.

4.9 Validity and Trustworthiness

According to Cohen et al. (2018), validity is an important key to effective research. He argues that if a piece of research is invalid, then it is worthless. On the other hand, Bertram and Christiansen (2020) bemoan that qualitative researchers argue that the term 'validity' is not applicable in interpretive research. Yet, they realise the need for a qualifying check on their work to know if the research is worthwhile. For this reason, they adopted different terms such as 'trustworthiness'. For interpretive research to be trustworthy, it must reflect the participants' reality. Considering this, in this study, various data gathering techniques such as participatory observations, focus group interviews, and reflective journals were employed for triangulation purposes. In addition, I watched videos from the focus group interviews with the participants and my critical friend, and then follow-up questions were asked for validation purposes. The study's validity was enhanced through presentations at the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE) EC Chapter colloquium.

4.10 Ethical Considerations

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

Beneficence means that the research process should benefit the research participants, other researchers or society as a whole (Bertram & Christiansen, 2014). This study was carried out to collectively improve learning strategies, which were intended to enrich hands-on practical activities with locally available resources to improve learners' understanding and sense making of the conservation of mechanical energy in Grade 10. Non-maleficence means that the research should not harm the research participants or any other people (Bertram & Christiansen, 2015). Thus, the participants' right to privacy was honoured (Derry et al., 2010). Pseudonyms were used to protect the participants' identities, and all the data used was taken in confidence.

I also respected the autonomy of all participants, and Ubuntu was used as a principle when contacting them. I first clearly explained the aim of the study. Thereafter, I gained the voluntary consent of every person who participated in this study, who had the freedom to withdraw from the study at any time, if they wished. As for the learners, consent was obtained from their parents or guardians and the same was done with the school and the Limpopo Department of Education. Similarly, the two IKCs were thoroughly informed of ethical issues that could arise in carrying out this study, and a consensus was reached between us. Proper consultations were done with the two community elders to make sure they felt respected throughout this study (Seehawer, 2018a)

4.10.1 Respect and Dignity

The study employed the perspective of Ubuntu as a quality of being human involving sharing, caring, respect and compassion, ensuring a happy and quality human community life in the spirit of a family (Muwang-Zake, 2010). Considering the above, both the learners and the IKCs were respected by using clan names because, in our culture, it is disrespectful to call an elder by name. Therefore, using clan names levelled power relations by treating the participants as equals concerning their values, interests, and needs. They were regarded as co-learners in the study. I also negotiated their willingness to volunteer in the study, using the Ubuntu perspective that knowledge was relational and shared with all.

I worked with two female IKCs to take part in the study to avoid raising power issues and show respect for both genders. Since this was an interventionist study, the final decision regarding the issue of anonymity depended on the participants. In my culture, IKCs find pride in their work, and therefore, they requested me to use their real clan names.

4.10.2 Transparency and Honesty

The aim of the study, reasons for choosing the site, and activities that would take place during the study were explained to the participants before they signed up and agreed to participate. Participants were assured that the study would not disrupt their daily activities. Consent and assent forms were written in both Sepedi and English; as some could not read and write, I also sought verbal consent.

Permission to conduct the study was obtained from all the gatekeepers, namely the Limpopo Province Department of Education, the school principal of Dimpe Secondary School where the study was conducted, the science teacher who was my critical friend, the IKCs as the practical demonstrators, and the learners and their parents or guardians.

4.10.3 Accountability and Responsibility

The study adhered to the principles and policy guidelines for educational research. My responsibility was to ensure that all data gathered in hard copy was stored safely in lockable cabinets, while data gathered in soft copy, electronically, was secured with passwords. Also, consent was obtained from the IKCs to use their real names as they wanted their identity to be revealed.

4.10.4 Integrity and academic professionalism

The data collected was given to the participants as part of member checking. I ensured that this study was my original work and that I used my own ideas. Where I used other people's ideas, I acknowledged them and correctly referenced them according to the referencing guidelines of Rhodes University.

4.11 Chapter Summary

In Chapter Four of the thesis, the underpinning research methodology was thoroughly outlined and discussed, providing a comprehensive framework for how the research was conducted. Key elements of this chapter included the following.

The study was anchored in the interpretivist and s. The interpretivist paradigm focused on understanding the world from the participants' perspectives, especially their experiences with science education in the context of maize seed planting. The Indigenous research paradigm added depth by integrating IK, languages and worldviews, emphasising an Ubuntu perspective. A qualitative case study approach was employed, deemed most suitable for exploring the interactive nature of the research and gaining a deep understanding of the Grade 10 learners' experiences. This design facilitated an in-depth investigation of the specific case of a Grade 10 Physical Sciences class in a rural school in the Limpopo Province.

The study incorporated participatory approaches, aligning with the Indigenous research methodology. This was supported by the DAIM, which facilitated the integration of Indigenous and scientific worldviews. The researcher's positionality as a Grade 10 Physical Sciences teacher and their reflexivity throughout the study were acknowledged. This included a focus on the cultural, ethnic, language, gender and other dimensions of the researcher's identity, influencing the research process.

Multiple data gathering methods were used, including focus group interviews (sharing circles), group activities, participatory observations, and videotaping. These methods enriched the data collection process, ensuring a comprehensive understanding of the participants' perspectives. The data were analysed using an inductive-deductive approach, categorising and grouping data to form themes. The analysis was framed by Vygotsky's sociocultural theory.

The study's validity was enhanced through presentations at the SAARMSTE EC Chapter colloquium. Data triangulation and honest participant engagement further contributed to the study's credibility. Ethical considerations were meticulously addressed, including respect and dignity, transparency and honesty, accountability and responsibility, informed consent, cultural sensitivity, beneficence and non-maleficence, and data protection and confidentiality.

In summary, Chapter Four provided a detailed account of the research methodology, encapsulating the paradigms, design, approaches, positionality, data collection methods, data analysis, validity, and ethical considerations. This comprehensive methodological framework laid the foundation for conducting a rigorous, ethically sound and culturally sensitive study.

CHAPTER FIVE: GROUP ACTIVITY AND PRESENTATIONS BY INDIGENOUS KNOWLEDGE CUSTODIANS

5.1 Introduction

The main goal of this interventionist study was to mediate Grade 10 learners' understanding of the conservation of mechanical energy using the traditional method of ploughing maize seeds. In this chapter, I thus present, analyse, and discuss data generated from observations during the learners' group activity and the practical demonstrations done by the two IKCs. The data presented here is aimed at answering my research questions one, two, and three:

1. What enables and/or constrains Grade 10 rural school learners to argue and make sense of the different types of energies and their transfer before intervention?
2. What do Grade 10 rural school learners know from their homes and community about maize seed planting and the conservation of mechanical energy?
3. How do the Indigenous Knowledge Custodians' presentations on the traditional ploughing of maize seeds and the consolidation thereof enable and/or constrain Grade 10 rural school learners to argue and make sense of the conservation of mechanical energy?

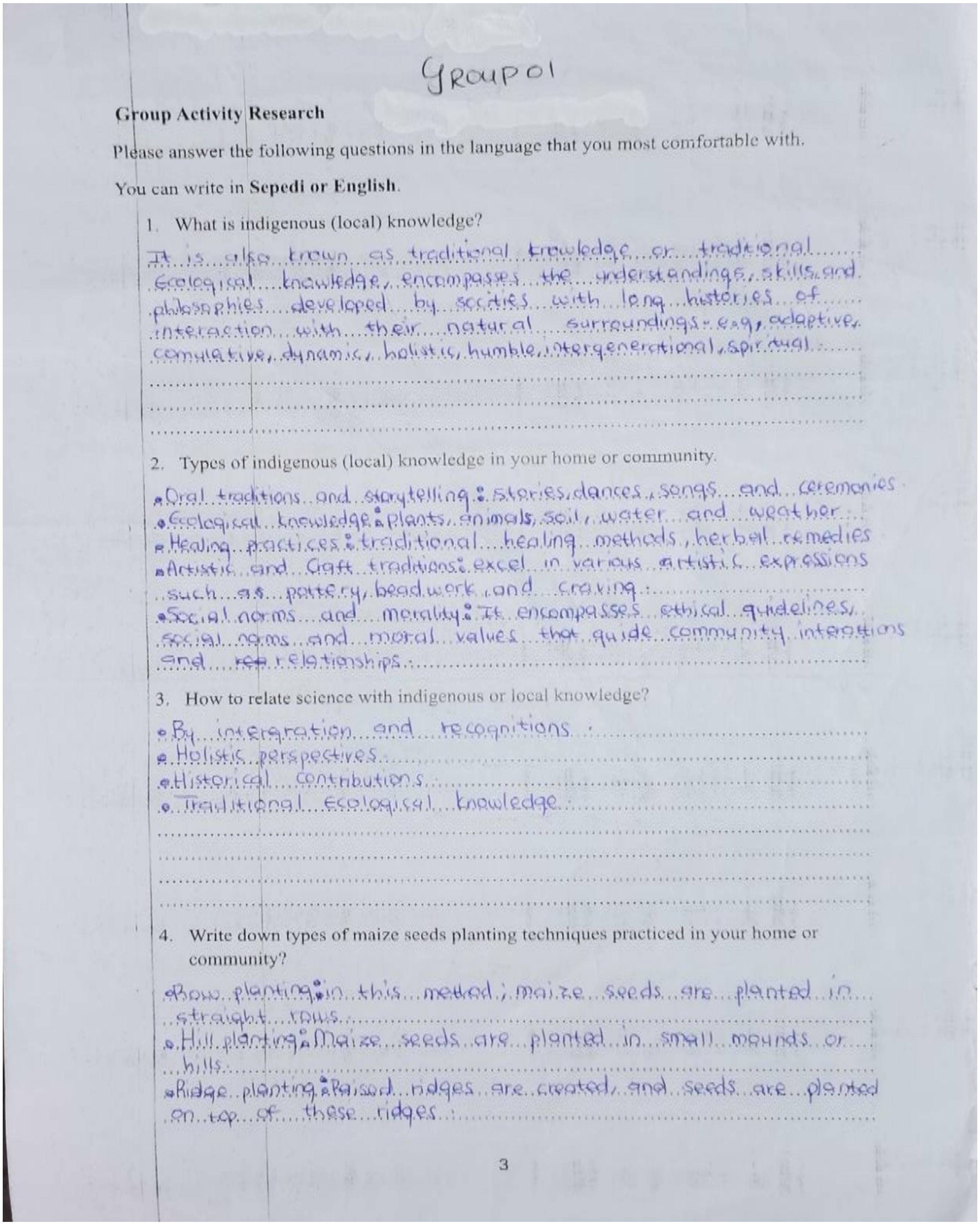
5.2 Summary of the Qualitative Data Generated During Group Activities

In the group activity, learners were divided into three mixed groups of five (boys and girls). In our first session, I asked the learners about their understanding of IK and examples thereof. The learners seemed to need to research what IK was. The main aim of doing this was to determine if the learners know was IK was before using it. This resulted in us having two group activities.

The first group activity was geared towards answering research question one, and the second group activity answered research question two. Similar to Nuntsu's (2020) study conducted in South Africa, learners were given six guiding questions in the first group activity to focus on and eight guiding questions for the second group activity. These guiding questions were intended to guide their discussions in their respective groups. I will first discuss the first group activity. The six guiding questions were:

1. What is Indigenous Knowledge?
2. Types of Indigenous Knowledge in your home or community?
3. How to relate science with Indigenous Knowledge?
4. Write down the types of maize seed planting techniques practised in your home or community.
5. The types of energies that you know and how they are transferred.
6. Briefly explain conservation of mechanical energy.

Each group was given 30 minutes for discussions and recorded their experiences on newsprint as shown in Figures 5.1–5.4 below. The leaners did mention that they used Google and AI to help them with their answers. One member of the group presented the work after discussions with their classmates. Learners were also given codes such as L1F, which meant learner number one female, L3M, which meant learner number 3 male and so on. The groups decided to name themselves. All the groups were thus given codes, for example, G1HLDT for group one Hash Tag Lets Do it, G2MM for group two Momentum Masters, and G3TAO for group 3 Together As Together.



Group 01

Group Activity Research

Please answer the following questions in the language that you most comfortable with.

You can write in **Sepedi or English**.

1. What is indigenous (local) knowledge?

It is also known as traditional knowledge or traditional Ecological knowledge, encompasses the understandings, skills and philosophies developed by socities with long histories of interaction with their natural surroundings - e.g, adaptive, comulative, dynamic, holistic, humble, intergenerational, spiritual.

2. Types of indigenous (local) knowledge in your home or community.

- Oral traditions and storytelling: stories, dances, songs and ceremonies
- Ecological knowledge: plants, animals, soil, water and weather
- Healing practices: traditional healing methods, herbal remedies
- Artistic and Craft traditions: excel in various artistic expressions such as pottery, beadwork, and craving.
- Social norms and morality: It encompasses ethical guidelines, social norms and moral values that guide community interactions and relationships.

3. How to relate science with indigenous or local knowledge?

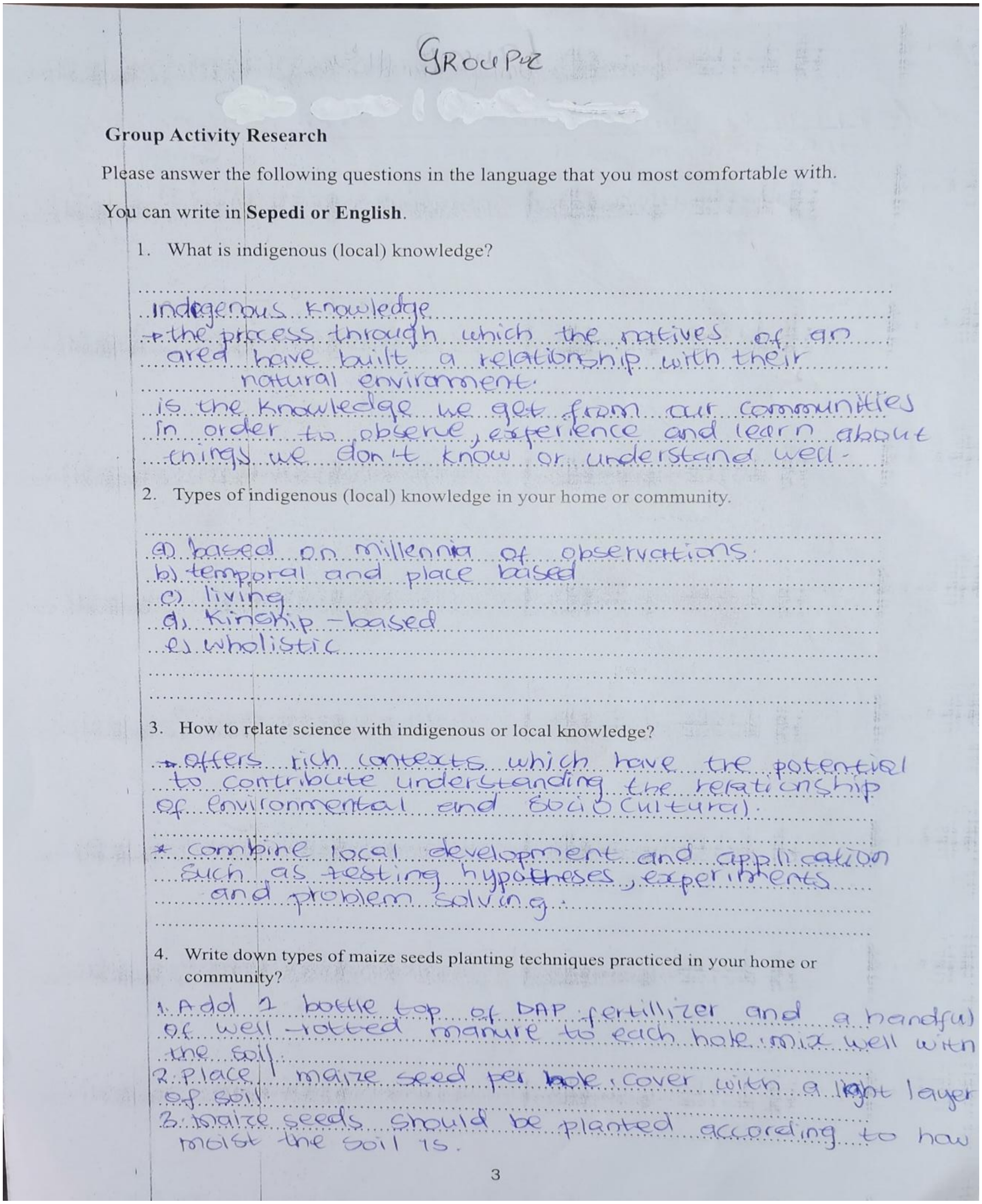
- By integration and recognitions.
- Holistic perspectives
- Historical contributions
- Traditional Ecological knowledge.

4. Write down types of maize seeds planting techniques practiced in your home or community?

- Row planting: in this method; maize seeds are planted in straight rows.
- Hill planting: Maize seeds are planted in small mounds or hills.
- Ridge planting: Raised ridges are created, and seeds are planted on top of these ridges.

3

Figure 5.1: Newsprint group one Hash Tag Let's Do it



GROUP 2

Group Activity Research

Please answer the following questions in the language that you most comfortable with.

You can write in **Sepedi or English**.

1. What is indigenous (local) knowledge?

indegenous knowledge
* the process through which the natives of an area have built a relationship with their natural environment.
is the knowledge we get from our communities in order to observe, experience and learn about things we don't know or understand well.

2. Types of indigenous (local) knowledge in your home or community.

a) based on millennia of observations.
b) temporal and place based
c) living
d) Kinship - based
e) wholistic

3. How to relate science with indigenous or local knowledge?

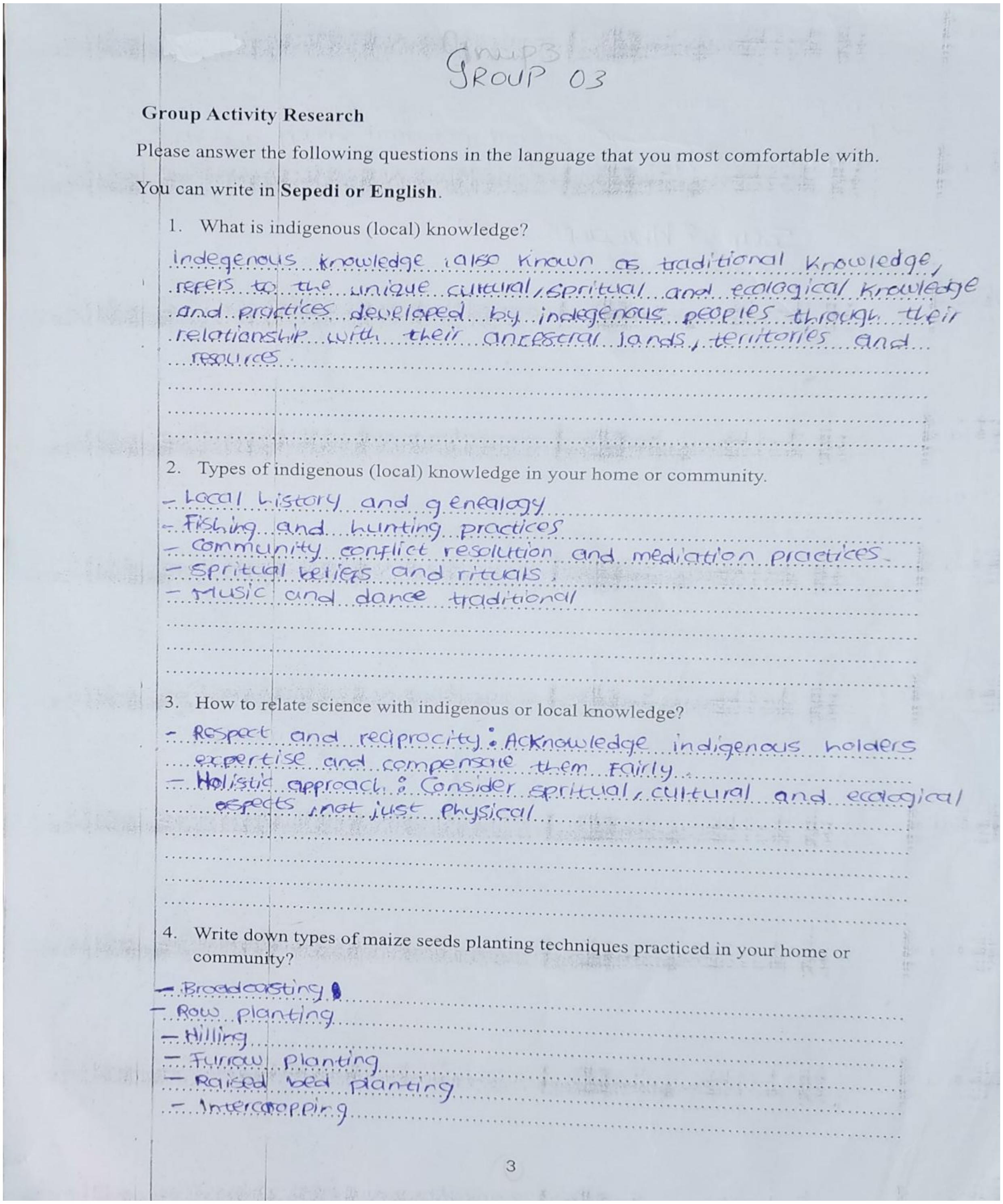
* offers rich contexts which have the potential to contribute understanding the relationship of environmental and socio cultural.
* combine local development and application such as testing hypotheses, experiments and problem solving.

4. Write down types of maize seeds planting techniques practiced in your home or community?

1. Add 1 bottle top of DAP fertillizer and a handful of well-rotted manure to each hole. mix well with the soil.
2. Place 1 maize seed per hole. cover with a light layer of soil.
3. maize seeds should be planted according to how moist the soil is.

3

Figure 5.2: Newsprint group two Momentum Masters


Group3
GROUP 03

Group Activity Research

Please answer the following questions in the language that you most comfortable with.

