

**Cultural Connections: Teaching Newton's Second Law through an
Indigenous Mountain Sliding Game (*Umtyibilizi*)**

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By

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DECLARATION OF ORIGINALITY

I Sinethemba Mdleleni (22M7469) 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 Degree of Master of Education 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.

A handwritten signature in black ink on a light gray background. The signature is stylized and appears to be 'S. Mdleleni'.

Signature: S. Mdleleni

Date: February 2025

DEDICATION

I would like to dedicate this thesis to my late father, Gqwetha Mdleleni and my mother, Tobeka Joyce Mdleleni, for teaching me to be a responsible and strong woman that I am today. My siblings: Aviwe Mdleleni, Lwando Mdleleni and Siphesihle Sanelisiwe Mdleleni. My partner: Yonela Mlungwana. No words can explain my gratitude towards their unwavering support through this journey. May the Lord bless you abundantly!

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To the District Director of O.R. Tambo Inland District, the principals of the two schools, the ten learners and the two Indigenous Knowledge Custodians, I sincerely thank you all for allowing me to conduct this study.

I appreciate my family's constant encouragement and belief in my abilities. Their love and support motivated me to complete this thesis.

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Lastly, I thank Ms Nikki Watkins for professionally editing my thesis.

ABSTRACT

Many learners seem to struggle to grasp the concept of Newton's laws in science, possibly due to decontextualised teaching methods used. To ameliorate this, the Curriculum Assessment and Policy Statement (CAPS) document recommends different teaching approaches, including the integration of Indigenous Knowledge (IK). However, it fails to mention how to integrate IK into the lessons. It is against this backdrop that this study sought to investigate how the use of the Indigenous mountain sliding game (*umtyibilizi*) can support the Grade 11 learners' talk and sense making of the topic of Newton's second law of motion.

It is a qualitative case study that employed a participatory approach. It is underpinned by the interpretivist and Indigenous research paradigms. Ten Grade 11 Physical Sciences learners from Mqanduli in the Eastern Cape Province and two Indigenous Knowledge Custodians 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 focus group interviews (sharing circles), group activities, 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 revealed that culturally relevant pedagogies, such as using *umtyibilizi*, facilitate learner engagement, collaborative learning and conceptual understanding. *Umtyibilizi* ignited the interest amongst my learners to learn science. However, uneven participation and difficulties with scientific language continue to prevail. These findings support the promise of IK in facilitating and bridging the gap between cultural and scientific knowledge while also pointing to the continued need for targeted mediation in persisting learning difficulties.

Keywords: Physical Sciences, Newton's second law, Indigenous Knowledge, Indigenous Knowledge Custodians, Ubuntu, Sociocultural Theory

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ABBREVIATIONS AND/OR ACRONYMS

CAPS:	Curriculum and Assessment Policy Statement
CTS:	Conceptual Teaching Strategies
DBE:	Department of Basic Education
IK:	Indigenous Knowledge
IKCs:	Indigenous Knowledge Custodians
LP:	Learners' Prior knowledge
MKO:	More Knowledgeable Other
RP:	Representations
SCT:	Sociocultural Theory
WS:	Westernised Science
ZPD:	Zone of Proximal Development

CHAPTER ONE: SITUATING THE STUDY

1.1 Introduction

As a Physical Sciences teacher in a school in the rural Eastern Cape, I have noticed that many learners seem to struggle to grasp the concepts of Newton's laws in science (Mullis et al., 2019). Possibly, this could be due to decontextualised teaching methods used in science classrooms. It is for this reason that this study's case study sought to investigate how the use of the Indigenous mountain sliding game (*umtyibilizi*) can support the Grade 11 learners' talk and sense making of the topic of Newton's second law of motion.

The study is introduced in this chapter, starting with a background of the study, followed by situating myself in the study and positionality and reflexivity. In addition, the statement of the problem and the purpose and significance of the study are also discussed. Furthermore, the research goal, objectives and research questions are stated. The data-gathering methods that were used are highlighted, viz., focus group interviews (sharing circles), group activities, observations (participatory and lesson observations), and learners' reflective journals. Lastly, a summary of the theoretical and analytical framework used to frame the study is discussed.

1.2 Background of the Study

Mullis et al. (2019) observed that learners seem to be facing challenges in their science studies. This could be due to the decontextualised teaching methods used. Scholars such as Oloruntegbe and Ikpe (2011) explored ways to address this issue, one of which involves integrating Indigenous Knowledge (IK) into modern science education. Aikenhead and Ogawa (2007) state that IK is learned through everyday practices and shared beliefs. In addition, IK is the knowledge passed down through generations among African communities (Kibirige & Van Rooyen, 2006), encompassing their beliefs, practices, and stories (Taylor & Cameron, 2016).

That is, IK is rooted in the experiences and observations of Indigenous communities. On the other hand, Western Science (WS) is described as the formal science taught in schools that relies on tested and proven scientific explanations (Seehawer & Breidlid, 2021). Proponents like Mukwambo (2017) advocate the integration of IK into WS to enhance learners' understanding. This approach involves incorporating cultural beliefs and values into science education as discussed by Kuhlane (2011).

This is what the South African Physical Science curriculum was trying to do when they included the African worldviews and ways of knowing (Taylor & Cameron, 2016). Integrating Indigenous Knowledge when teaching WS is indeed one of the ways to try to improve the way the learners understand science. According to Taylor and Cameron (2016), the South African Physical Sciences curriculum tries to integrate Indigenous Knowledge Systems into the WS, even though it falls short. The curriculum statement does have Indigenous examples stated in some of the topics, but it fails to state how these examples would be explained in each topic.