You can write in **Sepedi or English**.

1. What is indigenous (local) knowledge?

Indegenous knowledge ,also known as traditional knowledge, refers to the unique cultural, spritual and ecological knowledge and practices developed by indegenous peoples through their relationship with their ancestral lands, territories and resources.

2. Types of indigenous (local) knowledge in your home or community.

- Local history and genealogy
- Fishing and hunting practices
- Community conflict resolution and mediation practices
- Spritual beliefs and rituals
- Music and dance traditional

3. How to relate science with indigenous or local knowledge?

- Respect and reciprocity: Acknowledge indigenous holders expertise and compensate them fairly.
- Holistic approach: Consider spritual, cultural and ecological aspects, not just physical

4. Write down types of maize seeds planting techniques practiced in your home or community?

- Broadcasting
- Row planting
- Hilling
- Furrow planting
- Raised bed planting
- Intercropping

3

Figure 5.3 Newsprint group three Together As Together

Figure 5.4: Learners discussing in groups

Table 5.1: Learners' responses are recorded below

Questions	Group 1	Group 2	Group 3
1. Knowledge gain from society.	It is also known as traditional knowledge or traditional ecological knowledge, encompasses the understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. e.g adaptive, cumulative, dynamic, holistic, humble, intergenerational, spiritual.	Indigenous Knowledge is the process through which the natives of an area have built a relationship with their natural environment. Is the knowledge we get from our communities to observe, experience and learn things we don't know or understand well.	Indigenous knowledge, also known as traditional knowledge, refers to the unique cultural, spiritual and ecological knowledge and practices developed by Indigenous peoples through their relationship with their ancestral lands, territories and resources.
2. Ways in which Indigenous Knowledge is gained.	• Oral traditions and storytelling: stories, dances, songs and ceremonies. • Ecological knowledge: plants, animals,	• Based on millennia of observation • Temporal and place based • Living • Kinship-based • Holistic	• Local history and genealogy • Fishing and hunting practices • Community conflict resolution and mediation practices • Spiritual beliefs and rituals

Questions	Group 1	Group 2	Group 3
	soil, water and weather. • Healing practices: traditional healing methods, herbal remedies such pottery, beadwork and craving. • Social norms and morality: It encompasses ethical guidelines, social norms and moral values that guide community interactions and relationships.		• Music and dance traditional
3. Consider different aspects of Indigenous Knowledge.	• By integration and recognition, • Holistic perspectives • Historical contributions • Traditional Ecological Knowledge	• Offers rich contexts which have the potential to contribute to understanding the relationship of environment and sociocultural. • Combine local development and application such as testing hypothesis, experiments and problem solving.	• Respect and reciprocity: Acknowledge indigenous knowledge holders' expertise and compensate them fairly • Holistic approach: consider spiritual, cultural and ecological aspects, not just physical.
4. Different ways in which maize seeds are planted.	• Row planting: in this method, maize seeds are planted in straight rows. • Hill planting: Raised ridges are created, and seeds are planted in top of these ridges. • Flat planting: Seeds are directly sown on flat ground.	• Add 1 bottle top of DAP fertiliser and a handful of well-rotted manure to each hole. Mix well with the soil. • Place 1 maize seed per hole, cover with a light layer of soil. • Maize seeds should be planted according to how moist the soil is.	• Broadcasting • Row planting • Hilling • Furrow planting • Raised bed planting • Intercropping

Questions	Group 1	Group 2	Group 3
5. Types of energies and how they are transferred.	• Elastic energy • Gravitational Potential Energy • Kinetic energy	• Energy that we get from food • Energy from the sun • Heat energy	• Elastic energy • Gravitational Potential Energy • Kinetic energy
6. The sum of kinetic and gravitational potential energies.	• Is the sum of the gravitational potential energy and the kinetic energy of the system.	• States that the total amount of mechanical energy in a closed system in the absence of dissipative forces (e.g. friction, air resistance) remains constant.	• **S**tates that the total amount of mechanical energy in a closed system in the absence of dissipative forces (e.g. friction, air resistance) remains constant.

To make more sense of the data during the discussion and analysis of the results from all groups, learners seemed to gain a basic understanding of IK. For instance, their explanations seemed to show an understanding that IK is gained through social interactions (Vygotsky, 1978), orally, and through experience (Kohsaka & Rogel, 2021). They also mentioned how this knowledge can be gained in different ways, including oral traditions, storytelling, and many other ways, as mentioned in Table 5.1 above.

As alluded to earlier, the main aim of asking these questions and generating this information was to guide the learners in fully understanding what IK is and how it is mostly gained. With question 3, however, they did not necessarily answer the question in the way that was expected. Instead, they considered different aspects of IK as illustrated in Table 5.1 above. This offered us an opportunity to learn and further understand what the expectations of the questions were.

Moreover, when answering question 4, these learners went above and beyond in gathering information about the different ways in which maize seeds are planted, including broadcasting, row planting, hilling, furrow planting, raised bed planting, and intercropping, among others. This showed me that there is more than one way in which maize seeds are planted at their homes and in their communities. They also gave different explanations of the conservation of mechanical energy. The theme that came out is that the conservation of mechanical energy is the sum of gravitation potential energy and kinetic energy.

On reflection, I observed that in the group activities sessions, learners found it easy to engage in argumentation (Iwuanyanwu, 2022). The group activities provided them an opportunity to express their views freely in a non-threatening environment (Fakudze, 2021; Onwu et al., 2020). Additionally, the interpretivist paradigm enabled the researcher to gain a deeper understanding of the experience and perceptions of the learners through the group activity (Alharahsheh & Pius, 2020). Also, they respected each other's opinions and preferred to use their home language, Sepedi, as a communication tool for learning and cognitive development (Vygotsky, 1974). In addition, I also learned that the learners' participation in argumentation enhanced their conceptual, epistemological, and methodological understanding of the questions they wanted to answer (Wambsganss et al., 2021). It also promoted their critical thinking as they asked each other questions to get the depth of the answers that each learner suggested. They reflected on and evaluated the evidence of their argumentation regarding the five guiding questions (Wambsganss et al., 2021).

After the completion and presentation of the first group activity, the learners were then given five questions to use when gathering data information from their homes and communities on how the components of kinetic energy can be explained using IK and how they plant maize seeds as the second group activity. Below are the five guiding questions:

1. Define kinetic energy with the aid of a diagram (at the top and the bottom).
2. Define gravitational potential energy with the aid of a diagram at the top and bottom.
3. Draw a mind map that explains what conservation of mechanical energy is.
4. How do you plant maize seeds at home (use a diagram to illustrate)?
5. In which month and season are maize seeds planted at your home in your community?

Each group was given 30 minutes for discussions and recorded their responses on newsprint as shown in the example in Figure 5.4 below. One member of the group presented the work after discussions with their classmates. The three groups maintained their initial group names from the first group activity, and the same codes were used.

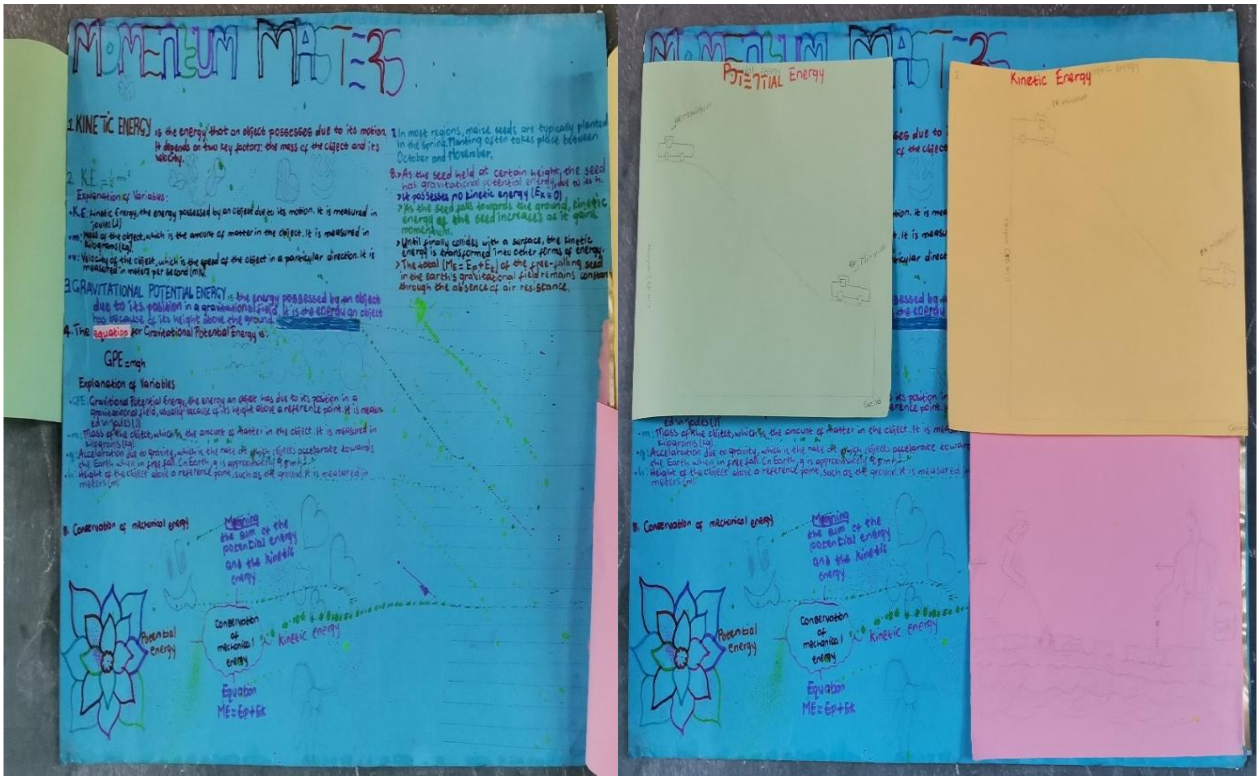


Figure 5.5: Newsprint presented by Momentum Masters

From the learners' group presentations, six themes emerged: kinetic energy: energy of motion; potential energy stored in an object due to its height; traditional maize ploughing; ploughing hole size; maize ploughing season; and relating maize ploughing with conservation of mechanical energy. These themes are used to discuss the data in order to answer the study's research question one. I read all three learners' group presentations and then summarised them as shown in Table 5.2 below.

Table 5.2: Showing group responses from the group activity

From Guiding Questions	Hash Tag Lets Do it Code G1HLDT	Momentum Masters Code G2MM	Together As One Code G3TAO
Theme 1 Kinetic energy: energy of motion	A bird has minimum kinetic energy at the top of a rondavel and maximum energy at the bottom of the rondavel.	A mini track has minimum Kinetic energy at the top of the hill and maximum kinetic energy at the bottom of the hill.	The ball at the top of the cupboard has minimum kinetic energy and it has maximum kinetic energy at the bottom of the cupboard.

From Guiding Questions	Hash Tag Lets Do it Code G1HLDT	Momentum Masters Code G2MM	Together As One Code G3TAO
Theme 2 Potential energy stored in an object due to its height.	The same bird as maximum potential energy at the top of the rondavel and minim potential energy at the bottom.	The same mini track has maximum potential energy at the top of the building and minimum potential energy at the bottom.	A bird has maximum potential at the top of the tree and minimum potential energy at the bottom.
Theme 3 Traditional maize ploughing.	Ploughing using a tractor by making furrows and dropping the seeds inside them.	Ploughing using a hoe to dig a hole and put the seeds inside the hole and covering it with soil.	Ploughing using a hoe by digging a hole and dropping the seed inside the hole.
Theme 4 Ploughing hole size.	Make sure that when you dropped the seed it falls between the furrows not the bottom or at the top.	Make sure that the hole is not too deep or too shallow because that will impact the growth of the maize seed.	Make a medium sized hole of about 2cm deep.
Theme 5 Maize ploughing season.	Dryland maize planting can commence between late-September to mid-December at spring and still get relatively good yields irrespective of the growing season of the cultivar.	In most regions, maize seeds are typically planted in the spring, planting often takes place between October and November.	We usually plant the first maize seeds in September each year when there is rain and in the northern hemisphere in the Spring season.
Theme 6 Relating maize ploughing with conservation of mechanical energy.	The total amount of mechanical energy in closed system in the absence of dissipative forces remains constant. This means that potential energy and kinetic energy cannot disappear.	As the seed held at certain height the seed has gravitational potential energy, due to its height. It possesses no kinetic energy ($E_K = 0$). As the seed falls towards the ground, kinetic energy of the seed increases as it gains momentum. Until it finally collides with a surface, the kinetic is transformed into other forms of energy. The total ($M_E = E_P + E_K$) of the free-falling seed in the earth's gravitational field remains constant through the absence of air resistance.	Start by explaining the process of planting maize seeds and the energy required to initiate growth. Use the analogy to illustrate how energy is converted from potential to kinetic and back to potential during the growth process.

The results showed that all the groups seemed to know what kinetic and gravitational potential energy are and how they can be effectively explained in relation to traditional maize seed ploughing. This was further shown when they used examples from home experiences and everyday experiences to show how they are converted. This showed that giving the learners the opportunity to facilitate their learning allowed them to think of ways in which kinetic and potential energy could be converted. For example, groups G1HLDT and G3TAO gave examples of a bird falling from the top of the rondavel and a cupboard to the bottom as examples of how potential energy is converted into kinetic energy. They used the example of a bird because the area in which they lived had a lot of different birds. This emphasises the importance of situated learning in science classrooms.

In the first group activity, the learners gave different ways in which maize seeds are planted. However, in the second group activity, the learners only mentioned two ways in which maize seeds were planted, which were with a hoe or a tractor. This was the knowledge that they knew. Group G2MM explained:

> *As the seed held at certain height the seed has gravitational potential energy, due to its height. It possesses no kinetic energy (EK = 0). As the seed falls towards the ground, kinetic energy of the seed increases as it gains momentum. Until finally collides with a surface, the kinetic is transformed into other forms of energy. The total (ME = EP + EK) of the free-falling seed in the earth's gravitational field remains constant through the absence of air resistance.*

On the other hand, G3TAO explained the relation this way:

> *…start by explaining the process of planting maize seeds and the energy required to initiate growth. Use the analogy to illustrate how energy is converted from potential to kinetic and back to potential during the growth process.*

From these excerpts, it could be surmised that the learners were able to identify the energy conversions that happened during the maize planting process. Like the first group activity, learners were able to argue about and engage with their existing knowledge (Govender, 2016; Gwekwerere, 2016). This further gave them an opportunity to express their views freely in a non-threatening environment (Fakudze, 2021; Onwu et al., 2020), and they respected each other's opinions. The learners seemed to enjoy learning in a non-graded and pressure-free environment when trying to get the correct answer when asked questions. Notably, both girls and boys were interactive.

Regarding the presentations, girls presented mostly in English and enjoyed being selected as group leaders. However, boys presented mostly in Sepedi. This was because most of the girls were part of the school's debating team and were used to presenting in English. The boys seemed to be comfortable and enjoyed expressing themselves in their mother tongue. This means that when learners are given a chance to interact in a relaxed atmosphere and are allowed to use the language they are comfortable with to scaffold learning, they can co-construct knowledge better. This resonates with Vygotsky's (1978) sociocultural theory, which emphasises the importance of culture and language during the mediation of learning, enabling learners to relate what is taught in class with their existing knowledge. Moreover, this aligns with Ogunniyi's (2007a) equipollent cognitive state, in that both languages were afforded equal status during these group presentations.

When it came to planting maize seeds, students appeared to understand the process. For example, G1HLDT commented: "*Ploughing using a tractor by making furrows and dropping the seeds inside them",* and G3TAO commented*: "Ploughing using a hoe by digging a hole and dropping the seed inside the hole"*. In addition, they explained the rationale behind their traditional maize seed practices and were able to apply that information to science.

5.3 Presentations by Indigenous Knowledge Custodians

The knowledge gained from the IKCs' presentation was then used to co-develop an exemplar lesson that integrated learners' IK into the topic under consideration.

Figure 5.6: [3]Showing the two IKCs: MaSebetha (blue) on the far left, next to her is MaMoyo (light pink)

[3] The IKCs consented for their photographs to be used.

Figure 5.6 above shows the two IKCs with the learners and me who co-presented their skills, wisdom, and knowledge of traditional maize seed ploughing using a hoe to the Grade 10 Physical Sciences learners. Similarly to Mayana's (2024) study, their clan names were used instead of giving them pseudonyms, for example, IKC one is [4]MaSebetha and IKC two is MaMoyo. If I gave the participants pseudonyms, calling them by those names would still violate the cultural rule, which says adults are not supposed to be called by their first names as it is considered disrespectful (Mutanho, 2021). The clan names were used throughout the thesis to level power issues and show respect.

The background of the two IKCs shows that there were similarities and differences between them. Both were female and Sepedi home language speakers. Both MaSebetha and MaMoyo were born in Kitty Village and had been doing substantive farming all their lives. Their ages were different, with MaMoyo being the oldest. Both have never worked formally until now as the cooking ladies at the school where the demonstrations were conducted. Both left school at standard 2, now known as Grade 9. The knowledge they currently have, they learnt from their parents who depended on subsistence farming to feed their families.

5.4 Summary of the Presentation by IKCs

The IKCs demonstrated and explained the process of traditional maize seed planting. Both were women, and they presented in Sepedi. Data generated from their presentations sought to address the following research question:

> *How do the Indigenous Knowledge Custodians' presentations on the traditional ploughing of maize seeds and the consolidation thereof enable and/or constrain Grade 10 rural school learners to argue and make sense of the conservation of mechanical energy?*

All 15 Grade 10 Physical Sciences learners, including those who participated in the focus group interviews (sharing circles), which are discussed in Chapter Six (Section 6.3), participated in the presentation by the IKCs. Also, I invited a critical friend to participate and video-record the

[4] 'Ma' prefixed to the woman's surname or clan name.

presentations with the permission of the participants. The presentations allowed the IKCs to showcase their skills, wisdom, and knowledge of traditional maize seed planting. From the IKCs' presentations, I developed some episodes and then combined sub-themes into themes in relation to the theory and literature. The themes and sub-themes are shown in Table 5.3 below.

Table 5.3: Shows the sub-themes and themes that emerged from data and supporting theory or relevant literature

Themes	Sub-themes	Literature	Theory
Theme 1: Nature of social interaction	Learner talk Asking questions Observing	Kim et al. (2018); Kim (2022)	Vygotsky (1978) SCT
Theme 2: Nature of participation	Explaining Promoted hands-on practical demonstration and visualisation Promoted double stimulation	Asheela et al. (2021); Bobek et al. (2016); Evagora et al. (2015) Mavuru and Ramnarain (2020) Morselli & Sannino (2021)	Vygotsky (1978) SCT Vygotsky (1978) SCT; Engeström (2014) CHAT
Theme 3: Nature of learning opportunities	Promoted border crossing and collateral learning Promoted arguments and dialogue Using language as a cultural resource Sense making	Aikenhead and Jegede (1999) Fakudze (2021); Amsa et al. (2020); Kim et al (2018); Govender (2016) Hewson et al. (2009) Fitzgerald and Palincsar (2019); Sengul et al. (2020)	Ogunniyi (2007a) Contiguity Argumentative Theory (CAT) Ogunniyi (2007a) CAT; Vygotsky (1978) SCT; Langenhoven and Stones (2013) DAIM Vygotsky (1978) SCT Vygotsky (1978) S

In this section, I present and discuss the themes that emerged from the presentations by the IKCs in relation to the literature and theory. Vygotsky's (1978) sociocultural theory (SCT) and the DAIM were used during data interpretation and discussion (Sections 4.5.1 and 4.5.2). For instance, Vygotsky (1978) argues that learners' cognitive development occurs during social interactions. He further states that as learners participate in different activities and internalise the effects of working together, they acquire new learning strategies.

In addition, extending on Ogunniyi's (2007a) CAT, Fakudze (2021) argues that DAIM provides learners with a learning environment that motivates them to express themselves freely and exchange views. Moreover, it affords learners an opportunity to reflect on what they have learned and even change their minds once presented with a stronger argument. As learners argued, they used language, leading to knowledge construction and sense making of science concepts. This makes language a cultural resource that makes science relevant. Drawing from Ogunniyi's (2007a) CAT, Anga'ama (2021) concurs that argumentation enhances learners' understanding of science and alerts them to the need to integrate IK into science and makes them understand that the two worldviews can complement each other in science classrooms.

5.4.1 Nature of social interactions between IKCs and learners

When we arrived at the school garden, the IKCs were so welcoming and generous, willing to share their wisdom, skills and knowledge of maize seed planting with the learners. Out-of-school science learning offers numerous benefits, including fostering a deeper understanding of scientific concepts, developing critical thinking and problem-solving skills, and promoting lifelong learning and a love for science, all while encouraging creativity and real-world applications (Neher-Asylbekov & Wagner, 2023). This is an aspect of Ubuntu, and as such, through the interactions, relationships were established. Notably, the two IKCs decided to co-present the traditional method of maize seed planting to my Grade 10 Physical Sciences class from Dimpe Secondary School (pseudonym).

I observed that learners were very excited and motivated to learn as the environment was non-threatening. They expressed themselves freely and asked questions of the IKCs when trying to understand their presentations. By asking questions of the elders, the learners challenged the cultural barriers and stereotypes (Ivana, 2022), because in Sepedi culture, we are not allowed to question the elders. This author believes that each culture has its own set of norms, such as those regarding behaviour and communication and there is a mutual understanding among members of the same culture. Therefore, within the context of this study, questioning elders in our culture is not allowed, yet my learners broke this cultural barrier.

For example, L3F asked MaMoyo, who was demonstrating how to prepare the soil before planting the seeds: *"Ke ka lebaka la eng re swanetše go lokišetša mmu pele re bjala dipeu tša lehea*?" (Why do we have to prepare the soil before we plant the maize seeds?). MaMoyo answered and said:

> *Go lokišetša mmu pele ga go bjala dipeu tša lehea go bohlokwa kudu ka lebaka la gore go kaonafatša sebopego sa mmu, go godiša go hwetšagala ga phepo, go tšwetša pele go ntšha*

meetse gakaone, le go thuša go laola mengwang, yeo ka moka e lego bohlokwa go kgolo ya dibjalo ye e phetšego gabotse le poelo ya godimo (Preparing soil before planting maize seeds is crucial because it improves soil structure, enhances nutrient availability, promotes better drainage, and helps control weeds, all of which are essential for healthy plant growth and high yields).

Weeks before the IKCs came to do their practical demonstrations, they advised us to irrigate the soil daily since the ground was too dry due to the delayed rains. MaSebetha explained: "*Monola wa mmu o bohlokwa kudu go mela ga lehea ka fao go bjala ka mobung wa monola go bohlokwa*" (Soil moisture is critical for maize germination, so planting into moist soil is essential).

The IKCs co-demonstrated the process of maize seed planting, starting by asking the learners to water the ground in preparation to start ploughing maize seeds. Before the learners started to water the ground, MaMoyo gave this instruction: *"Le seke la nošetša mmu go feta tekano gobane ge re ka dira seo dipeu tša rena di ka se gole eupša di tla bola"* (Do not over water the soil because if we do that our seeds will not grow but rot). Although the IKCs had no formal teaching experience, they encouraged learners to ask questions to ascertain if they clearly understood their presentations.

My critical friend and I were co-learners in the study; therefore, we also interacted with the learners and the IKCs during the presentation by asking questions. For instance, my critical friend wanted to know from the IKCs how deep to plant the maize seeds, and she said: "*Kamoo go tsenelela go bjala dipeu tša lehea?"* MaMoyo answered and said:

> *Ga ke na dikelo tše di nepagetšego le ge go le bjalo lešoba ga se la swanela go ba le le tseneletšego kudu goba le le sa tsepamago kudu. Ge lešoba le tseneletšego kudu peu e tla tšea nako ye telele go mela gomme ge e le ye e sa tsepamago kudu dipeu di tla mela le ge go le bjalo lehlaka le tla robega gabonolo (I don't have the exact measurements; however, the hole should not be too deep or too shallow. If the hole is too deep, the seed will take longer to germinate, and if too shallow, the seeds will germinate; however, the stalk will break easily).*

The IKCs indicated that they used a hoe to dig up the holes. At this stage, I asked the IKCs to slowly demonstrate the dropping of the seeds inside the holes, closing the holes and covering the seeds with the soil. My critical friend (MaNgwepe), who is also a Physical Science teacher, after observing that seeds are planted in rows with spaces in-between said: *"Did you notice how the IKCs make sure that there's enough space in-between for the seeds to grow nicely"*.

Figure 5.7: IKCs explaining the maize seed ploughing process.

5.4.2 Nature of participation

MaSebetha and MaMoyo took us through a step-by-step process to help us clearly understand the method of traditional maize seed planting. As the IKCs demonstrated the process, both the learners and I took notes and asked questions of the IKCs to ensure that we followed the process correctly, while MaNgwepe (my critical friend) took photos, and video recorded the process with the participants' permission. I thus discuss this step-by-step process as explained by the IKCs below.

5.4.2.1 Process of planting traditional maize seeds

Below, I will discuss the steps to be taken before and during maize seed planting from the stories of the two IKCs and my grandparents, whose clan names are used in this study. My grandmother's clan name is Mogaleadi, and my grandfather's clan name is Tlou. I initially planned to use my grandparents as principal IKCs; however, because of their ill health, they could not make it. Fortunately, they managed to tell me stories that concurred with the IKCs' stories about the process that should be taken before and during maize seed planting.

Figure 5.8: Me and my grandparents (parents of my mother)

- **Preparation of the soil**

Tlou said, *"Pele ga pšalo ya dipeu tša lehea mmu o swanetše go lokišwa ka tshepedišo ye e bitšwago goParaka (go hlakanya mmu le manyoro a gotswa tsakeng)"* (Before the planting of the maize seeds, the soil needs to be prepared by a process called goParaka (mixing soil with kraal manure)). The preparation of the soil for maize cultivation using kraal manure includes spreading the manure evenly over the plot in August and September, and working it into the soil, allowing it to decompose before planting. This process is time-consuming, and it involves hard labour, Tlou said. Kraal manure is a natural fertiliser made of dried cow dung. It is considered to be the fertiliser compared to nitrogen, phosphorus and potassium (NPK) manure by both grandparents and the two IKCs because it is free and full of nutrients needed for the overall health of the plant. Nwodoka et al. (2016) and Solomon et al. (2012) also argue that cow manure is an effective organic fertiliser for maize cultivation. While inorganic NPK fertilisers generally produce taller plants (Nwodoka et al., 2016; Solomon et al., 2012), cow manure can yield comparable results in terms of leaf number, stem diameter, and biomass (Nwodoka et al., 2016; Solomon et al., 2012).

Nitrogen-enriched cow dung has demonstrated grain yields similar to inorganic fertilisers, while also improving soil nutrient content (Ayoola & Makinde, 2008). Cow manure biochar application significantly enhances maize yield, nutrient uptake, and water use efficiency in sandy soils (Uzoma et al., 2011). Figure 5.2 shows the two types of manure kraal: cow manure (left) and NPK (right).

Figure 5.9: Kraal cow manure (left) and NPK manure (right)

- **Moisture**

After the preparation of the soil, it is a waiting game for the first rain to come and water the fields, because, as Mogaleadi said, *"Monola o bohlokwa kudu pele ga pšalo ka ge seo se netefatša gore dipeu di hwetša meetse a go lekana go mela"* (Moisture is very important before planting as that ensures that the seeds get enough water to germinate). This was similar to MaSebetha, who said, *"Pula ya mathomo ya ngwaga e bohlokwa kudu go pšalo ya mabele ka lebaka la gore e fa monola wo o nyakegago go mela ga peu le kgolo ya mathomo ya dibjalo*" (The first rain of the season is crucial for maize planting because it provides the necessary moisture for seed germination and initial plant growth). Rusinamhodzi et al. (2011) concur that when adequate fertiliser is available, rainfall becomes the most critical determinant of maize yield in southern Africa. If it does not rain at the expected time, dry-soil planting takes place. However, excessive rainfall can be detrimental, potentially destroying crops or reducing plant population (Rashid & Rasul, 2011).

- **Planting the maize**

Tlou's said we usually start planting maize seeds from the 16th of December each year, whereas MaMoyo said *"Re thoma go bjala ka December"* (We start planting in December). Tlou further elaborated, saying *"Re thoma go lema dipeu tša lehea ka di 16th December ka gore ka nako yeo pula ya mathomo ena e nele"* (We start ploughing maize seeds on the 16th of December because by then the first rain has fallen). "*In the olden days, many people in the community used ploughs drawn by oxen; however, now ploughs are drawn by tractor",* Tlou said. He elaborated that if we are ploughing in our gardens, we use hoes instead of a tractor because the space is too small for a tractor, or it is cheaper to use a hoe than to hire a tractor.

At the fields, the tractor starts by dropping the plough onto the ground, then the planters of different heights follow the tractor and drop the maize seeds inside the row made by the plough, Mogaleadi said. The planters should not drop the seeds at the bottom of the rows or on top of the rows rather in the middle of the row, Tlou said. The reason being that if they drop the seed at the bottom of the row, the seeds take longer to pop up from the ground and if at the top, the seeds will pop out of the ground quickly; however, if they are in the middle, the roots will grow deep enough to stabilise the stalk, Tlou said.

5.5 Chapter Summary

In this chapter, I presented, analysed and discussed data from learners' group activities and the four IKCs' presentations. The main aim of the chapter was to answer my first and second research questions of this study. I also used my observations during the participatory observation to check whether learners' sense making of the conservation of mechanical energy shifted or not as they interacted with the IKCs. It became evident that IK could be used to teach scientific concepts that seem abstract to learners, as the learners were arguing with each other on the kind of scientific concepts that emerged from the practical demonstrations.

Moreover, the interactions between the IKCs and the learners were made possible using learners' local language, Sepedi, as this allowed them to engage freely in a non-threatening environment. The IKCs engaged learners actively, and as a result, they were free to ask questions, breaking the cultural barrier (Ivana, 2022) of not questioning elders. The use of easily available resources (Asheela et al., 2021; Shinana et al., 2021) from the community, such as maize seed planting, enabled learners to identify scientific concepts that emerged from their presentations. Lastly, the findings from the learners' group activities on *stories* told when sitting around the fire revealed that they deemed that some stories were not relevant to science. Arguably, this depends on the listener's analysis of the story as espoused by Seehawer et al. (2022). In the next chapter, I present, analyse and discuss data generated from focus group interviews (sharing circles), lesson observations and learners' reflective journals.

CHAPTER SIX: LESSON OBSERVATION, FOCUS GROUP INTERVIEWS (SHARING CIRCLES) AND LEARNERS' JOURNAL REFLECTIONS

6.1 Introduction

In the previous chapter, I presented, analysed and discussed qualitative data from learners' group discussions and the participatory observation during the practical demonstrations by the two IKCs. In this chapter, I thus present, analyse and discuss qualitative data from lesson observations in which I used a lesson exemplar that integrated IK into learning the conservation of mechanical energy, focus group interviews (sharing circles), and learners' journal reflections. The data sought to answer my fourth research question:

> How do exemplar lessons that integrate the traditional ploughing of maize seeds enable and/or constrain Grade 10 Physical Sciences learners from a rural school to argue and make sense of the conservation of mechanical energy?

6.2 Data Generated from Lesson Observation

Kraus (2023) defines observing as watching and mentally grasping an ongoing process. This resonates with the process of lesson observation in this study. MaNgwepe, who was my critical friend, observed the lesson module that I presented in class to learn from and reflect on it. Thus, in this section, I discuss data generated from what I presented on the conservation of mechanical energy and the intervention lesson that integrated IK in the above-mentioned topic. All the lessons were video recorded with the permission of the participants.

Table 6.1: Shows data gathering tools and codes discussed in this section

Data gathering tools	Codes used
Lesson on practical activity after intervention	LPAAI
Lesson module that integrated INDIGENOUS KNOWLEDGE	LMIK
Sharing circles interview Learner-codes in sharing circles interview	SCI
Learner journal reflections	LJR

Source: Adapted from Nuntsu (2020)

A lesson that introduced learners to the conservation of mechanical energy was taught in class before the intervention; hence, the study employed a Vygotskian perspective of double stimulation (Sannino, 2015). Learners were asked to draw a mind map based on the scientific concepts involved in the conservation of mechanical energy. This was coded as LPAAI (lesson on practical activity after intervention). After the lesson presentation in class, learners were taken to the school garden where traditional maize seeds dropping was presented with the hope of identifying science concepts related to the conservation of mechanical energy from this demonstration. After the presentation by the IKCs, my critical friend and I co-planned an exemplar lesson that integrated IK into learning the conservation of mechanical energy. This was coded as LMIK (Lesson module that integrated IK) in the study. The lesson module was taught in class while my critical friend observed.

Then, I used a sharing circle interview coded as SCI in the study to ascertain how learners found the presentation by the IKCs and the exemplar lessons that integrated IK into the conservation of mechanical energy. The aim was to see if there was a shift or not in learners' sense making of the topic. During the SCI, learners' clan names were used to level power gradients (Mutanho, 2021) and to create a non-threatening environment so that they could argue freely. They were coded, for example, L1K (for learner one whose clan name was Kwena).

The SCI was complemented by using learners' journal reflections since not all learners took part in the SCI. However, only 10 learners managed to submit their journal reflections. The journal reflections were coded as L1JR to L10JR (learner 1 journal reflections to learner 10 journal reflections).

6.2.1 Data generated from lessons on conservation of mechanical energy

In this section, I present and discuss the data that emerged from lesson observations. During the observations, learners were tasked with observing me as I presented the traditional way of maize seed planting, focusing on the dropping of the seed inside the holes or rows made. The lesson took about one hour. My critical friend (MaNgwepe) was also there to observe me while I was teaching the lesson I had planned with her. The lesson observations provided an opportunity for the learners to engage with me as I was presenting. These observations were conducted in an authentic cultural setting. We used a sharing circle instead of the traditional way of sitting in class.

Figure 6.1: During lesson observations

As alluded to earlier, I presented a lesson on the conservation of mechanical energy prior to the intervention exemplar lesson that integrated IK. In this lesson, learners investigated the scientific concepts of mechanical energy. Furthermore, the lesson emphasised that the gravitational potential energy of the object above the ground has a value, while kinetic energy is equal to zero, and gravitational potential energy at the bottom is zero, while kinetic energy has a value. Learners were asked to draw mind maps of learned science concepts (Figure 6.2 below).

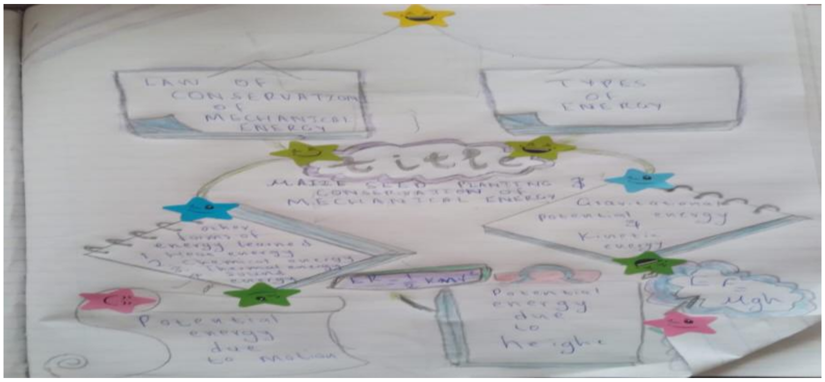


Figure 6.2: Hash Tag Let's Do it concept map

Their next activity was a hands-on practical activity. Learners planted their maize seeds in their groups in the garden, doing exactly what they learned from the IKCs. This activity provided the learners with a practical understanding of the relationship between kinetic energy and gravitational potential energy as they were dropping the maize seeds inside the holes they have created using a hoe, fostering an interactive and immersive learning environment.

Figure 6.3: Learner practical activity

The thematic analysis revealed two main themes that emerged from the observations (as presented in Table 6.2 below).

Table 6.2: Themes that emerged from lesson observations

Theme	Description
Enhanced learning experience through the integration of IK into science education	The incorporation of IK to enrich the learning experience in the context of science education
Experiential learning through hands-on activities	Learning was facilitated through practical, hands-on activities to provide direct experiences and engagement with the subject matter

6.2.2.1 Theme 1: Enhanced learning experience through the integration of IK into science

The lesson I presented was on the conservation of mechanical energy. The learners were grouped into three groups. Each group had five members. For an ice-breaking activity, I asked my learners to tell me how they plant maize seeds at their respective homes. Koena noted: *"Rena ka gae re bjala ka mogoma gape re tsomisa manyora a dikgomo"* (We at home, we plant with a hoe and cow manure). Tlhanagane said: "*Kua masemomg re tsomitsa trekere go lema*" (In the fields we use for a tractor to plough). For the second activity, I asked the learners to explain how mechanical energy can be further explained using daily activities. Moroka'a pula said: *"Ge re raloka polo kua lebala, re iragela godimo"* (The ball is kicked upwards while we play soccer on the field, and it gains gravitational potential energy going up).

The first theme that emerged from the lesson observation was the enhanced learning experience by integrating IK into science teaching and learning. The exemplar lesson I taught on conservation of mechanical energy aimed to integrate learners' IK of the traditional way of maize seed planting with modern science. This approach produced positive results as learners were actively engaged in the lesson. Each learner enjoyed planting the seeds, with Keona saying, "*Ga se nke ka nagana gore re ka tswalanya physics le go bjala dipeu tša lehea yeo e lego karolo ya agricultural sciences"* (I never thought that we could relate physics with maize seed planting, which is part of agricultural sciences). Notably, Keona was usually a shy learner who did not like to talk too much in class. However, in the garden, she was very talkative and interactive. The literature consistently highlights the numerous benefits of learning environments beyond the traditional classroom, emphasising their potential to enhance engagement, learning, and well-being, as shown with

Keona (Singh, 2024). These benefits include increased student engagement, improved academic outcomes, and positive social-emotional development (Singh, 2024).

This suggests that the use of the traditional way of maize seed planting activity as a medium has the potential to facilitate learning of mechanical energy, as this significantly heightened their interest and participation. Integrating IK into science education is vital as it allows for the assimilation of cultural perspectives and traditional wisdom into the learning process. By recognising and valuing IK, learners are provided with a more holistic understanding of scientific concepts, fostering a sense of cultural pride and identity. This result aligns with the findings by Wilujeng and Prasetyo (2018), who reported that by incorporating IK into science education, students can benefit from a more holistic and culturally relevant learning experience that enhances their understanding of science while also connecting the gap of science education pathways that a learner obtains in schools and community. Similarly, Ngai et al. (2010) highlighted that integrating Indigenous cultures into education can promote intercultural understanding and improve outcomes for Indigenous learners.

In the context of the conservation of mechanical energy lesson, the integration of IK not only enriched the learning experience but also allowed learners to connect with the subject matter on a deeper level, promoting meaningful and contextualised learning. This is in line with Van Zyl et al.'s (2023) study, which underscores that integrating IK into modern science in the form of community-based learning assists students to contextualise and broaden their understanding of communities' health needs and develop collaboration and communication skills. This approach had a positive effect on my learners by creating a sense of cultural relevance and authenticity, thereby enhancing their motivation and engagement in the learning process.

In addition, during the delivery of the exemplar lesson on maize seed planting, my critical friend, MaNgwepe, was videotaping. After the lesson, she also reflected and highlighted the positive effect of integrating IK into science lessons (Figure 6.4 below).

Figure 6.4: Reflecting on lesson observation with my critical friend after the lesson

MaNgwepe further agreed with the approach and mentioned that she would adopt a similar strategy in her classroom. She reflected:

> *The lesson was great. It includes their culture and must not be erased by Western life. Because our learners think Western culture is better than our culture. They undermine their culture, so lessons like these will bring back that dignity to our knowledge. Even by bringing the community members into our classrooms and displaying more, they will understand that if adults know about it and even at school is being taught, that will mean something to them. That will be sustainable for our learners. Even in my classroom, I would integrate IK and bring community members because learners learn more from them. They are the best modellers who will be modelling the reality.*

From this excerpt, it could be deduced that MaNgwepe passionately advocates the preservation and integration of IK into education, emphasising its vital role in restoring cultural dignity, combating the prevalent perception that Western culture supersedes Indigenous traditions and instilling a sense of dignity and pride in learners regarding their knowledge systems. Her insight underscores the importance of incorporating community members into the educational process, highlighting their influence as role models and their capacity to impart authentic, experiential knowledge to learners.

Furthermore, MaNgwepe's perspective emphasises the importance of integrating IK into science education to counterbalance the dominance of Western-focused science content with contextually relevant knowledge from communities. Furthermore, the literature highlights the potential of integrating IK to enrich science education and improve educational outcomes for Indigenous students who have long been underrepresented in current education systems (Jin, 2021). Similarly, Handayani (2018) noted that including IK in the science curriculum provides a new perspective on science learning and contributes to cultural sustainability. In addition, the integration of IK can promote scientific literacy and enhance the relevance and authenticity of science learning materials (Parmin & Fibriana, 2020; Rajagukguk et al., 2020).

6.2.2.2 Theme 2: Experiential learning through practical and hands-on activities

The second theme that emerged from the lesson observation was experiential learning through hands-on practical activities. During the lesson on conservation of mechanical energy, we went out to the garden and used it as our classroom for the day. Learners actively participated in planting the maize seeds. Learning was facilitated through hands-on practical activities to provide direct experience and engagement with the subject matter (Asheela et al., 2021). The learners' active engagement and visible signs of enjoyment during the lesson underscored the effectiveness of experiential learning.

For instance, when asked what they enjoyed about the lesson, MaMoloko enthusiastically replied: *"Ke be ke thabela go bjala merogo go tšwa sekolong sa tlasana gomme ke be ke le karolo ya komiti ya dirapana moo, ka fao go ithuta fisiks ka go lema dirapana*" (l enjoyed planting vegetables from primary school and I was part of the garden committee there, it's the best experience for me hence). Koena further said: *"Ke kgona go lebelela ka moo gravitational potential energy a fetošetšwago kinetic energy ke lebeletse"* (I can observe how gravitational potential energy is converted into kinetic energy in real time). These responses highlight the use and importance of hands-on practical activities in the conservation of mechanical energy lesson. By promoting active participation (Sedlacek & Sedova, 2017), experiential learning enhances learners in their understanding of mechanical energy and fosters a sense of excitement and curiosity about the topic.

Moreover, by providing direct experiences through hands-on activities, learners were able to explore and interact with the maize planting tools, such as a hoe, thereby gaining a deeper understanding of the conservation of mechanical energy. This approach not only caters to diverse learning styles but also facilitates a more profound and memorable learning experience by enabling learners to internalise abstract concepts through tangible experiences. Furthermore, the enjoyment and enthusiasm displayed by the learners during the practical activities indicated a heightened level of motivation and engagement, contributing to a more authentic learning experience.

Previous studies have also emphasised the value of experiential learning through practical activities in promoting learner engagement and understanding (Lê & Tran, 2023; Sumarmi et al., 2020; Voukelatou, 2019). For instance, research by Sumarmi et al. (2020) demonstrated that experiential learning models enhance learners' learning scores. Furthermore, a case study by Voukelatou (2019) demonstrated the significant impact of experiential learning on acquiring knowledge and developing social skills, contributing to the promotion of cultural heritage and traditional values in secondary education. Lê and Tran (2023) also found that experiential learning in the context of teaching the Vietnamese language in secondary schools effectively encourages learners to analyse and apply knowledge to real-world situations. Moreover, Murray (2018) emphasised that experiential learning is an educational orientation aimed at integrating theoretical and practical elements of learning.

6.3 Data Generated from the Sharing Circles

Sharing circles are like focus groups, and they are concerned with gaining knowledge through discussions (Chilisa, 2012; Lavallee, 2009). The purpose of using a sharing circle interview in this study was to establish how learners found the experience of having the IKCs present to them and learning the concept of conservation of mechanical energy using their local knowledge. Not all learners participated in the SCI, and only five were selected by others to participate.

When asked the reasons for being selected to represent others in the SCI, one of the learners, L5T, commented: *"They selected me because they know I can speak without being ashamed of others"*. Using SCI resonates well with the way cultural knowledge is shared at home through storytelling when sitting around the fire. This is a traditional way of sitting in a circle and it levels power relations. It also provides all participants with an opportunity to express their views in a non-threatening environment, where everyone gets an equal opportunity to share knowledge and is free to argue. Notably, this approach resonates with the Ubuntu perspective where people relate as equals with respect to their values, needs and opinions (Ogunniyi, 2021; Seehawer, 2023).

To ameliorate power dynamics in my study, my clan name and those of the learners were used during the SCI. This created a friendly atmosphere where learners freely shared their knowledge and thoughts and respected each other's views. However, there were those learners who tried to dominate the interview, but I managed to control the situation by explaining to them that it was important that everyone should get an equal chance to share their opinions. Mostly, girls were more vocal as they could proficiently express themselves in English. This was evident as L4MZ said: *"I was chosen to be part of the interview because they know that I can speak English clearly and with confidence"*. To mitigate the situation, I allowed the boys, who struggled to express themselves in English, to use Sepedi, their mother tongue. As a result, even those who were shy about expressing their views spoke. This showcased the spirit of Ubuntu, being there for each other, respecting and valuing each other, and revealed that learners who were regarded as weak in class could argue when provided with an opportunity to do so.

Using clan names also helped build relationships between the learners and me, as they viewed me as the co-constructor of knowledge rather than their science teacher. Even after the data gathering process, learners still used my clan name in class while respecting me as their teacher. Another important aspect that emerged from these relationships was that, similar to Seehawer et al.'s (2022) study, a community was developed. It appeared that using clan names made my learners very happy and free to express themselves. This reduced tensions and improved power relations, and as a result, learners freely asked questions in class and actively participated in my lesson.

During the SCI, learners indicated that they enjoyed observing the IKCs' practical demonstrations of maize seed dropping during the planting. What was outstanding to them was the science that emerged in this demonstration. They alluded to the fact that they were not aware that traditional maize seed dropping had science embedded in it. For example, L6DL commented: *"I was not aware that dropping maize seeds inside the hole converted gravitational potential energy into kinetic energy"*. Also, they acknowledged that what they did at home related to science taught at school; the only difference was that, at school, terms were used. For instance, L5T stated: "*I always play soccer with my friends, and I didn't know that as the ball at the top in the air has gravitational potential energy and when it reaches the ground it gains kinetic energy"*. Regarding the lesson consolidation using the exemplar lesson that integrated IK into science, learners found this experience very interesting. For instance, L5T commented:

> *I could understand the lesson easily, because we been ploughing maize seeds like this for years at home, I mean it's like relating the knowledge that I already have from home with sciences. I must say ke kwa bose (I am enjoying myself).*

From the above excerpts, it was evident that learners easily understood science concepts when their IK was integrated. This is consistent with the views of Seehawer (2021), who argues that integrating learners' IK into science familiarises them with science concepts by connecting them to their daily life activities. More so, learners revealed that they had prior knowledge of planting maize seeds at home, and this helped them understand the lesson clearly and easily. This was evident as L6DL stated: *"I enjoyed the lesson, it helped me to understand science more"*. In line with these learners' points of view, it was evident that learners come to school with their local knowledge, but due to cognitive dissonance (Le Grange, 2007), they are unable to connect this knowledge and, in the process, make sense of scientific concepts. This made me realise that I had been depriving my learners of an opportunity to see science as fun and interesting by using methods of teaching and learning that decontextualised science from learners' sociocultural backgrounds (Mavuru & Ramnarain, 2020). Hence, learners considered it an abstract and boring subject. However, the intervention strategy helped them cross the river that was situated between their home and school. After the intervention, science was clearer, accessible, and relevant to them in their own contexts, becoming familiar to them. Consequently, their sense making of the topic and related concepts shifted.

Figure 6.5: Showing the sharing circle in the classroom

6.4 Data Generated from Learners' Journal Reflections

The purpose of using learners' journal reflections was the same as that of the SCI, as explained earlier – to find out how learners found the experience of observing the IKCs' presentations and the exemplar lesson that integrated IK into learning the conservation of mechanical energy. However, the focus was on those learners who did not participate in the SCI; some because they were too shy to speak and would rather write. Only eight learners managed to submit their journals, mostly girls. These girls claimed that they enjoyed the strategy of reflecting after every lesson taught. As a result, they even suggested that they would appreciate it if other teachers could adopt this strategy, as it helped improve their language proficiency and would help their teachers identify areas where they lacked understanding of the lessons. This was evident as L3MX commented: *"To me, if we can do reflections after each lesson taught so that the teacher can know if we understood the lesson or not. I feel like other teachers can use the same method"*. L1MB also commented: *"I like doing reflections after the lesson because this improved my English writing and speaking"*.

It was evident from the data presented from the SCI and LJRs that IK from the practical demonstrations of maize seed planting by the IKCs and the consolidation lesson that integrated IK into the conservation of mechanical energy was related to science learnt in class. This made science relevant, and the learners found it clearer and easier to understand (Mavuru & Ramnarain, 2020). The school garden was used as a tool for maize seed planting, as presented by local people, and served as a resource that was used to learn science at school (Aikenhead & Jegede, 1999).

Table 6.3: Shows relevance between WS science and IK

Western Science	**Indigenous Knowledge from the Indigenous Knowledge Custodians**
Mixtures	IKCs combined soil with kraal manure preparation the soil for planting.
Radiation	Dry the kraal manure in the sun.
Gravitational Potential Energy	Dropping the maize seed from a certain height.
Kinetic Energy	The energy the maize seeds possess when they hit the ground.
Force of gravity	The seeds are pulled down by the force of gravity.
Air Friction	If there is wind, the seeds experience more air friction.
Conservation of Mechanical Energy	In a closed system, where only conservative forces (like gravity) act, the total mechanical energy (potential + kinetic) remains constant, meaning energy transforms between forms but does not disappear. This happens when the maize seeds are dropped from a certain height and until it hits the ground.

Source: Adapted from Simasiku (2022, p. 233)

Table 6.4: Shows the integration of IK into the conservation of mechanical energy concepts

IK	**WS**
Drying the kraal manure in the sun.	Radiation
Dropping the maize seeds from a certain height.	Gravitational potential energy Air friction Force of gravity
The maize seeds hit the ground.	Kinetic energy

The data from the lesson observation, SCI and LJR from learners were colour-coded to identify themes (see Appendices D1& C5). After identifying the similarities, themes were constructed and are presented in Table 6.4 with relevant theory and literature.

Table 6.5: Shows themes that emerged with relevant theory and literature

Themes	**Literature**	**Theoretical Framework**
Learners' attitudes towards learning science improved	Agunbiade et al. (2017); Handayani et al. (2018)	SCT
Observing natural environments enhanced learners' understanding of the link between IK and science	Aikenhead & Jegede (1999); Ogunniyi (2007a); Sannino (2015); Mavuru & Ramnarain (2020); Grant (2022)	SCT, DAIM
Social interactions afforded learners an opportunity for argumentation	Vygotsky (1978); Ogunniyi (2007a); Langenhoven & Stones, 2013; Anga'ama (2021); Okoroh (2021)	SCT, DAIM

Learners' sense making of conservation of heat energy enhanced	Aikenhead & Jegede (1999); Mukwambo (2014); Agunbiade (2017); Mavuru & Ramnarain (2020); Seehawer (2021)	SCT

Table 6.6: Shows themes and categories grounded in data from SCI and LJR

Theme 1: Learners' attitude towards learning science improved
Category 1: Enjoyment Interest Motivation
Theme 2: Observing natural environments enhanced learners' understanding of the link between IK and science
Category 1: Double stimulation and out-of-school learning Category 2: Contextualising science Category 3: Hands-on practical activities and visualisation influenced learning
Theme 3: Social interactions afforded learners an opportunity for argumentation
Category 1: Active participation and a participatory approach Category 2: Use of language as a cultural tool Category 3: Observed shifts in learners' ZPD
Theme 4: Learners' sense making of conservation of heat energy and related concepts enhanced
Category 1: Use of easily accessible cultural tools Category 2: Application of science in real-life situations (from school to home)

I now discuss each of these themes in detail below, integrating the categories.

6.4.1 Learners' attitudes towards learning science improved

It appeared that mediating the learning of the conservation of mechanical energy using the Indigenous way of maize seed planting and consolidation using the exemplar lesson that integrated IK into the topic aroused the learners' interest in learning science. This was evident in learners' responses when I asked them how these presentations changed or did not change their views about learning science. For instance, L3JR mentioned that *"I found out that science was fun and easy to understand",* while L4JR said: "*It made me more curious to learn science"*. In this respect, it was clear that learners were enthusiastic about learning science when they could relate the activities, both in class and out-of-school learning, to their everyday life experiences, as reiterated by

Gwekwerere (2016). They explained that their interest in learning the topic was aroused by the fact that they could see the connection between the science concepts learnt in class and their local knowledge. One learner, L1MB, put it this way: "*I enjoyed learning science when our knowledge from home was involved".* This resonates with Agunbiade et al. (2017), who accentuate that when learners find science content relevant to their local knowledge and immediate environment, their interest in the subject is likely to increase. Concurring, Onwu et al. (2020) underscore that contexts that are familiar and accessible to learners are likely to stimulate interest and curiosity in learning the science concepts.

6.4.2 Observing natural environments enhanced learners' understanding of the link between IK and science

The study involved a sequence of learning activities for learners to engage in. In the first lesson, learners were introduced to the concepts related to the conservation of mechanical energy. They participated in practical activities that were carried out in class. However, to the learners, concepts such as conduction, insulation and others were abstract, as they could not connect them to their prior knowledge. As a result, these concepts did not make sense to these learners; therefore, doing the practical activity in the lesson was a meaningless task to them (Grant, 2022). They experienced a conflict of motives (Sannino, 2015), trying to cross over from their home knowledge to science knowledge. The following statements illustrate these sentiments. For example, L2DU said: "*At home we would wait until it rained to start going to the fields and plough".*

According to the perspective of double stimulus, the first activity done in class was the first stimulus and necessitated the introduction of the second stimulus (Sannino, 2015). To help learners break away from the conflicting situation, I introduced them to the second stimulus in the form of traditional maize seed planting and a consolidation lesson that integrated their local knowledge. These served as a catalyst for sense making of the concepts. Learners changed these activities to something meaningful and were able to make sense of the conservation of mechanical energy and related terms. This resonates with Mavuru and Ramnarain's (2020) study, which underscores that learners feel comfortable when using materials from their surroundings in learning science as it becomes less abstract. For example, when asked about their experiences of learning the conservation of mechanical energy from the practical demonstrations by the IKCs and using the exemplar lesson that integrated their local knowledge into the topic, learners said the following:

> *To me understanding the topic of conservation of mechanical energy was made easier, I did not know that maize farming that we do at home was related to science (L1MB).*
>
> *I understand the topic better now because at home we came back from the fields we would be tired and sweating not knowing that from Life Sciences that the fat from our body into glucose (L1JR).*
>
> *I enjoyed visiting the IKCs to see how conservation of mechanical energy is conserved (L2JR).*
>
> *I liked the lesson module that integrated IK in science, through this method I was able to link concepts that emerged from fire making with science and made sense of them (L6DL).*

The excerpts above revealed that learners learn easily when they can make connections between their prior knowledge and new concepts (Ahied et al., 2020). Moreover, integrating IK into science familiarised learners with the topic by connecting it to their daily life activities (Seehawer, 2021). Furthermore, engaging learners in hands-on practical activities and visualisation, which involved learners observing real-life objects (Asheela et al., 2021), such as traditional maize seed planting, enhanced their understanding of the topic and related terms. Learners could see how gravitational potential energy was converted into kinetic energy and how mechanical energy was conserved when only gravity acted on it. This suggests that learners were able to make sense of the knowledge systems according to what fit best in the given context, rather than drawing on WS only (Seehawer, 2021).

6.4.3 Social interactions afforded learners an opportunity for argumentation

Where easily accessible cultural tools (Asheela et al., 2021) are used to mediate learning, the potential for social harmony is higher than when unfamiliar learning tools are employed (Mutekwe, 2018). This viewpoint is in line with the activities that took place in the context of this study. During the practical demonstrations by the IKCs, learners interacted with each other and the IKCs. Also, during the lesson presentation, they interacted with each other as they worked in groups. Research has revealed that where there are social interactions (Vygotsky, 1978), there are discussions and arguments (Ogunniyi, 2007a). L1JR commented that *"arguing, asking questions and working in groups helped me to understand some of the concepts, such as conserved and* *constant".* As learners discussed and argued during both the participatory observations and the lesson presentation, they used their Indigenous language, Sepedi. In support of this, Vygotsky (1978) argues that meaningful learning is enhanced when learners learn through social interactions using language as a cultural tool. Using their mother tongue during these social interactions enabled explicit understanding of the emerging concepts.

In class, learners worked in three groups of five. This allowed them to be actively involved in the knowledge construction as they were able to come up with some mind maps on the concepts that emerged during the practical demonstrations and participatory observations. When prompted about how they found the experiences of the participatory observations and lesson presentation, a learner commented: *"I enjoyed the lesson module, we were actively involved in the lesson, co-operated with each other, those who understood the lesson helped to make others understand as well"* (L6DL). L2JR also noted: *"We were actively involved in the lesson, doing presentations, and I love working in the school garden".* Working in groups also afforded them an opportunity to ask questions and help each other to understand the lesson better. Those learners who understood the lesson shared the information with others in the group to help them understand – this meant they were more knowledgeable than others (Vygotsky, 1978). This was evident as L5DU said: *"Another thing that I liked was that asking questions was easy, in a non-threatening environment, working as a group, helping each other. All questions were easy to answer".*

Therefore, it was evident that both the practical demonstrations by the IKCs and the lesson module that integrated learners' local knowledge explored learners' independent problem-solving skills, as learners were able to connect IK with science concepts learnt in class. Taking them to the school garden (out-of-class learning) offered them an environment for active learning and interacting with others, and the IKCs freed them from the formal science classroom constraints that inhibited enjoyment of science learning (Agunbiade et al., 2017). On the other hand, the lesson observation was a guide for me as a teacher to reflect on my teaching practice.

6.4.4 Learners' sense making of the conservation of mechanical energy was enhanced

The study revealed that as learners argued and interacted with each other and the IKCs using their mother tongue, they constructed knowledge and made sense of the scientific concepts involved in the conservation of mechanical energy. At the beginning of the lesson, learners seemed to struggle to make sense of the concepts involved in the topic because they could not relate them to their IK. However, the intervention strategy of traditional seed planting enabled learners to navigate their way between the borders they crossed from home to school. The following comments illustrate these sentiments:

> *I enjoyed the demonstrations by the indigenous knowledge custodians who are more knowledgeable in our culture, it has made my understanding of science better and easier. I would appreciate it if more of these demonstrations can be organised so that we integrate this knowledge in science and being in the garden (L5MZ).*
>
> *Through this method I was able to link these concepts with maize seeds planting and made sense of them, such as Potential energy, radiation and mixtures. (L10DL).*
>
> *I learnt a lot about conservation of mechanical energy; I now know that when I dropped an object above the ground it has gravitational potential energy. (L3JR).*

The excerpts above indicate that mediating learning of the conservation of mechanical energy using the interventionist strategy of traditional maize seed planting enabled learners to make sense of the topic by negotiating meaning across the two knowledge systems (Ogunniyi, 2007a; Seehawer & Breidlid, 2021), that is, IK and WS. To them, the two knowledge systems complemented each other instead of competing (Mukwambo et al., 2014) as they were able to identify scientific concepts learnt in class in the practical demonstrations. When asked if they had any suggestions about how to improve science learning, L2DU commented: "*I think if we can be given an opportunity to explore for ourselves by doing practical activities and find more knowledge from home, then combine this knowledge with science to see if this works well for us"*. This suggests that learners were able to make sense of the knowledge systems according to what fit best in the given context, rather than drawing on WS only (Seehawer, 2021).

In all, integrating learners' local knowledge into science has the potential to make science relevant and accessible to learners (Mavuru & Ramnarain, 2020). The strategy allowed learners to cross the cultural borders as espoused by Aikenhead and Jegede (1999). This concurs with my study, since my learners passed village after village and field after field on their way to school using scholar transport. They saw maize seeds planted each year but still struggled to link their local knowledge to scientific concepts, which is an experience they encountered every day in science classrooms. Therefore, through integrating the IK of maize seeds planting into the topic, learners navigated this boarder and made sense of the topic. They even commented that their understanding of the concepts would enable them to use them in their real-life situations. For example, L5T suggested: *"If we can integrate our prior knowledge in science, that can give us a better understanding of the science concepts learnt at school and can help us apply them in our real-life situations".* On reflection, I noticed that integrating IK into science motivated all learners to take part in the lesson, even those who were regarded as slow learners. I was impressed to see one of those learners involved in meaningful argumentation in his group. As a result, the group chose him to be part of the sharing circle interview, and he contributed much knowledge during the interview.

6.5 Chapter Summary

Chapter Six aimed at analysing and interpreting the data obtained from lesson observations, focus group interviews (sharing circles) and learners' reflective journals. The main objective of the chapter was to answer the following research question: How do exemplar lessons that integrate the traditional ploughing of maize seeds enable and/or constrain Grade 10 Physical Sciences learners from a rural school to argue and make sense of the conservation of mechanical energy?

The thematic analysis of the data revealed four key themes as presented in the comparative analysis, namely:

1. Learners' attitudes towards learning science improved
2. Observing natural environments enhanced learners' understanding of the link between IK and science
3. Social interactions afforded learners an opportunity for argumentation
4. Learners' sense making of the concept of conservation of heat energy was enhanced

These themes provided valuable insights into the factors that facilitate or hinder learners' engagement with the topic of conservation of mechanical energy. The research question was effectively answered based on the key themes. Learners' attitudes towards learning science improved as a result of the integration of science and IK. This was evident from learners' responses when I asked them how the presentations, both from the IKCs and the lesson consolidation, changed or did not change their views about learning science. Observing natural environments enhanced learners' understanding of the link between IK and science. This emerged when the learners felt more comfortable using materials from their surroundings when learning science, as it became less abstract to them. Social interactions afforded learners an opportunity for discussion; taking the learners to the school garden allowed them to interact more freely and increased argumentation for sense making. Learners' sense making of the concept of conservation of heat energy was enhanced due to the out-of-class learning context. The next chapter presents a detailed account of the discussion of the main findings of the study, providing a comprehensive analysis and interpretation of the thematic insights derived from the data and their implications for educational practice and future research.

CHAPTER SEVEN: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

7.1 Introduction

In the previous chapter, I presented, analysed and discussed the data generated from the lesson observations, focus group interviews (sharing circles) (SCI) and LJRs. The three data generation methods were used for triangulation purposes. In this chapter, I present a summary of my findings and provide some recommendations. I also suggest areas of future research, acknowledge the limitations of my study and present some personal reflections. The chapter is wrapped up with the overall conclusion of the study.

7.2 Overview of the Study

The main goal of this interventionist study was to mediate Grade 10 learners' understanding of the conservation of mechanical energy using the traditional method of ploughing maize seeds. To achieve this goal, the following research questions were addressed:

1. What enables and/or constrains Grade 10 rural school learners to argue and make sense of the different types of energies and their transfer before intervention?
2. What do Grade 10 rural school learners know from their homes and communities about the conservation of mechanical energy?
3. How do the presentations on traditional ploughing of maize seeds by the IKCs and consolidation thereof enable and/or constrain Grade 10 rural school learners to argue and make sense of energy conservation?
4. How do exemplar lessons that integrate the traditional ploughing of maize seeds enable and/or constrain Grade 10 Physical Sciences learners from a rural school to argue and make sense of the conservation of energy?

This research study consisted of three phases of data generation and analysis. The first phase explored learners' experiences in learning the conservation of mechanical energy before the intervention. The underlying assumption of this phase was that learners have prior knowledge, and it, therefore, focused on what learners knew from their homes and communities about the conservation of mechanical energy. This phase aimed to find out what learners already knew about how mechanical energy is conserved or can be conserved from everyday experiences. The first phase sought to answer research questions one and two of this study.

The second phase focused on two observations. Firstly, the participatory observation where the IKCs presented the practical demonstration of traditional maize seed planting and secondly, the lesson observation, where an exemplar lesson was presented that integrated learners' IK in science. This phase aimed to explore how integrating learners' IK in science teaching and learning helped learners to make sense of the conservation of mechanical energy. The second phase sought to answer research question three of this study.

The third phase sought to find out if there was a shift or not in learners' sense making of the conservation of mechanical energy because of the intervention strategies used. This phase sought to answer research question four. Data sets that emerged from the above-mentioned phases were analysed using concepts from the SCT. The data generated for research questions one, two and three was presented, analysed and discussed in Chapter Five, and the data for research question four was presented in Chapter Six of this study. In addition, data generated from the lesson observation, focus group interviews (sharing circles), and learner reflection journals were presented in Chapter Six. I now discuss the summary of findings below by addressing the research questions sequentially.

7.3 Summary of Findings

I present the key findings that emerged from different phases of this study according to each research question.

7.3.1 Phase 1: Group activities

The main aim of stage one of the study was to determine learners' prior knowledge and assess whether they could link it with the concepts taught in the conservation of mechanical energy and related topics. This information was evident in learners' responses to the group activity guided questions provided. As noted earlier, data gathered in phase one sought to answer research questions one and two:

> *What enables and/or constrains Grade 10 rural school learners to argue and make sense of the different types of energies and their transfer before intervention?*
>
> *What do Grade 10 rural school learners know from their homes and community about maize seed planting and the conservation of mechanical energy?*

As detailed in Chapter Five above, the findings from the group discussion included the types of energies and energy transfers that the learners know, as well as their understanding of IK and how it is transmitted. The learners gave the types of energies as potential energy, kinetic energy, mechanical energy, gravitational energy, among others. The learners also seemed to know about IK and how it is transferred from generation to generation. It was also evident that the learners knew the different ways of planting maize seeds, such as broadcasting, row planting, hilling, furrow, raised bed planting and intercropping.

These views showed the potential for integrating learners' prior everyday knowledge into science lessons (Kuhlane, 2011) so that they can negotiate meaning across the two distinct worldviews, IK and WS. It can be surmised, therefore, that learners could reach an equipollent cognitive state, as espoused by Ogunniyi's (2007a) CAT, because they could see that the two knowledge systems could work side by side instead of one dominating the other.

Furthermore, during the group discussion session, I observed that learners found it easy to make arguments, as they were accustomed to argumentation. Moreover, they enjoyed participating in groups, as this afforded them an opportunity for social interaction (Vygotsky, 1978), which in turn facilitated argumentation (Ogunniyi, 2007a) and helped them engage with their IK, leading to meaningful learning (Handayani et al., 2018). Also noteworthy was that using their mother tongue language during group discussions provided learners with an opportunity to freely express their views in a non-threatening environment (Fakudze, 2021) with the more knowledgeable peers (Vygotsky, 1978), helping others to see the science embedded in these discussions. It was also interesting to note that group sessions helped even those learners who were usually quiet in class and often regarded as slow learners, as they felt able to contribute meaningfully within their groups. This supports Vygotsky's (1978) SCT, which emphasises the importance of culture and language. According to Bruner (1960), when learners interact in a relaxed atmosphere using the language they are comfortable with, it scaffolds learning. Resultantly, co-construction of knowledge becomes easier. So, both languages (Sepedi and English) were afforded an equal status during these group discussions, thereby enabling the reaching of an equipollent cognitive state (Ogunniyi, 2007a).

Essentially, the rationale of research question one in this study was to facilitate meaningful learning by connecting learners' prior everyday knowledge with the new concepts related to the conservation of mechanical energy taught in class. The findings revealed that stimulating learners' prior everyday knowledge in the lesson helped them comprehend new concepts during the learning activities (Ahied et al., 2020). Taber (2020) echoes this, arguing that learners come to school with some local knowledge from home, and when integrated into science learning, effective and meaningful learning occurs.

In the lesson, Vygotskian scaffolding (Morselli & Sannino, 2021) was applied through a variety of activities, such as gathering information from home about maize seed planting and discussing this information and related stories. These activities helped learners make connections between the new science concepts taught in class and what they already knew and encouraged learners to take responsibility for their own learning as they expanded their knowledge together in group discussions. In line with this point of view, Mavuru and Ramnarain (2020) postulate that one of the benefits of social interactions is the shared construction of knowledge.

7.3.2 Phase 2: Observations

The rationale for the observation stage was to explore whether or not learning opportunities were created for the Grade 10 Physical Sciences learners during the IKCs' practical demonstration of traditional maize seed planting and the presentation of the exemplar lesson that integrated learners' IK into the topic under consideration. Data generated from phase two sought to answer research question three:

> *How do the presentations on traditional ploughing of maize seeds by the IKCs and consolidation thereof enable and/or constrain Grade 10 rural school learners to argue and make sense of energy conservation?*

7.3.2.1 Participatory observation

From the literature, there is evidence to suggest that teachers seem to struggle to explain science concepts exclusively in English, and they are not aware of teaching strategies that can help them integrate learners' IK into science lessons (Glasson et al., 2010). Considering the above statement, I selected a formative intervention as an approach in this study because I imagined that it might address the problem of IK integration into science that we as teachers face.

Accordingly, to answer research question three, we went to our school garden and observed the traditional maize seed planting process. The rationale for inviting IKCs to the school garden to demonstrate to the learners how maize seeds are traditionally planted was to tap into their cultural heritage as custodians of this cultural practice and to explore whether there was science embedded in the process, particularly in relation to the conservation of mechanical energy. This resonates with Kozaner's (2021) belief that changes in teaching strategies also affect areas where learning activities take place, which are not limited to classroom settings.

Based on the data analysis, it appeared that the IKCs were more knowledgeable in the traditional maize seed planting process, which also seemed to reflect scientific principles. This was evident as learners identified several science concepts that emerged from the practical demonstration, including mixtures, radiation from the sun, force of gravity, air friction, gravitational potential energy, kinetic energy and conservation of mechanical energy. This finding is consistent with Handayani et al. (2018), who assert that authentic environments provide learners with an opportunity to construct their own learning. It appeared that the practical demonstration could be used to teach science concepts that seemed abstract to learners as they were involved in participatory learning (Ma, 2023), which exposed them to seeing things in an out-of-school learning context as opposed to being confined to class. The same view is shared by Onwu et al. (2020), who argue that learners effectively learn when learning is mediated by using contexts familiar to them. Essentially, the practical demonstration afforded learners an opportunity to visualise science and engage in hands-on practical activities (Asheela et al., 2021).

Furthermore, as purported by Vygotsky (1978), the social interactions that occurred between the IKCs, learners, my critical friend, and me were amazing. It was interesting to observe how learners interacted, participated and argued with the IKCs and among themselves, sharing knowledge and asking questions of the IKCs about how traditional maize seed planting conserves mechanical energy. This was evident as L6F commented that "*se se ra gore ge re lahlela peu ya lehea mo fase re kgona go bona conservation of mechanical energy in real time".* This means that when we drop the maize seed on the ground, we can see the conservation of mechanical energy in real life.

In my view, the social interactions during the participatory observation were made possible using Sepedi, our mother tongue, as a cultural tool. This created a non-threatening environment; hence, learners asked questions freely, enabling them to make sense of the concepts involved in the conservation of mechanical energy. Engaging learners in discussions about the kind of science embedded in the IK of maize seed planting using Sepedi enabled all learners to actively participate. Even those learners who are usually marginalised in class because they are too shy to talk, and those who are regarded as slow learners, were actively involved. They freely expressed their views, and I was amazed at the kind of potential they possessed. As a consequence, one of them was selected to represent the class in the sharing circle, and I could see that he had the potential to argue. Thus, using Sepedi as a cultural tool helped me to see that learners' ability to argue improved because of creating a conducive space for them.

On the other hand, although the IKCs had no formal teaching experience, they were able to actively engage learners in the presentation by asking questions to ascertain if they understood the presentation. For instance, MaSebetha asked, *"Le sa gopola gore ke ka lebaka la eng le swanetse ke go nošetša fase pele re ka bjala dipeu tša lehea?"* (Do you remember why you had to water the ground before we could plant the maize seeds?) L10M answered: ***"****Go nošetša fase pele ga pšalo go thuša dibjalo go atlega ka go netefatša gore mmu o kolobile."* (Watering the ground before planting helps plants thrive by ensuring the soil is moist.) Consequently, the findings showed that the study lent itself to the possibility of fostering the development of the Ubuntu spirit in learners, something of which they were not aware. They saw how the IKCs interacted with them during the presentation, noting their kindness, willingness to share their knowledge with them, and how they showed them respect, although they were learners.

Also noteworthy in the findings of this study was that the practical demonstration of traditional maize seed planting by the IKCs could be used to teach other science concepts beyond conservation of mechanical energy, as illustrated in Table 6.4. It is interesting to note that learners not only identify science concepts embedded in traditional maize seed planting, but there is also integration across other subjects, such as natural sciences and life sciences. They identified that, for the plants to grow, they need radiation from the sun when drying the manure, which speaks to decomposition taught in Grade 8 natural sciences. They also mentioned metabolism in the body, saying that the fat in our bodies is converted to glucose when doing work, which connects to concepts taught in life sciences.

Therefore, it appeared that the practical demonstration enhanced learners' motivation and engagement in learning science when their IK was integrated. Hence, they were able to connect and fill in the gaps between their local knowledge and the taught concepts of conservation of mechanical energy and related concepts. Thus, using the traditional maize seed planting demonstration helped learners to navigate the border situated between home and school and enhanced their sense making of the topic (see Section 1.2.1). To them, it became clear that IK and WS can work together in a complementary manner instead of competing against one another (Ogunniyi, 2007a).

7.3.2.2 Lesson observation

The exemplar lesson that integrated learners' IK of maize seed planting was presented to consolidate the lesson after the presentation by the IKCs. The consolidation lesson aimed to find the influence of integrating IK into learning the conservation of mechanical energy. The findings revealed that presenting the lesson exemplar that integrated IK into learning the conservation of mechanical energy improved learners' attitudes towards learning science. When learners were prompted about their views of learning science using the strategy, L3JR reflected that *"I found out* *that science was fun and easy to understand"*. L6DL stated, "*I enjoyed the lesson; it helped me to understand science more. For example, I already know that at home we plant maize seeds each year"*.

It was clear that learners were enthusiastic about learning science when they could relate the exemplar lesson to their everyday life activities (Gwekwerere, 2016). Furthermore, the findings of the study revealed that social interactions afforded learners an opportunity for argumentation. The exemplar lessons created a conducive learning environment that enabled discussions and the active participation of learners. Through these interactions, learners took responsibility for their learning (Grant, 2022; Msomi & Akhurst, 2023), as they argued with each other in trying to identify science concepts that were embedded in the practical demonstration. This means learners actively contributed to their own learning and that of their peers. Grant (2022) concurred, asserting that the SCT (Vygotsky, 1978) promotes discussions and argumentations between learners to expand their knowledge collaboratively and build problem-solving skills. Research has revealed that where there is social interaction (Vygotsky, 1978), there is also discussion and argument (Ogunniyi, 2007a). The use of their mother tongue language when reflecting on their thinking during the lesson presentation led the learners to draw mind maps (see Figure 6.7) of the science concepts that emerged during the practical demonstration. From these mind maps, they identified concepts related to the conservation of mechanical energy and drew concept maps (see Figure 6.2). As reiterated by Vygotsky (1978), meaningful learning is enhanced through social interactions and the use of language as a cultural tool.

7.3.3 Phase 3: Reflective space

The main aim of phase 2 was to find out whether there was a shift in learners' sense making of the conservation of mechanical energy because of the presentation by the IKCs and the exemplar lesson that integrated IK into learning the conservation of mechanical energy. This was manifested in learners' responses during the sharing circles interviews (SCI) and the LJR. Phase 3 sought to answer research question four:

How do exemplar lessons that integrate the traditional ploughing of maize seeds enable and/or constrain Grade 10 Physical Sciences learners from a rural school to argue and make sense of the conservation of mechanical energy?

It was essential to examine the change that occurred while also investigating the effectiveness of the formative intervention using traditional maize seed planting. The findings of the study revealed that observing natural environments enhanced learners' understanding of the link between IK and science. It became evident that engaging learners in hands-on practical activities and visualisations that involved them observing real-life objects (Asheela et al., 2021; Mavuru & Dudu, 2021) enhanced their understanding of the topic. This was evident in L7JR's reflection that *"learning that gravitational potential energy is converted into kinetic energy helped to understanding conservation of mechanical energy"*. Moreover, integrating learners' IK into science familiarised them with the topic by connecting it to their daily life activities, which aroused their interest in learning science. In support of this point of view, Seehawer (2021) reiterates that contexts that are familiar and accessible to learners are likely to stimulate curiosity.

On the other hand, the research study showed that learners' sense making of the concept of conservation of mechanical energy was enhanced. Mediating learning of this topic using the formative intervention strategy of traditional maize seed planting enabled learners to make sense of the topic and related terms. This occurred as learners negotiated meaning across the two knowledge systems, WS and IK. It became evident that learners understood that these two knowledge systems worked together in a complementary manner, rather than competing (Ogunniyi, 2007a; Mukwambo et al., 2014; Seehawer & Breidlid, 2021), as they identified science concepts that emerged from the presentation. For instance, L1JR commented, *"I have learnt that when maize seeds planting there is force of gravity in action"*. Also, L1MB reflected that *"to me understanding the topic of conservation of mechanical energy was made easier, I did not know that maize seeds planting that we do at home was related to science"*. Thus, as learners negotiated meaning across the two distinct thought systems (Ogunniyi, 2007a), they were able to integrate them and make sense of the topic and the related terms.

It also emerged that integrating learners' IK of maize seed planting in the lesson enhanced their argumentation and sense making of the topic and made them aware of the need to integrate IK into science and to understand that the two knowledge systems complement each other in science learning. When prompted for suggestions that might improve science learning, L2TAO responded that *"Ke nagana gore ge re ka fiwa sebaka sa go itlhahloba ka go dira mediro ye e šomago le go hwetša tsebo ye ntši go tšwa gae, gona kopanya tsebo ye le science go bona ge e ba se se re šomela gabotse"* (I think if we can be given an opportunity to explore for ourselves by doing practical activities and find more knowledge from home, then combine this knowledge with science to see if this works well for us).

On the other end of the spectrum, the focus of the LJRs was on those learners who were not part of the SCI, to establish whether their sense making of the topic shifted or not as a result of the lesson exemplar and the presentation by the IKCs. Findings from learners' reflective journals revealed that both the IKCs' presentations and the lesson presentation enhanced their understanding of the topic. Also, learners made it clear that the presentations gave them the courage to argue and the ability to reflect. Similarly to Simasiku's (2022) study, findings from the LRJs strengthened my research data gathering tools. For instance, learners commented on how they enjoyed the strategy of reflecting after every lesson presentation and how this improved their English language proficiency and writing skills. As evidenced in what L3MM said: "*Go nna, ge re ka kgona go naganišiša ka morago ga thuto ye nngwe le ye nngwe yeo e rutwago gore morutiši a kgone go tseba seo re se kwešišitšego goba re sa se kwešišego thutong. Ke duma ge barutiši ba bangwe le bona ba ka šomiša leano le dithutong tša bona."* (To me, if we can reflect after each lesson taught so that the teacher can know what we have understood or not in the lesson. I wish other teachers could also use this strategy in their lessons). One of the important aspects that the learners mentioned was their wish that other teachers would also create reflective spaces for learners in their subjects, so that the teachers could gain insight into their teaching practices.

7.4 New Knowledge in the Study

Previously, some studies have used the formative intervention strategies of IK integration into science. However, none of them have used the formative intervention strategy of traditional maize seed planting to mediate learning of the conservation of mechanical energy. Therefore, using this strategy is new knowledge in this research area. Moreover, implementing the intervention strategy of traditional maize seed planting revealed that, beyond mediating conservation of mechanical energy, other science concepts can be taught using this Indigenous practice. It also became evident that integration across other subjects can be done using the traditional maize seeds planting process.

Another important aspect of the study that became new knowledge was using the mother tongue language of the learners, which gave them the courage to argue, in particular, those learners who were regarded as too shy to speak and/or as slow learners. Using their mother tongue language allowed them to actively contribute to their learning and that of others to the extent that one of them was selected to participate in the SCI. This made their understanding of the topic easier and challenged the narrative that they are too shy to speak or slow to learn.

Also, similarly to Mayana (2020), it was significant to note that in this study, learners appreciated the strategy of reflecting after the lesson to such a point that they felt that other teachers should employ the same strategy to inform their teaching practice and, in the process, improve learners' Sepedi and English proficiency and writing skills. Lastly, although the IKCs had no formal teaching experience, they could actively engage learners during their presentation by asking them questions to ascertain whether they understood the lesson, which is a strategy that is commonly used by teachers.

7.5 Recommendations

Based on the findings above, I recommend that teachers, as cultural knowledge brokers (Simasiku, 2022; Wyatt et al., 2017), should tap into the cultural heritage and wisdom of Indigenous elders – as they are the custodians of our culture and more knowledgeable on our cultural practices and beliefs – to enhance teaching and make science relevant. Teachers should invite IKCs into their science classrooms to participate in the education of their children. This, in turn, can motivate learners to learn science and appreciate and value their culture.

In addition, research question three of this study sought to find out whether the presentation by the IKCs shifted (or did not shift) learners' sense making of the conservation of mechanical energy. The findings revealed that because of this presentation, learners' sense making of the topic shifted. Supporting this viewpoint, Handayani et al. (2018) state that integrating IK into science supports meaningful learning. I therefore recommend that the DBE should capacitate teachers on how to teach contextualised and culturally responsive science lessons that are relevant to learners' everyday life experiences, as espoused by Seehawer (2021). As teachers, we need to navigate how to help learners cross the border that is situated between their home knowledge and school science, as it is not going away.

Moreover, I recommend that, as we change teaching strategies, we must also change areas where lessons take place and include out-of-school learning contexts. Kozaner (2021) accentuates that change in teaching strategies also affects the places where learning activities take place, which are no longer limited to the classroom environment. To add, the findings of this study revealed that learners were actively involved in their learning, in shared thinking and in questioning during the out-of-school learning activity that took place at the school garden. In fact, Kozaner (2021) states that out-of-school learning integrates real objects, links the lessons to real events and encourages learners to participate, as they are fun and engaging.

As teachers, we work intensively with the curriculum, but the problem lies in the curriculum's formulation and implementation (DBE, 2011). In this regard, the findings of the study revealed that learners were able to pull the threads together by identifying emerging concepts from the practical demonstration by the IKCs and were able to draw mind maps and concept maps. Hence, it could be argued that this study ignited a spark that it is time to document IK in science curricula and textbooks. This might assist teachers in integrating IK into their science lessons and thus contextualising science content. Therefore, science teachers, textbooks and question papers need to address what the CAPS document advocates and start integrating IK into science by drawing from learners' everyday life experiences.

Finally, I recommend that teachers form professional learning communities (PLCs) in their schools, clusters and districts, where they can come together to learn with and from each other on how IK can be integrated into science. This is a bottom-up strategy (Seehawer, 2018), where teachers collaboratively plan lessons that integrate IK into science, presenting them while others observe, with the aim of improving the quality of their teaching. These PLCs can even invite IKCs, who are the custodians of our culture, to do the presentations. Then, the improved lessons can be taught by teachers in their respective science classrooms.

7.6 Areas of Further Research

Further research in the field of physical sciences can be done on how to improve learners' argumentation, because some South African rural learners are not used to argumentation. They do not typically question the information in written texts. Henceforth, the use of DAIM can be considered as it creates a non-threatening atmosphere for learners to argue (Okoroh, 2021).

Furthermore, mobilising this formative intervention strategy of traditional maize seed planting to mediate learning of the conservation of mechanical energy can be used by teachers to co-develop exemplar lessons that integrate *stories* on maize seeds ploughing told at home when sitting around the fire. This could be done by teachers in their respective PLCs, where lesson studies can be conducted.

7.7 Limitations of the Study

This study only involved 15 learners in a Grade 10 Physical Sciences class from Dimpe Secondary School (pseudonym) in the Waterberg District. For this reason, the sample was too small, and the results cannot be generalised as representing all learners in the whole district or Limpopo Province at large. However, the power of the Indigenous African women in the bottom-up decolonisation of the science curriculum in this study cannot be ignored, as this improved the quality of the teaching and learning of science. On the other hand, the SCI was conducted after school hours because I did not want to disrupt the normal school teaching time. This meant that learners may have come to the interviews tired and hungry from their regular school learning activities and eager to go home, as the school nutrition programme ended at noon. This might have affected their participation in the interviews.

In addition, although the use of the learners' mother tongue language, Sepedi, played a significant role in this study as it created a non-threatening environment (Fakudze, 2021), I am aware that in the process of translation from Sepedi to English, some of the information might have been lost or distorted. In this regard, MaNgwepe, who was my critical friend, assisted by ensuring that the quality was maintained when transcribing the IKCs' presentations and the SCI.

Another significant aspect was that the study was conducted in an out-of-school learning context, and it cannot be ignored that learners tend to be more excited when the learning activity takes place outside the classroom. Therefore, it might happen that some of the learners did not pay much attention to the presentation and instead were excited to get relief from the classroom confinement. Nevertheless, MaNgwepe and I tried to manage this, as did the IKCs, who noticed that some learners were not paying attention to the presentation and drew them back to the presentation by asking questions.

7.8 My Personal Reflections

I joined Rhodes University in 2022. I felt it was time for me to further my studies. I applied to three universities, including the University of Limpopo, which is within walking distance of my home. However, the only university that showed interest and a willingness to register me was Rhodes University. Besides that, I had always wanted to attend Rhodes University because, through research, I found out that it is rated among the best universities in South Africa. I completed my first year and passed, and at the end of that year, my classmate (MaDlamini) and I met our second-year supervisor, Professor Ngcoza, who had just come back from sabbatical leave.

He was happy to meet us, and the following year, during our first session, he introduced us to Dr Mutanho. They familiarised us with the concept of IK, which I had heard about before in the curriculum documents. Even though that was the case, I used to overlook it, because to me, it did not mean much. Our assessment that year was to write a mini thesis about teachers' perspectives on the integration of IK in teaching science. We were given a chance to come up with our own topics that spoke to the main topic. My thesis focused on teachers' perspectives on the integration of IK when teaching the Grade 10 energy topic. The findings of my mini research study revealed that teachers were integrating IK with science to enhance their learners' understanding of the science concepts.

In 2024, we had an opportunity to attend the SAARMSTE Conference in Namibia. The current Namibian president, Netumbo Nandi-Ndaitwah, gave a speech that was clear, engaging, well-organised and memorable, connecting with the audience and leaving a lasting impact through a compelling message. Just by listening, I was inspired to register for my master's and later on my PhD. In addition, I did not want to be 'a university drop-out' – Professor Ngcoza and Dr Mutanho would often cite Dr Chikunda, who used to say, "A university student who has not attained the PhD level is regarded as a university drop-out".

These were not my only motivations. My passion for contextualising science in my classroom also triggered my interest in pursuing my studies. I felt that our learners experience an everyday struggle, trying to cross the border situated between their home knowledge and science knowledge – what Aikenhead and Jegede (1999) refer to as 'border crossing'. Thus, I decided to explore some strategies that might help them cross over.

Notwithstanding, in my quest to try and help learners navigate this border, there were many challenges that I came across. I had to go through several processes, including getting permission from the IKCs and the learners' parents. Taking learners outside the classroom was not easy to manage, as some regarded this as just an outing instead of a learning activity, and they were more interested in being outside the classroom than in learning. However, with the help of the IKCs, who were presenting, we managed to maintain discipline.

The journey was challenging and rewarding at the same time, and it has contributed to my professional development in many ways. One of the challenges that I faced was having my proposal rejected for modifications about three times, and my ethics clearance was also initially declined. That experience nearly discouraged me to the point of giving up. However, because I had developed a passion for and knowledge of integrating IK into my science lessons, I was encouraged to roll with the punches. The study also introduced me to working in a Community of Practice (CoP) (Lave & Wenger, 1991; Wenger, 1998) with my colleagues and my supervisors, where the aspect of Ubuntu was showcased. I learnt a lot of values from my CoP, as they were caring, loving, respectful and kind to each other. I learnt that when we work together as a family, no one is left out.

In January 2025, I was appointed to a new school – a much larger school. This came with challenges of its own, whereby I knocked off late and was very tired, since I also graded 12 physical sciences teachers. I had no energy and time to work on my thesis when I got home, because I also had wifely duties to perform. However, my husband was very supportive of me. When he saw how much I was struggling, he offered to do most of the house chores and cooking so that I could focus on my thesis. I cannot forget our CoP – the encouraging messages they used to send on the WhatsApp group were so invigorating, even though they did not know how much I was struggling.

This study has taught me to value and respect other people's ideas, including those of my learners. Moreover, the study afforded me the opportunity to work with my learners as my co-researchers. The use of clan names during social interactions between the IKCs, my learners and me helped to level power gradients (Mutanho, 2021). Moreover, the use of Sepedi was also significant in the study. This created a non-threatening environment, allowing everyone to participate. The Ubuntu and willingness shown by the IKCs to share their wisdom, knowledge and skills were so heartwarming. They also felt very appreciated and that their culture was valued and had a place in science classrooms.

7.9 Conclusion

The main goal of this interventionist study was to mediate Grade 10 learners' understanding of the conservation of mechanical energy using the traditional method of ploughing maize seeds. To achieve this goal, the following data gathering tools were used: group activity, participatory and lesson observation, a focus group interview (sharing circle) and LJR. The findings from this study confirmed that the processes involved in the traditional maize seed planting process were scientific, and this helped learners to make sense of the conservation of mechanical energy and enhanced their argumentation. It was also noteworthy that learners were actively participating, interacting, arguing and freely asking questions during the group activity and during the presentation by the IKCs.

Moreover, the study aimed to establish how the practical demonstration by the IKCs and the lesson exemplar that integrated IK in science shifted (or did not shift) the learners' sense making of the conservation of mechanical energy. The findings revealed that learners understood that their everyday lived experiences relate to science (Gwekwerere, 2016), but they could not connect this to science because of the science concepts used at school. Hence, integrating learners' IK of traditional maize seed planting into the conservation of mechanical energy positively shifted their sense making of the topic.

Notably, the presentation of traditional maize seed planting was done by women only, and their level of expertise and enthusiasm was outstanding. This revealed the significance of the power of African women in the bottom-up decolonisation of the science curriculum. These women, uneducated as they were, carried powerful knowledge that enhanced learners' understanding of the topic. The IKCs appreciated the fact that their cultural knowledge was acknowledged in science classrooms. This resonates with Triyanto and Handayani (2020), who postulate that integrating IK into science classrooms is a way for local communities to gain a better space and access to school science and a way for learners to appreciate their culture and values.

Furthermore, it became evident in the study that social interactions afforded learners an opportunity to argue during group activities and during the lesson presentation and the presentation by IKCs. This led to the co-construction of knowledge. This coheres with Mavuru and Ramnarain's (2020) study, which accentuates that one of the benefits of social interaction is the shared construction of knowledge. So, through argumentation, learners' understanding of concepts involved in the conservation of mechanical energy and related terms was enhanced, and they became aware of the need to integrate IK into science. As reiterated by Ogunniyi (2007a) and Okoroh (2021), this helps learners understand that the two knowledges can complement each other. In addition, the findings of the study revealed that learners' language proficiency improved through using LJRs. Both the learners and I also learnt the skill of traditional maize seed planting, which was passed on to us by the IKCs, who had learnt it from their forefathers. This indicates that there was mutual benefit in the study.

On the other end of the continuum, it appeared that there was a clash between Eurocentric perspectives of research ethics and IK. For instance, in this study, anonymity was a problem because the Indigenous women wanted their names to appear in the research, as they had contributed powerful knowledge, uneducated as they were. This contradicts Eurocentric research ethics. In addition, asking them to participate voluntarily and explaining that they could withdraw at any time without any prejudice was regarded as disrespectful and insulting by these women.

This means, although we take this as a polite gesture in a Eurocentric perspective, it takes another perspective in many African cultures. Therefore, this calls for reviewing how research ethics are understood, rather than assuming that they are universal. This resonates with the work of Keane (2021), who postulates that ethical research standards are not always universally moral, applicable and relevant.

In summary, the findings from this study revealed that learner argumentation and, hence, sense making of the conservation of mechanical energy and other related concepts improved because of the IKCs' presentation and the lesson exemplar that integrated learners' IK into the topic under consideration.

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APPENDICES

APPENDIX A1: ETHICAL CLEARANCE

RHODES UNIVERSITY
Where leaders learn

Education Faculty Research Ethics Committee
Rhodes University
Education Building, Grey Street, Grahamstown/Makhanda, 6139, South Africa
PO Box 94, Grahamstown/Makhanda, 6140, South Africa
t: +27 (0) 46 603 8315
e: dean.education@ru.ac.za

2 March 2025

Makgwedi Malemela

Education Department

g22m1328@campus.ru.ac.za

Dear Ms Makgwedi Calendula Malemela

Re: From Field to Classroom: Bridging Maize Farming and Mechanical Energy Conservation

APPLICATION NUMBER: 2024-7936-9258

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

Approval is granted for 1 year. An annual ethics renewal application needs to be submitted each year. Should any substantive change(s) be made during the research process, that may have ethical implications, you should notify the Education Faculty REC Chair via email. This includes changes in investigators. The REC Chair will advise as to whether a new application is necessary.

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

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

Sincerely,

Dr Mandy Hlengwa

Chair: Education Faculty Research Ethics Committee

Page 1 of 1

APPENDIX A2: RESEARCH APPROVAL FROM THE PREMIERES OFFICES

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

OFFICE OF THE PREMIER

TO: DR MC MAKOLA

FROM: PROF I SWARTS

CHAIRPERSON: LIMPOPO PROVINCIAL RESEARCH ETHICS COMMITTEE (LPREC)

REVIEW DATE: 05 FEBRUARY 2025

SUBJECT: FROM FIELD TO CLASSROOM: BRIDGING MAIZE FARMING AND MECHANICAL ENERGY CONSERVATION

RESEARCHER: MALEMELA MC

Dear Colleague

The above researcher's research proposal served at the Limpopo Provincial Research Ethics Committee (LPREC). The committee is satisfied with the methodological and ethical soundness of the proposed study.

Decision: The proposal is granted full approval.

Regards

Chairperson: Prof I Swarts

Swarts

Secretariat: Ms J Mokobi

Date: 06/02/2025

APPENDIX A3: DEPARTMENT OF EDUCATION RESEARCH APPROVAL

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

CONFIDENTIAL

Ref: 2/2/2 Enq: Makola MC Tel No: 015 290 9448 E-mail: MakolaMC@edu.limpopo.gov.za

MALEMELA M.C
Rhodes University
Drostdy Road
Grahamstown
6139
makgwedicalendula@gmail.com

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH.

1. The above bears reference.
2. The Department wishes to inform you that your request to undertake research titled:

"**FROM FIELD TO CLASSROOM: BRIDGING MAIZE FARMING AND MECHANICAL ENERGY CONSERVATION**" has been approved.

3. The following conditions should be considered:

3.1 The research should not have any financial implications for Limpopo Department of Education.

3.2 Arrangements should be made with the Circuit Office and the School concerned.

3.3 The conduct of research should not in any how disrupt the academic programmes at the school(s).

3.4 The research should not be conducted during the time of Examinations especially in the fourth term.

REQUEST FOR PERMISSION TO CONDUCT RESEARCH: MALEMELA MC Page 1

Cnr 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X 9489, Polokwane, 0700
Tel:015 290 7600/ 7702 Fax 086 218 0560

The heartland of Southern Africa-development is about people

3.5 During the study, applicable research ethics should be adhered to; in particular the principle of voluntary participation (the people involved should be respected and treated with dignity).

3.6 Upon completion of the research, the researcher shall share the final product of the research with the Department.

4 Additionally, you are expected to produce this letter at School(s)/Office(s) where you intend to conduct your research as evidence that permission has been granted for access to the research site(s).

5 The Department appreciates the contribution that you wish to make and wishes you success in your investigation.

Best wishes,

MC Makola PhD

10/02/2025
Date

Molope NM
Acting DDG: CORPORATE SERVICES

11/02/2025
Date

REQUEST FOR PERMISSION TO CONDUCT RESEARCH: MALEMELA MC Page 2

Cnr 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X 9489, Polokwane, 0700
Tel:015 290 7600/ 7702 Fax 086 218 0560

The heartland of Southern Africa-development is about people

APPENDIX A4: GATE KEEPERS' LETTERS

LETTER TO THE SCHOOL PRINCIPAL: DIMPE SECONDARY SCHOOL

RU 120 1904-2024 YEARS OF EXCELLENCE

RHODES UNIVERSITY
Where leaders learn

Education Department
Rhodes University
P.O. Box 94
Grahamstown
6140

Subject: Request for Permission to Conduct Educational Research with Grade 10 Physical Sciences Leaners at Dimpe Secondary School.

Dear Mr Kgatla M.V

(Principal at Dimpe Secondary School)

I am Makgwedi Calendula Malemela (Student number: 22M1328), a part-time student at Rhodes University, South Africa studying for Masters in Science Education. I am a Physical Sciences teacher at Dimpe Secondary School(pseudonym), Palala South Waterberg District. I hereby humbly request your permission to conduct a research study with 15 grade 10 Physical Sciences learners at Dimpe Secondary School. The study will commence in February/March 2025. The main goal of this interventionist study is to mediate the learning of the conservation of mechanical energy in Grade 10 using traditional ways of ploughing maize seeds.

The study will take place at Dimpe Secondary School's garden in Kitti Village, where the practical demonstration of the ploughing maize seeds will be held. The demonstration will be conducted by two Indigenous Knowledge Custodians from the sorrounding communities. My critical friend, a Physical Sciences teacher, will take notes, videos and pictures during the demonstration.

Furthermore, this study seeks to address the gap in curricular relevance by exploring how the integration of IK, specifically traditional maize seeds planting techniques, can mediate and enhance the learning of scientific principles in Grade 10, thereby contributing to a more effective and culturally responsive pedagogical approach. The project will be divided into two phases.

The first phase of this study involves Indigenous Knowledge Custodians (IKCs) sharing their knowledge on how and why maize seeds a ploughed traditionally. This phase will only take a day. The study's second phase will be a one-month implementation phase where the grade 10 interested learners will work once a week in the afternoon to discuss what they have learned during the demonstration. Data collection methods will involve focus group interviews (sharing circles), group activities, observations (participatory and lesson observations) and learners' reflective journals. The study has been approved by higher degrees committee in the faculty of education and for any further information you can contact ethics (information below) or my self on 0622449942 or email at makgwedicalendula@gmail.com.

I would like to assure your office that, should I be granted permission, the research ethics will apply throughout the process of the study. In the final thesis, pseudonyms will be used for the school and all participants to conceal their identities.

Your consideration in this regard will be highly appreciated.

Yours Sincerely

Ms Makgwedi Malemela

(Student number: 22M1328)

Should you have any concerns or questions, please do not hesitate to contact me at 062 244 9942, or my supervisors, Prof Kenneth Ngcoza (k.ngcoza@ru.ac.za) and Dr Clement Simuja (c.simuja@ru.ac.za) or at the Faculty of Education at Rhodes, at (046) 6038385.

Sincerely

Makgwedi Malemela

(Student number: 22M1328)

The Rhodes University Ethics Committee can be contacted at:

Dr Janet Hayward, Rhodes University, Research Office, Ethics Coordinator: ethics-commitee@ru.ac.za

Telephone: +27 (0) 46 603 8111 Fax: +27 (0) 86 616 7707

Room 220, Main Admin Building,

Drostdy Road,

Grahamstown, 6139

LETTER TO A CRITICAL FRIEND

Rhodes University

Drostdy Road

Grahamstown

6139

LETTER TO THE PHYSICAL SCIENCES TEACHER (CRITICAL FRIEND)

Enquiries: Ms Makgwedi Calendula Malemela

Cell number: 0622449942

Dear …………………………………………………………………………... (Teacher Name)

Re: From Field to Classroom: Bridging Maize Farming and Mechanical Energy Conservation

Ms Makgwedi Malemela (22M1328) is currently a part-time student at Rhodes University, South Africa studying for a master's degree in science education. She is a Science teacher at Dimpe Secondary School Kitti Village Lephalale and has requested my permission to participate in the research project mentioned above. The nature and purpose of the research project and this informed consent declaration have been clearly explained to me in a language that I understand.

As a participant I am aware that:

The main goal of this interventionist study is to mediate the learning of the conservation of mechanical energy in Grade 10 using the traditional way of ploughing maize seeds.

1. I will be involved in a day-long phase with her and fifteen grade 10 learners in a practical demonstration of how maize seeds are traditionally ploughed. The practical demonstration will be conducted by two Indigenous Knowledge Custodians (IKCs) and I as a critical friend (Physical Science teacher) will be taking notes and video recording the demonstrations.
2. I will be part of the presentations by two IKCs that will take place in the school garden at Dimpe Secondary School.
3. By participating in this research project, I will contribute to knowledge and understanding of indigenous practices that can be integrated into the Physical Sciences curriculum to address the conservation of mechanical energy.
4. My participation is entirely voluntary and should I at any stage wish to withdraw from further participation, I may do so without any prejudice.

5. I understand that participation in the research is voluntary and that I can be excluded from the research.

6. I understand that I will reflect on journals after every activity which will take about 20-40 minutes of my time for each activity.

7. The researcher will use the participants' pseudonyms to conceal their identities unless they express their willingness to have their names included in the thesis in writing.

8. There may be risks associated with my participation in the project. I am therefore aware of the following steps:

   a) All information shared will not be used for purposes other than the above-mentioned research project.
   b) All the data collected will be kept in a locked cupboard and electronic data will be kept in a computer and hard drive only accessible through a secure password kept by the researcher; and
   c) The researcher intends to publish the research findings in the form of a thesis towards a master's degree in science education and later present it at colloquiums and conferences or journal articles.

9. Any further questions that I might have concerned the research, or my participation will be answered by the University of Rhodes Masters student

(makgwedicalendula@gmail.com) or the supervisor Professor Kenneth Ngcoza (k.ngcoza@ru.ac.za) and co-supervisor and Dr Clement Simuja (c.simuja@ru.ac.za)

10. There are no legal ramifications for signing this declaration of informed consent.

11. A copy of this informed consent declaration will be kept in a safe place by the researcher.

Your consideration in this regard will be highly appreciated.

Should you require any further information, please do not hesitate to contact me or my supervisors. Our contact details are as follows Ms Makgwedi Calendula Malemela (makgwedicalendula@gmail.com), Prof Kenneth Ngcoza (k.ngcoza@ru.ac.za) and Dr Clement Simuja (c.simuja@ru.ac.za) .

Your consideration will be highly appreciated in this regard. Lastly, if you agree or do not agree to participate in this research, please complete the consent form below.

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

Agree to participate in the study. ☐

Secondly, I am aware that information about the study must be kept confidential and a high level of professionalism is expected from me. ☐

Do not wish to participate in the study. ☐

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

Yours Sincerely

Ms Makgwedi Calendula Malemela (Student number: 22M1328)

The Rhodes University Ethics Committee can be contacted at:

Dr Janet Hayward, Rhodes University, Research Office, Ethics Coordinator: ethics-commitee@ru.ac.za

Telephone: +27 (0) 46 603 8111 Fax: +27 (0) 86 616 7707

Room 220, Main Admin Building,

Drostdy Road,

Grahamstown, 6139

LETTER TO PARENTS/ GUARDIANS

Education Department
Rhodes University
P.O. Box 94
Grahamstown
6140

Subject: Request for Permission for your child to be involved in my study.

Dear Parent/Guardian

I am Makgwedi Calendula Malemela (Student number: 22M1328), a part-time student at Rhodes University, South Africa studying for master's in science education. I am a Physical Science teacher at Dimpe Secondary School, Palala South Waterberg District. The main participants in this project are the grade 10 learners at Dimpe Secondary School. The study will commence February/March 2025. The main goal of this interventionist study is to mediate the learning of the conservation of mechanical energy in Grade 10 using the traditional way of ploughing maize seeds.

I request your permission for your child to be involved in this study. Your child will be involved in a one-day practical demonstration of how maize seeds are ploughed traditionally. Data collection methods will involve focus group interviews (sharing circles), group activities, observations (participatory and lesson observations) and learners' reflective journals. Your child's name will not be revealed without your consent.

If you have anything you need to know please feel free to contact me at 062 244 9942 or my supervisors, Prof Kenneth Ngcoza (k.ngcoza@ru.ac.za) and Dr Clement Simuja (c.simuja@ru.ac.za) or at the Faculty of Education at Rhodes, at (046) 6038385.

Yours sincerely

Makgwedi Malemela

(Student number: 22M1328)

APPROVAL

I,____

Parent/Guadian of ____

I permit Makgwedi Malemela to work with my child and be part of her project. I am pleased with the assurance that my child`s name will not be revealed without my permission. Also, the research report about this will be made available whenever I want it.

Signature________________ Date______________

The Rhodes University Ethics Committee can be contacted at:

Dr Janet Hayward, Rhodes University, Research Office, Ethics Coordinator: ethics-commitee@ru.ac.za

Telephone: +27 (0) 46 603 8111 Fax: +27 (0) 86 616 7707

Room 220, Main Admin Building,

Drostdy Road,

Grahamstown, 6139

Education Department
Rhodes University
P.O. Box 94
Grahamstown
6140

Motswadi/mohlokomedi yo a rategago

Ke Makgwedi Calendula Malemela (Nomoro ya moithuti: 22M1328), moithuti wa nakwana Yunibesithing ya Rhodes, Afrika Borwa ke ithutela master's thutong ya mahlale. Ke morutiši wa Physical Saense Sekolong sa Sekontari sa Dimpe, Seleteng sa Palala South Waterberg. Batšeakarolo ba bagolo mo protšekeng ye ke baithuti ba mphato wa 10 sekolong sa sekondari sa Dimpe. Thuto e tla thoma ka Dibokwane/Hlakola 2025. Maikemišetšo a magolo a nyakišišo ye ya tsenogare ke go tsena gare ga thuto ya Conservation of Mechanical ka Mphato wa 10 ka go šomiša mokgwa wa setšo wa go lema dipeu tša lehea.

Ke kgopela tumelelo ya gago gore ngwana wa gago a tšee karolo thutong ye. Ngwana wa gago o tla akaretšwa pontšhong ye e šomago ya letšatši le tee ya ka fao dipeu tša lehea di lengwago ka setšo. Mekgwa ya kgoboketšo ya datha e tla akaretša dipoledišano tša sehlopha sa nepo (didiko tša go abelana), mediro ya sehlopha, ditebelelo (ditebelelo tša go tšea karolo le tša thuto) le dijenale tša go naganišiša tša baithuti. Leina la ngwana wa gago le ka se utollwe ntle le tumelelo ya gago. Ke rata go tshepiša gore o na le tokelo ya go hwetša tshedimošo yeo e tlago kgoboketšwa nakong ya nyakišišo ye ya nyakišišo nako efe goba efe ge o e nyaka.

Ge o na le selo seo o swanetšego go se tseba hle ikwe o lokologile go ikgokaganya le nna go 062 244 9942 goba baokamedi ba ka, Prof Kenneth Ngcoza (k.ngcoza@ru.ac.za) le Dr Clement Simuja (c.simuja@ru.ac.za) goba Lefapheng la Thuto kua Rhodes, go (046) 6038385.

Ya gago ka potego

Makgwedi Malemela

(Nomoro ya moithuti: 22M1328)

TUMELELO

NNA,____

Motswadi/mohlokomedi yo a rategago wa

____

Ke dumelela Makgwedi Malemela go šoma le ngwanaka mo porojekeng ya gagwe. Ke thabile ka kgonthišišo ya gore leina la ngwana wa ka le ka se utollwe ntle le tumelelo ya ka. Gape, pego ya nyakišišo mabapi le se e tla hwetšagala neng le neng ge ke e nyaka.

Mosaeno________________________ Letsatsikgwedi_____________________

The Rhodes University Ethics Committee can be contacted at:

Dr Janet Hayward, Rhodes University, Research Office, Ethics Coordinator: ethics-commitee@ru.ac.za

Telephone: +27 (0) 46 603 8111 Fax: +27 (0) 86 616 7707

Room 220, Main Admin Building,

Drostdy Road,

Grahamstown, 6139

LETTER TO THE INDIGENOUS KNOWLEDGE CUSTODIAN 1 and 2.

Education Department
Rhodes University
P.O. Box 94
Grahamstown
6140

LETTER TO THE INDIGENOUS KNOWLEDGE CUSTODIAN 1

Enquiries: Ms Makgwedi Malemela

Cell number: 062 244 9942

Dear Sir

RE: PERMISSION LETTER: PRESENTATION OF PRACTICAL DEMONSTRATION ON TRADITIONAL WAYS OF MAIZE SEEDS PLOUGHING.

I am Makgwedi Calendula Malemela (Student number: 22M1328), a part-time student at Rhodes University, South Africa studying for master's in science education. I am a Physical Science teacher at Dimpe Secondary School, Palala South Waterberg District. The study involves fifteen grade 10 Physical Sciences learners, a Physical Science teacher as a critical friend and two Indigenous knowledge Custodians. The Study will commence in February/March 2025. The main goal of this interventionist study is to mediate learning of the conservation of mechanical energy in Grade 10 using the traditional way of ploughing maize seeds.

The demonstrations of traditional maize seeds ploughing will be conducted at Dimpe Secondary School's Garden in Kitti Village. The demonstrations will be conducted by two Indigenous Knowledge Custodians and notes, videos, and pictures during the demonstration.

I sincerely ask that you perform a live demonstration of the process of making ploughing maize seeds traditional to fifteen grade 10 learners at Dimpe secondary School.

I would like to request permission to record your presentation. Depending on the ethical permissions, I would like you to be available to deliver this presentation one afternoon in February 2025, during the first part of my study.

Signature: ....

Your cooperation will be highly appreciated.

Yours Sincerely

Ms Makgwedi Malemela

I can be reached at 062 244 9942 or email(makgwedicalendula@gmail.com).

Note: My supervisor is Prof. Kenneth M. Ngcoza at Rhodes University, email address (k.ngcoza@ru.ac.za). My co-supervisors Dr Clement Simuja (c.simuja@ru.ac.za).

Translation/phetolelo

Thobela Mohlomphegi

RE: LENGWALO LA TUMELO: TLHAHLOBO YA PONTŠHO YA GO ŠOMIŠA KA DITSELA TŠA SETŠO TŠA GO LEMA DIPEO TŠA MOPONE.

Ke Makgwedi Calendula Malemela (Nomoro ya moithuti: 22M1328), moithuti wa nakwana Yunibesithing ya Rhodes, Afrika Borwa ke ithutela master's thutong ya mahlale. Ke morutiši wa Physical Saense Sekolong sa Sekontari sa Dimpe, Seleteng sa Palala South Waterberg. Thuto e akaretša baithuti ba lesomehlano ba mphato wa lesome wa Physical Saense, morutiši wa Physical Saense ya bjalo ka mogwera yo bohlokwa le Bahlokomedi ba babedi ba tsebo ya Setšo. Thuto e tla thoma ka Dibokwane/Hlakola 2025. Maikemišetšo a magolo a nyakišišo ye ya tsenogare ke go tsena gare ga thuto ya Conservation of Mechanical Energy mo Mphatong wa 10 ka go šomiša mokgwa wa setšo wa go lema dipeu tša lehea.

Dipontšho tša go lema dipeu tša lehea tša setšo di tla swarwa ka Dimpe Secondary School's Garden ka Kitti Village. Dipontšho di tla swarwa ke Bahlokomedi ba babedi ba Tsebo ya Setšo le dinoutse, dibidio, le diswantšho nakong ya pontšho.

Ke kgopela ka pelo ka moka gore le dire pontšho ye e phelago ya tshepedišo ya go dira gore go lema dipeu tša lehea e be tša setšo go baithuti ba lesomehlano ba mphato wa lesome sekolong sa magareng sa Dimpe.

Ke rata go kgopela tumelelo ya go rekota tlhagišo ya gago. Go ithekgile ka ditumelelo tša boitshwaro, ke rata gore le be gona go nea thero ye thapama e nngwe ka Dibokwane 2025 , nakong ya karolo ya mathomo ya thuto ya-ka.

Ke a dumela ☐ GOBA ga ke dumelelane ☐ (kgetha ka go bea X) ka lepokising

Mosaeno: .... Letsatsikgwedi : ………………………

Tirišano ya lena e tla lebogwa kudu.

Ya gago Ka pelo ka moka.

Mohumagadi Makgwedi Malemela

Nka fihlelelwa go 062 244 9942 goba email(makgwedicalendula@gmail.com). Ela hloko: Mookamedi wa ka ke Prof Kenneth M. Ngcoza Yunibesithing ya Rhodes, aterese ya imeile (k.ngcoza@ru.ac.za). Balebeledi mmogo le nna Dr Clement Simuja (c.simuja@ru.ac.za).

Education Department
Rhodes University
P.O. Box 94
Grahamstown
6140

LETTER TO THE INDIGENOUS KNOWLEDGE CUSTODIAN 2

Enquiries: Ms Makgwedi Malemela

Cell number: 062 244 9942

Dear Madam

RE: PERMISSION LETTER: PRESENTATION OF PRACTICAL DEMONSTRATION ON TRADITIONAL WAYS OF MAIZE SEEDS PLOUGHING.

I am Makgwedi Calendula Malemela (Student number: 22M1328), a part-time student at Rhodes University, South Africa studying for master's in science education. I am a Physical Science teacher at Dimpe Secondary School, Palala South Waterberg District. The study involves fifteen grade 10 Physical Sciences learners, a Physical Science teacher as a critical friend and two Indigenous knowledge Custodians. The Study will commence in February/ March 2025. The main goal of this interventionist study is to mediate learning of the conservation of mechanical energy in Grade 10 using the traditional way of ploughing maize seeds.

Traditional maize seeds ploughing demonstrations will be conducted at Dimpe Secondary School's Garden in Kitti Village. The demonstrations will be conducted by two Indigenous Knowledge Custodians and notes, videos, and pictures during the demonstration.

I sincerely ask that you perform a live demonstration of the process of making ploughing maize seeds traditional to fifteen grade 10 learners at Dimpe secondary School.

I would like to request permission to record your presentation. Depending on the ethical permissions, I would like you to be available to deliver this presentation one afternoon in February 2025, during the first part of my study.

Signature: ....

Your cooperation will be highly appreciated.

Yours Sincerely

Ms Makgwedi Malemela

I can be reached at 062 244 9942 or email(makgwedicalendula@gmail.com).

Note: My supervisor is Prof. Kenneth M. Ngcoza at Rhodes University, email address (k.ngcoza@ru.ac.za). My co-supervisors Dr Clement Simuja (c.simuja@ru.ac.za).

Translation/Phetolelo

Thobela Mohlomphegi

RE: LENGWALO LA TUMELO: TLHAHLOBO YA PONTŠHO YA GO ŠOMIŠA KA DITSELA TŠA SETŠO TŠA GO LEMA DIPEO TŠA MOPONE.

Ke Makgwedi Calendula Malemela (Nomoro ya moithuti: 22M1328), moithuti wa nakwana Yunibesithing ya Rhodes, Afrika Borwa ke ithutela master's thutong ya mahlale. Ke morutiši wa Physical Saense Sekolong sa Sekontari sa Dimpe, Seleteng sa Palala South Waterberg. Thuto e akaretša baithuti ba lesomehlano ba mphato wa lesome wa Physical Saense, morutiši wa Physical Saense ya bjalo ka mogwera yo bohlokwa le Bahlokomedi ba babedi ba tsebo ya Setšo. Thuto e tla thoma ka Dibokwane/Hlakola 2025. Maikemišetšo a magolo a nyakišišo ye ya tsenogare ke go tsena gare ga thuto ya Conservation of Mechanical Energy mo Mphatong wa 10 ka go šomiša mokgwa wa setšo wa go lema dipeu tša lehea.

Dipontšho tša go lema dipeu tša lehea tša setšo di tla swarwa ka Dimpe Secondary School's Garden ka Kitti Village. Dipontšho di tla swarwa ke Bahlokomedi ba babedi ba Tsebo ya Setšo le dinoutse, dibidio, le diswantšho nakong ya pontšho.

Ke kgopela ka pelo ka moka gore le dire pontšho ye e phelago ya tshepedišo ya go dira gore go lema dipeu tša lehea e be tša setšo go baithuti ba lesomehlano ba mphato wa lesome sekolong sa magareng sa Dimpe.

Ke rata go kgopela tumelelo ya go rekota tlhagišo ya gago. Go ithekgile ka ditumelelo tša boitshwaro, ke rata gore le be gona go nea thero ye thapama e nngwe ka Dibokwane 2025, nakong ya karolo ya mathomo ya thuto ya-ka.

Ke a dumela ☐ GOBA ga ke dumelelane ☐ (kgetha ka go bea X) ka lepokising

Mosaeno: ....   Letsatsikgwedi : ………………………

Tirišano ya lena e tla lebogwa kudu.

Ya gago Ka pelo ka moka.

Mohumagadi Makgwedi Malemela

Nka fihlelelwa go 062 244 9942 goba email(makgwedicalendula@gmail.com). Ela hloko: Mookamedi wa ka ke Prof Kenneth M. Ngcoza Yunibesithing ya Rhodes, aterese ya imeile (k.ngcoza@ru.ac.za). Balebeledi mmogo le nna Dr Clement Simuja (c.simuja@ru.ac.za).

APPENDIX A5: ASSENT LETTERS

CHILD PARTICIPANT'S ASSENT FORM

INFORMED CONSENT DECLARATION

(Grade 10 participants)

Project Title: From Field to Classroom: Bridging Maize Farming and Mechanical Energy Conservation.

Purpose of the study: The main goal of this interventionist study is to mediate the learning of the conservation of mechanical energy in Grade 10 using the traditional way of ploughing maize seeds.

Conservation of Mechanical Energy is one of the topics taught in grade 10 Physical Sciences. As your Physical Sciences teacher, I would like you to participate in the project, whereby two Indigenous Knowledge Custodians from the community will demonstrate how maize seeds are traditionally ploughed. The practical demonstration will be used to explain how mechanical energy is conserved. A Physical Sciences teacher from the nearby school will be my critical friend in the project and will take notes, videos, and pictures of the projects as evidence of work without showing learners' images. The activities in this project have all been approved by your guardian and school Principal. The study will commence in February/ March 2025.

Should you agree to participate, you will be involved in the practical demonstrations by Indigenous Knowledge Custodians and four afternoon sessions of about an hour once a week over a spread of a month.

Researcher's name: Ms Makgwedi Malemela

Name of participant: ___

1. Has the researcher explained what s/he will be doing and wants you to do?

YES	NO

2. Has the researcher explained why s/he wants you to take part?

YES	NO

3. Do you know that your name and what you say will be kept a secret from otherpeople?

YES	NO

4. Did you ask the researcher any questions about the research?

YES	NO

5. Has the researcher answered all your questions?

YES	NO

6. Do you understand that your participation is voluntary and that you can withdraw from the research without any harm or anything that will affect your studies?

YES	NO

7. Do you know who to talk to if you are worried or have any other questions to ask?

YES	NO

8. Has anyone forced or put pressure on you to take part in this research?

YES	NO

9. Do you know that your parent/guardian, principal, and teacher are aware and have approved your participation in this research?

YES	NO

10. Are you willing to take part in the research?

YES	NO

____________________________ ______________________

Signature of Grade 10 learner **Date**

Dr Janet Hayward, Rhodes University, Research
Office, EthicsEthics Coordinator:
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Room 220, Main Admin Building, Drostdy Road, Grahamstown,6139

CHILD PARTICIPANT'S ASSENT FORM

INFORMED CONSENT DECLARATION

(KGOLETŠO YA TUMELELO YEO E BEILWEGO LE TSEBISO)

(Grade 10 participants)

Thaetlele ya Protšeke: Go tloga Tšhemong go ya ka Phapošing ya Borutelo: Go dira Moedi wa Temo ya Poone le Conservation of Mechanical Energy.

Maikemišetšo a nyakišišo: Maikemišetšo a magolo a nyakišišo ye ya tsenogare ke go tsena gare ga thuto ya Conservation of mechanical energy mo Mphatong wa 10 ka go šomiša mokgwa wa setšo wa go lema dipeu tša lehea.

Conservation of Mechanical Energy ye nngwe ya dihlogo tšeo di rutwago mo mphatong wa 10 Physical Saense. Bjalo ka morutiši wa gago wa Physical Saense, ke rata gore o be karolo ya projeke, yeo ka yona Bahlokomedi ba babedi ba Tsebo ya Setšo go tšwa setšhabeng ba tlago bontšha ka fao dipeu tša lehea di lengwago ka setšo. Pontšho ye e šomago e tla šomišwa go hlaloša conservation of mechanical energy. Morutiši wa Physical Saense go tšwa sekolong sa kgauswi e tla ba mogwera wa ka yo bohlokwa mo protšekeng gomme o tla ngwala dinoutse, dibidio, le diswantšho tša diprotšeke bjalo ka bohlatse bja mošomo ntle le go bontšha diswantšho tša baithuti. Thuto e tla thoma ka Dibokwane/Hlakola 2025.

Ge o ka dumela go tšea karolo, o tla akaretšwa go ya dipontšho tše di šomago ke Bahlokomedi ba Tsebo ya Setšo le dithulaganyo tša mathapama tše nne tša mo e ka bago iri gatee ka beke go phatlalala ga kgwedi.

Leina la monyakišiši: Mohumagadi Makgwedi Malemela

Leina la motšwasehlabelo: ---

1. Na monyakišiši o hlalositše seo a tlago go se dira le seo a nyakago gore o se dire?

Ee	Aowa

2. Na monyakišiši o hlalositše gore ke ka lebaka la eng a nyaka gore o tšee karolo?

Ee	Aowa

3. Naa o a tseba gore leina la gago le seo o se bolelago di tla bolokwa sephiri go batho ba bangwe?

Ee	Aowa

4. Na o botšišitše monyakišiši dipotšišo mabapi le nyakišišo ye?

Ee	Aowa

5. Na monyakišiši o arabile dipotšišo tša gago ka moka?

Ee	Aowa

6. Na o kwešiša gore go tšea karolo ga gago ke ga boithaopo le gore o ka ikgogela morago nyakišišong ntle le kotsi goba selo se sengwe seo se tlago ama dithuto tša gago?

Ee	Aowa

7. Na o tseba gore o ka boledišana le mang ge e ba o tshwenyegile goba o na le dipotšišo tše dingwe tšeo o swanetšego go di botšiša

Ee	Aowa

8. Na go na le motho yo a go gapeleditšego goba a go gateletšago go tšea karolo nyakišišong ye?

Ee	Aowa

9. Na o a tseba gore motswadi/mohlokomedi wa gago, hlogo ya sekolo, le morutiši ba a tseba ebile ba dumeletše go tšea ga gago karolo nyakišišong ye?

Ee	Aowa

10. Na o ikemišeditše go tšea karolo nyakišišong?

Ee	Aowa

-- --

Mosaeno wa moithuti wa Mphato wa 10 **Letšatšikgwedi**

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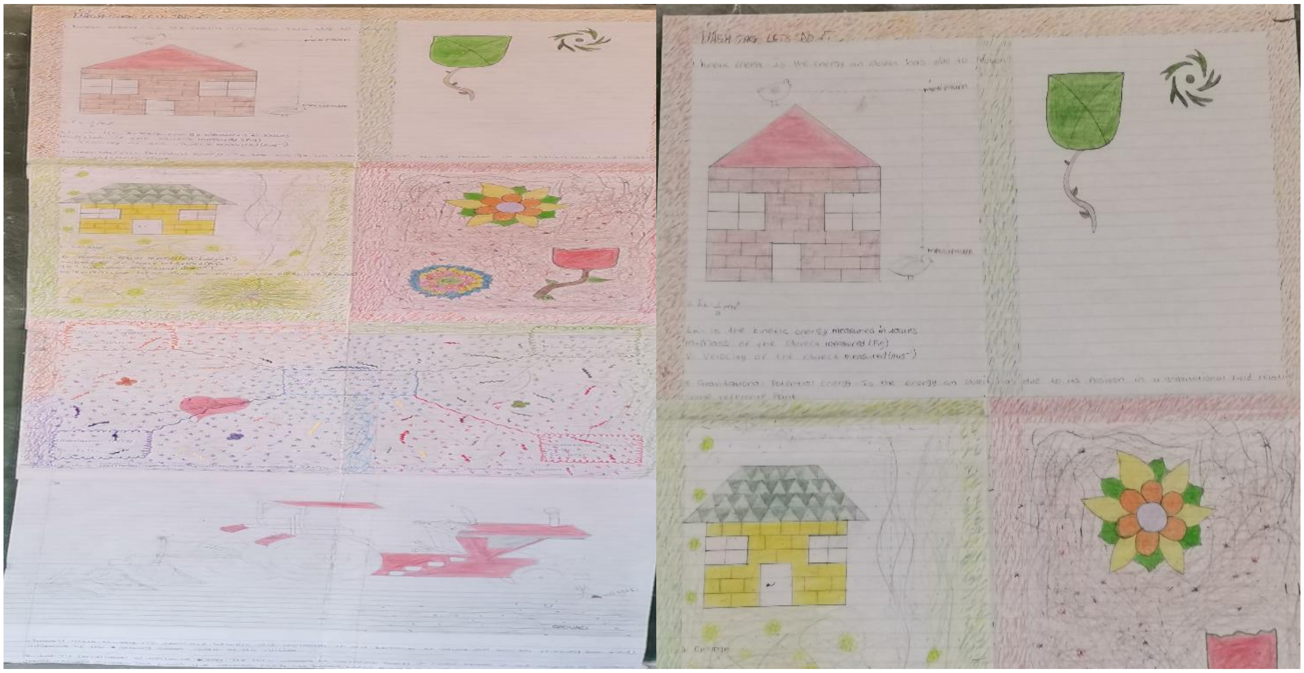
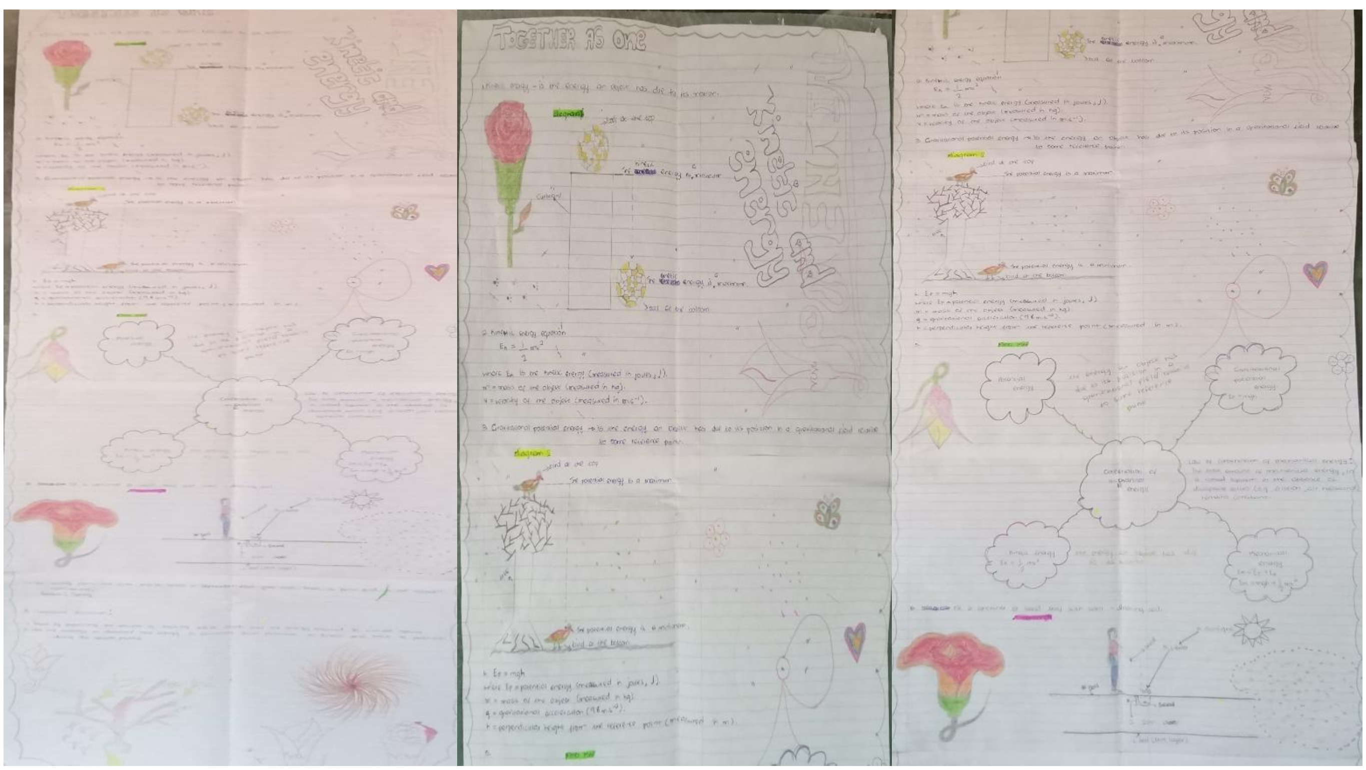
APPENDIX B: FIGURES USED



Hashtag Lets Do It Newsprint



Together As One Newsprint

APPENDIX C1: DATA-GATHERING METHODS

Stage	Method to be used to gather data	Purpose	Research question
Stage 1	Lesson observation Focus group interview (Sharing circles)	**To find out** What enables and/or constrains Grade 10 rural school learners to interact and make sense of the conservation of mechanical energy before the intervention?	1
Stage 2	Group Activities	**To find out** What do Grade 10 rural school learners know from their homes and community about the conservation of mechanical energy?	2
Stage 3	Presentations of IKCs	**To find out** How do the Indigenous Knowledge Custodians' presentations on the traditional ploughing of maize seeds and the consolidation thereof enable and/or constrain Grade 10 rural school learners to argue and make sense of the conservation of mechanical energy?	3
Stage 4	Lesson Observation Reflective Journals	To find out How do exemplar lessons that integrate the traditional ploughing of maize seeds enable and/or constrain Grade 10 Physical Sciences learners from a rural school to argue and make sense of the conservation of mechanical energy?	4

APPENDIX C2: FOCUS GROUP INTERVIEW SCHEDULE

FOCUS GROUP INTERVIEW SCHEDULE

1. Could you please tell me why you were chosen to represent your group in this focus group interview (Ice Breaker)?

2. How are you finding the way Physical Sciences is taught?

3. How are you finding learning Physical Sciences?

4. Could you please explain what you understand Conservation of Mechanical Energy?

5. What are the key components of Conservation of Mechanical Energy?

6. How do you learn Conservation of Mechanical Energy?

7. What difficulties do you experience when learning Conservation of Mechanical Energy?

8. Are there any specific aspects of Conservation of Mechanical Energy that you find hard to relate to daily life?

9. What else would you like to share with me regarding teaching and learning of Physical Sciences in general?

APPENDIX C3: GROUP ACTIVITIES QUESTIONS

First Group Activity Questions

1. What is Indigenous Knowledge?
2. Types of Indigenous Knowledge in your home or community?
3. How to relate science with Indigenous Knowledge?
4. Write down types of maize seeds planting techniques practiced in your home or community?
5. The types of energies that you know and how they are transferred.
6. Briefly explain conservation of mechanical energy.

Second Group Activity

1. Define kinetic energy with the aid of a diagram (at the top and at the bottom).
2. Define gravitational potential energy with the aid of a diagram of a diagram at the top and bottom).
3. Draw a mind map that explains what conservation of mechanical energy.
4. How do you plant maize seeds at home (use a diagram to illustrate).
5. In which month and season are maize seeds planted, in your home and community?

APPENDIX C4: OBSERVATION SCHEDULE

Observation Schedule (Adapted from Nikodemus, 2017)

Name of the school………………………. Observation Date …………… Grade…….

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

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

Social interactions	**Remarks**
The participation of learners during the lesson	
The interaction of learners in class with one another	
The interaction of learners in class with the teacher	
The interaction of learners with the community members	
How learners take other learners' views	

How learners are motivated in the lesson	
How learners treat one another	
Learners' courage to respond to their peers' thoughts and discussion	
Other things:	
Language	**Remarks**
The use of English and how it impacts participation	
The use of mother tongue and how it impacts on participation	
How learners' everyday experiences and ways of talking and knowing are expressed during the lesson	
Other things:	
Learner talk	**Remarks**

The involvement of learners in active learning	
Learners exploring concepts and ideas emerging from the practical demonstration	
Learners' interpretations of concepts and ideas emerging from the practical demonstration	
Learners construct clear scientific explanations from the demonstration	
Learner's sense making shifts or (not) as a result of the practical demonstration	
Other things:	
Attitudes	**Remarks**
Learners' view on IK	
Learners' interest in IK	
Leaners' enjoyment of the lesson as a whole	

Learners' feelings about the use of IK in the lesson	
Learners' attitudes before and after the lesson where IK is integrated	
Other things:	

APPENDIX C5: JOURNAL REFLECTIONS

Journal Reflections

Instruction: Answer All the Following Questions

1. What have you learned from the exemplar lesson that integrates maize seed plouhing?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………….

2. What have you learnt from the Indigenous Knowledge Custodians' practical demonstrations?

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3. What have you enjoyed in this lessons?

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

4. What have you not enjoyed in this lesson?

………………………………………………………………………………………………

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5. How can the lesson be improved?

………………………………………………………………………………………………

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APPENDIX D1: GROUP ACTIVITIES (COLOUR CODED)

Key: Knowledge gain from society.

Ways in which Indigenous Knowledge is gained.

Consider different aspects of Indigenous Knowledge.

Different ways in which maize seeds are planted.

Types of energies and how they are transferred.

The sum of kinetic and gravitational potential energies

First Group Activity Questions

1. What is Indigenous Knowledge?

Group 1: It is also known as traditional knowledge or traditional ecological knowledge, encompasses the understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. e.g adaptive, cumulative, dynamic, holistic, humble, intergenerational, spiritual.

Group 2: Indigenous Knowledge the process through which the natives of an area have built a relationship with their natural environment. Is the knowledge we get from our communities to observe, experience and learn things we don't know or understand well.

Group 3: Indigenous knowledge also known as traditional knowledge, refers to the unique cultural, spiritual and ecological knowledge and practices developed by indigenous peoples through their relationship with their ancestral lands, territories and resources.

2. Types of Indigenous Knowledge in your home or community?

Group 1: Oral traditions and storytelling: stories, dances, songs and ceremonies.

Ecological knowledge: plants, animals, soil, water and weather.

Healing practices: traditional healing methods, herbal remedies such pottery, beadwork and craving.

Social norms and morality: It encompasses ethical guidelines, social norms and moral values that guide community interactions and relationships

Group 2: based on millennia of observation, Temporal and place based, Living, Kinship-based, Wholistic.

Group 3: local history and genealogy, fishing and hunting practices, community conflict resolution, and mediation practices, spiritual beliefs and rituals, music and dance traditional.

3. How to relate science with Indigenous Knowledge?

Group 1: By integration and recognitions, Holistic perspectives, Historical contributions, Traditional Ecological knowledge.

Group 2: Offers rich contexts which have the potential to contribute understanding the relationship of environment and sociocultural. Combine local development and application such as testing hypothesis, experiments and problem solving.

Group 3: Respect and reciprocity: Acknowledge indigenous knowledge holders' expertise and compensate them fairly. Holistic approach: consider spiritual, cultural and ecological aspects, not just physical.

4. Write down types of maize seeds planting techniques practiced in your home or community?

Group 1: Row planting: in this method, maize seeds are planted in straight rows.

- Hill planting: Raised ridges are created, and seeds are planted in top of these ridges.
- Flat planting: Seeds are directly sown on flat ground.

Group 2: • Add 1 bottle top of DAP fertilizer and a handful of well-rotted manure to each hole. Mix well with the soil.

- Place 1 maize seed per hole, cover with a light layer of soil.
- Maize seeds should be planted according to how moist the soil is.

Group 3: Broadcasting, Row planting, Hilling , Furrow planting, Raised bed planting and Intercropping.

5. The types of energies that you know and how they are transferred.

Group 1: Elastic energy, Gravitational Potential Energy, Kinetic energy.

Group 2: Energy that we get from food, Energy from the sun and Heat energy.

Group 3: Elastic energy, Gravitational Potential Energy and Kinetic energy.

6. Briefly explain conservation of mechanical energy.

Group 1: Is the sum of the gravitational potential energy and the kinetic energy of the system.

Group 2: states that the total amount of mechanical energy in a closed system in the absence of dissipative forces (e.g. friction, air resistance) remains constant.

Group 3: states that the total amount of mechanical energy in a closed system in the absence of dissipative forces (e.g. friction, air resistance) remains constant.

Second Group Activity

Key: Theme 1 Kinetic energy: energy at the top.

Theme 2 Potential Energy: stored in an object due to its height:

Theme 3 Traditional maize ploughing.

Theme 4 Ploughing hole size.

Theme 5 Maize ploughing season.

Theme 6 Relating maize ploughing with conservation of mechanical energy.

1. **Define kinetic energy with the aid of a diagram (at the top and at the bottom).**

   Hash Tag Lets Do it Code G1HLDT

   A bird has minimum kinetic energy at the top of a rondavel and maximum energy at the bottom of the rondavel.

   Momentum Masters Code G2MM

   A mini track has minimum Kinetic energy at the top of the hill and maximum kinetic energy at the bottom of the hill

   Together As On Code G3TAO

The ball at the top of the cupboard has minimum kinetic energy and it has maximum kinetic energy at the bottom of the cupboard.

2. **Define gravitational potential energy with the aid of a diagram of a diagram at the top and bottom).**

   Hash Tag Lets Do it Code G1HLDT

   The same bird as maximum potential energy at the top of the rondavel and minim potential energy at the bottom

   Momentum Masters Code G2MM

   The same mini track has maximum potential energy at the top of the building and minimum potential energy at the bottom.

   Together As On Code G3TAO

   A bird has maximum potential at the top of the tree and minimum potential energy at the bottom.

3. **Draw a mind map that explains what conservation of mechanical energy.**

   Hash Tag Lets Do it Code G1HLDT

   Ploughing using a tractor by making furrows and dropping the seeds inside them.

   Momentum Masters Code G2MM

   Ploughing using a hoe to dig a hole and put the seeds inside the hole and covering it with soil.

   Together As On Code G3TAO

   Ploughing using a hoe by digging a hole and dropping the seed inside the hole.

4. **How do you plant maize seeds at home (use a diagram to illustrate).**

   Hash Tag Lets Do it Code G1HLDT

   Make sure that when you dropped the seed it falls between the furrows not the bottom or at the top.

   Momentum Masters Code G2MM

   Make sure that the hole is not too deep or too shallow because that will impact the growth of the maize seed.

Together As On Code G3TAO

Make a medium sized hole of about 2cm deep.

5. **In which month and season are maize seeds planted, in your home and community**

   Hash Tag Lets Do it Code G1HLDT

   Dryland maize planting can commence between late-September to mid-December at spring and still get relatively good yields irrespective of the growing season of the cultivar.

   Momentum Masters Code G2MM

   In most regions, maize seeds are typically planted in the spring, planting often takes place between October and November.

   Together As On Code G3TAO

   We usually plant the first maize seeds in September each year when there is rain and in the northern hemisphere in the Spring season.

6. Hash Tag Lets Do it Code G1HLDT

   The total amount of mechanical energy in closed system in the absence of dissipative forces remains constant. This means that potential energy and kinetic energy cannot disappear.

   Momentum Masters Code G2MM

   As the seed held at certain height the seed has gravitational potential energy, due to its height. It possesses no kinetic energy (EK = 0). As the seed falls towards the ground, kinetic energy of the seed increases as it gains momentum. Until finally collides with a surface, the kinetic is transformed into other forms of energy. The total (ME = EP + EK) of the free-falling seed in the earth's gravitational field remains constant through the absence of air resistance.

   Together As On Code G3TAO

Start by explaining the process of planting maize seeds and the energy required to initiate growth. Use the analogy to illustrate how energy is converted from potential to kinetic and back to potential during the growth process.

APPENDIX D2: IKCs' PRESENTATION (COLOUR CODED)

IKCs Presentation

Key: Mediation of learning

Culture and Language

Social Interaction

Zone of Proximal Development

More Knowledgeable Other

SCENE1: Explaining traditional maize planting using a hoe.

MaSebetha (IKC 1): *Mobu o omile kudu go ka bjalwa lehea. O hloka meetse.*

The soil is too dry to grow maize. You need water.

MaMoyo (IKC 2): *O nepile. Ngwaga wo o be o fiša kudu. Ka tsela yeo fase le omile kudu.*

You're right. This year was very hot. That is why the ground is very dry.

Tlou (Grade 10 learner): *Gomme pula ya se na.*

And it didn't rain.

Researcher: *Ke dumelelana le lena.*

I agree with you.

MaSebetha (KC1): *Ke ka fao ke boletšego gore monola wa mmu o bohlokwa kudu go mela ga lehea ka fao go bjala ka mobung wa monola go bohlokwa.*

That is why I said soil moisture is very important for maize germination so planting in moist soil is important.

Mamoyo (IKC 2): *Ka fao bana baka, re swanetše go thoma ka go nošetša fase pele re ka thoma go bjala. Ka gore pele re ka thoma go bjala re swanetše go dira gore mmu o na le monola, gore leshepe le gone gofeta botse.*

So, my children, we must first water the ground before we start planting. Because before we start planting, we need to make the soil moist, so that digging holes with the hoe will not be hard.

MaSebetha (IKC 1): *Gomme o dire bonnete bja gore molete wa gago ga se wa tsenelela kudu goba o sa tsepamago kudu.*

And make sure your hole isn't too deep or too shallow.

Phuti (Grade 10 learner): *Lebaka?*

The reason?

MaNgwepe (Critical Friend): *Kamoo go tsenelela go bjala dipeu tša lehea?*

How to deep plant maize seeds?

MaMoyo (IKC 2): *Ga ke na dikelo tše di nepagetšego le ge go le bjalo lešoba ga se la swanela go ba le le tseneletšego kudu goba le le sa tsepamago kudu. Ge lešoba le tseneletšego kudu peu e tla tšea nako ye telele go mela gomme ge e le ye e sa tsepamago kudu dipeu di tla mela le ge go le bjalo lehlaka le tla robega gabonolo.*

I don't have the exact measurements however the hole should not be too deep or too shallow. If the hole is too deep the seed will take longer to germinate and if too shallow the seeds will germinate however the stalk will break easily.

Motsholadi (Grade 10 learner): *Bjale manyora ona lea tsomisa ge le lokitse mmu gore le tle le gone gobjala?*

Do you use manure when you are preparing the soil?

MaSebetha (IKC 1*): Re šomiša manyoro a kgomo e sego monontšha wa dikhemikhale. Lebaka go ba manyoro a kgomo ienhances kgolo ya dibjalo le mahala lona.*

We use cow manure not chemical fertilizer. Reason being cow manure enhances the plants growth and its free.

MaSebetha (IKC 1): *Ibile pula ya mathomo ya ngwaga e bohlokwa kudu go pšalo ya mabele ka lebaka la gore e fa monola wo o nyakegago go mela ga peu le kgolo ya mathomo ya dibjalo.*

The first rain of the season is crucial for maize planting because it provides the necessary moisture for seed germination and initial plant growth.

SCENE 2: Preparation of the soil demonstration

MaMoyo (IKC 2) : *Le seke la nošetša mmu go feta tekano gobane ge re ka dira seo dipeu tša rena di ka se gole eupša di tla bola.*

Do not over water the soil because if we do that our seeds will not grow but rot.

SCENE 3: Digging holes with a hoe and planting the maize seeds

MaSebetha (IKC 1): *Ka ge boletsi, gore molete wa gago ga se wa tsenelela kudu goba o sa tsepamago kudu.*

As we have already mentioned, make sure your hole isn't too deep or too shallow

MaMoyo (IKC 2): Re thoma go bjala ka December.

We start planting in December.

Chuene (Grade 10 learner): *Re kwele batswadi.*

Noted elders.

MaMoyo (IKC 2): *Ge o lahlela peu ya gago ka gare ga lešoba, kgonthiša gore e fihla tlase ga lešoba. Ge o feditše khupetša lešoba ka mmu wo o kolobilego.*

When you throw your seed inside the hole, make sure that it reaches the bottom of the hole. when you done cover the hole with the moist soil.

MaSebetha (IKC 1): *Dipeu di tla tšea matšatši a go lekana 14 goba e re ke re dibeke tše 2 gore di mela. ge pula e sa na netefatša gore o nošetša serapa mo e nyakilego go ba matšatšing a mangwe le a mangwe a 2 go ya go a 3.*

The seeds will take around 14 days or let me say 2 weeks to germinate. if it does not rain make sure that you water the garden almost every 2 to 3 days.

Reseacher: *Rea leboga ge le gonne go fihla batswadi.*

Thank you for coming elders.

APPENDIX D3: STORIES FROM MY GRANDPARENTS.

Grandmothers name is Mogaleadi

Grandfathers name is Tlou

Key: Preparation of the soil

Moisture

Planting maize seeds

Tlou: *Pele ga pšalo ya dipeu tša lehea mmu o swanetše go lokišwa ka tshepedišo ye e bitšwago goParaka (go hlakanya mmu le manyoro a gotswa tsakeng".*

Before the planting of the maize seeds the soil needs to be prepared by a process called *goParaka* (mixing soil with kraal manure).

Mogaleadi: *Ee, re swanetše go lokišetša mmu goba go sego bjalo go ka se be le phepo ye e lekanego godimo ga dipeu tša lehea gore di gole di phetše gabotse ka mo go kgonegago.*

Yes, we must prepare the soil or else there would not be enough nutrients on the maize seeds to grow as healthy as possible.

Tlou: *Go lokišetša mmu bakeng sa temo ya lehea ka go šomiša manyoro a kraal, go akaretša go phatlalatša manyoro ka go lekana godimo ga plot ka Phato le Lewedi le go a šoma ka mobung go e dumelela go bola pele ga pšalo. Tshepedišo ye e ja nako, gomme e akaretša mošomo o thata.*

The preparation of the soil for maize cultivation using kraal manure, includes spreading the manure evenly over the plot in August and September and work it into the soil allowing it to decompose before planting. This process is time consuming, and it involves hard labor.

Tlou: *Ge re lokišetša mmu re rata go hlakanya mmu le manyoro a kgomo go feta manyoro a Naetrotšene Fosforo le Potasiamo (NPK). Cow manaure hape tseba e le Kraal manyoro ke tlhaho , tletse phepo le mahala.*

When we prepare the soil, we prefer to mix the soil with cow manure rather than Nitrogen Phosphorus and Potassium (NPK) manure. Cow manure also known as Kraal manure is natural, full of nutrients and free.

Mogaleadi: *Monola o bohlokwa kudu pele ga pšalo ka ge seo se netefatša gore dipeu di hwetša meetse a go lekana go mela.*

Moisture is very important before planting as that ensures that the seeds get enough water to germinate.

Tlou: *Re thoma go lema dipeu tša lehea ka di 16th December ka gore ka nako yeo pula ya mathomo ena e nele.*

we start ploughing maize seeds on the 16th of December because by then the first rain has fallen.

Tlou: In the olden days many people in the community used ploughs drawn by oxen however now ploughs are drawn by tractor. If we are ploughing in our gardens, we use hoes instead of tractor because the space is small for a tractor or its cheaper using a hoe than hiring a tractor.

Mogaleadi : *Mašemong terekere e thoma ka go lahlela mogoma fase ke moka balemi ba botelele bjo bo fapanego ba latela terekere gomme ba lahlela dipeu tša lehea ka gare ga mothaladi wo o dirilwego ke mogoma.*

At the fields the tractor starts by dropping the plough onto the ground then the ploughers of different heights follow the tractor and drop the maize seeds inside the row made by the plough.

Tlou: *Balemi ga se ba swanela go lahlela dipeu ka fase ga methaladi goba godimo ga methaladi go e na le go lahlela bogareng bja mothaladi.*

The ploughers should not drop the seeds at the bottom of the rows or on top of the rows rather at the middle of the row.

Tlou: *Lebaka e le gore ge re ka lahlela peu ka fase ga mothaladi, dipeu di tšea nako ye telele go tšwelela fase gomme ge ka godimo dipeu di tla tšwelela ka ntle ga fase ka pela le ge go le bjalo medu e tla gola ka botebo go tiiša lehlaka.*

The reason being that if we drop the seed at the bottom of the row, the seeds take longer to pop up on the ground and if at the top the seeds will pop out of the ground quickly however the roots will grow deep enough to stable the stalk.

APPENDIX E: LESSON PLAN AND OBSERVATION SCHEDULE

LESSON PLAN AND OBSERVATION SCHEDULE

Lesson Plan: Introduction to Conservation of Mechanical Energy using maize seeds planting.

Objective: Learners will understand the conservation of mechanical energy.

Materials: a hoe and maize seeds

1. Engage (15 minutes):

Discuss traditional maize seeds planting and ask learners about their experiences.

Ask guiding questions:

"What factors influence how fast the seed hits the ground?

2. Explore (25 minutes):

Divide learners into groups.

Each group will be allocated a piece of land in the garden.

They will plant their own maize seeds.

3. Explain (20 minutes):

Introduce Conservation oof Mechanical Energy and connect it to their observations.

Discuss how gravity (force) and air friction affect how fast the seeds falls to the ground.

4. Elaborate (10 minutes):

Challenge learners to explain how friction influences their results.

5. Evaluate (10 minutes):

Learners reflect on the lesson.

Observation Schedule (Adapted from Nikodemus, 2017)

Name of the school: Dimpe Secondary School (pseudonym)

Observation Date: 21 March 2025

Grade 10

Subject: Physical Sciences

Number of participants: 15

Lesson Topic: Introduction to Conservation of Mechanical Energy using maize seeds planting.

Observer: MaNgwepe.

Social interactions	**Remarks**
The participation of learners during the lesson	The children were interacting with one another, conversing, solving problems as a group, and collaborating.
The interaction of learners in class with one another	The learners interacted with each other by communicating with one another they were engaging and responding to one another's questions

The interaction of learners in class with the teacher	The learners interacted with the teacher on a high level and had a very good communication with the teacher
The interaction of learners with the community members	The learners responded and reacted with respect with the IKCs
How learners take other learners' views	The learners did not make fun of other learners rather they corrected them when wrong and mostly listened attentively to their classmates' opinions and views.
How learners are motivated in the lesson	Learner motivation in the lesson was enhanced by creating a positive and engaging learning environment.
How learners treat one another	They treated other learners with respect and did not make fun of another learner's answer
Learners' courage to respond to their peers' thoughts and discussion	The learners discussed very well and had the courage to respond in a very calm and nice they also considered other learner's views

Other things:	The learners learnt very good communication with their classmates/peers, respect and teamwork
Language	**Remarks**
The use of English and how it impacts participation	The learner did not quite use English as their strong and more used language and because of that all of the learners participated
The use of mother tongue and how it impacts on participation	I strongly believe that the learners used their mother tongue and that led to all of the learners to participate
How learners' everyday experiences and ways of talking and knowing are expressed during the lesson	The way the learners are taught to be good listeners and knowing how to respond or talk back to another person were very much during the lesson because the learners did not talk back in a rude way and paid attention and listened attentively to another person
Other things:	The learners learnt many ways to express their answers and not keep them to themselves
Learner talk	**Remarks**

The involvement of learners in active learning	All learners were active even those who are known to be quiet had something to say
Learners exploring concepts and ideas emerging from the practical demonstration	The learners seem to be connecting concepts to what was happening during the practical demonstration
Learners' interpretations of concepts and ideas emerging from the practical demonstration	The learners seem to be connecting concepts to what was happening during the practical demonstration
Learners construct clear scientific explanations from the demonstration	The learners understood the demonstrations as a result the learners constructed clear scientific explanations
Learner's sense making shifts or (not) as a result of the practical demonstration	The way the learners were shifting it demonstrated how maize seeds are supposed to be planted.
Other things:	
Attitudes	**Remarks**

Learners' view on IK	The learners showed very much interest on the IK, they were having fun
Leaners' enjoyment of the lesson as a whole	The learners had a very good way of showing enjoyment by laugh in every scene of the lesson
Learners' feelings about the use of IK in the lesson	They were happy and very proud of their work and felt it made understanding easier
Learners' attitudes before and after the lesson where IK is integrated	The learners always showed interest before and after the IK was illustrated and demonstrated to them how maize seeds are traditionally ploughed.
Other things:	The learners were kind and friendly to the IKC and to one another loved and respected their chance of showing their talent