The integration of IK into WS seems like a way in which the African child could be assisted to better understand WS. Mukwambo (2017) argues that the process of integrating IK as a catalyst can quicken the rate of understanding for learners. This involves integrating how people of different cultures live, which is centred on their specific beliefs and values, into science to help the learners understand science better. Kuhlane (2011) explains this as the learners' prior everyday knowledge.

This form of teaching and learning has the potential to enable learners to apply the science they do in class to their own contexts. This creates better understanding and an ability for them to critically reason while collateral learning takes place (Aikenhead & Jegede, 1999). Furthermore, Aikenhead and Jegede (1999) suggest that integrating IK allows learners to apply scientific knowledge in their contexts, promoting better understanding and critical thinking.

For example, in the context of my study a local game, *umtyibilizi* (mountain sliding game), was used to explain the forces acting on an object on an incline to introduce Newton's second law of motion. However, Taylor and Cameron (2016) note that integrating IK into the South African Physical Sciences curriculum faces challenges. The curriculum seems to lack specific guidance on

how to integrate IK into each topic, which could hinder effective implementation. Yet, integrating IK into science education offers potential benefits for African learners.

1.3 My Life Experiences – Situating Myself in the Study

On the 15th of March 1992, my parents were blessed with their third-born child, who happened to be the only girl at the time. I was born in the small town of Nqamakwe in the Eastern Cape. My parents built their home at Bhongweni in Mthatha where they had their last child. I do not recall much during those years, but I remember when I was graduating from Grade R my parents were expecting my little sister. She was born the following year (1999) when I was doing Grade 1.

In the years that followed, I focused on my schoolwork and ensured that I improved because my father always made sure that he checked our schoolwork. I would enjoy a break from school by visiting my maternal grandmother's house. This is where I was first introduced to Indigenous games such as *umtyibilizi* and *upuca* (a game played by putting stones in a circle and trying to keep one out while throwing another stone in the air) by my cousins. I would play this game until we were told that we were too old for it and that we should let our younger cousins play it. Also, at school, nothing was mentioned about this game when we were taught science.

In 2012, I enrolled for a Diploma in Mathematical Technology (in Applied Science) at the Cape Peninsula University of Technology. I was always glued to my books and never really took time off to view the beautiful city of Cape Town. In 2015, I did a BTech in Project Management at the same institution. The following year (2016), I furthered my studies by enrolling in a Master of BMS: Project Management but I decided to cancel studying and go back home full-time. I had planned on studying further while also working so I felt discouraged when the interviews for the job opportunities I went to did not end with good news.

After almost a year of being home and looking for a job, a neighbour told me to give her my documents because they were looking for a Mathematics and Physical Sciences teacher in the school where she worked. In February 2017, I started teaching and applied for a Postgraduate Certificate in Education at UNISA, and I started in July. In August of the same year, I started working at the school I am currently in and became permanent in 2018.

When I first started teaching as a temporary teacher in a town school in Mqanduli, I never realised the importance of tailoring my lessons to the learners' contexts. While I had some knowledge of IK from home, I could not see how it applied to my role as a Physical Sciences teacher. However, when I secured a permanent position in a rural school, I quickly realised the necessity of using the local environment to explain scientific concepts. I often had to rely on the things I observed in the village because my learners had likely never encountered some of the examples mentioned in the textbooks.

I vividly recall a time when I had to purchase a packet of Muesli, a breakfast cereal, because my Grade 10 learners were unfamiliar with it, despite it being listed as an example of a mixture in their textbook. This experience highlighted the importance of connecting lessons to the learners' everyday lives and surroundings as reiterated by Gwekwerere (2016) and other scholars.

In 2021, I decided that I should study further my studies, and I applied for the BEd Honours in Science Education at Rhodes University. I found this to be a very eye-opening experience and journey as our lecturer introduced us to the integration of IK. As a result, that helped to improve my practice. It was during these years that the idea of using the mountain sliding game (*umtyibilizi*), the game I used to play as a child, to explain Newton's law was born.

1.4 My Positionality and Reflexivity

Holmes (2020) defines positionality as more than just position; instead, it has to do with ethnicity, culture, language, marital status, qualifications, and so on, and how these beliefs might shape the study. Also, it is about the insider/outsider issues and how these influence the research process. I was an insider in my study because I shared the context and experiences of teaching Physical Sciences in a rural school, which gave me an in-depth understanding of the challenges faced by both teachers and learners. On the other hand, I was an outsider as a researcher, adopting an analytical perspective that required me to maintain objectivity and distance to critically evaluate the data and findings.

I was thus conscious of my dual role as a teacher and researcher, which might create power dynamics. That is, as a Physical Sciences teacher in a rural school, I was aware of the challenges that may stem from my role and influence over the learners who took part in my research. To address this issue of positionality, I emphasised that participation was voluntary and that there would be no negative consequences for non-participation. Participants could withdraw at any stage without penalty.

I also positioned myself as a co-learner rather than an authoritative figure by engaging Indigenous Knowledge Custodians (IKCs) in the study. For example, the use of sharing circles instead of sitting in front of the learners was employed in this study. This helped to bridge the power gap and created a more non-threatening and collaborative environment. I also involved a critical friend (another teacher) to reflect with and encourage open expression of ideas to ensure that I was not biased. This reduced perceived pressure on learners. The learners were engaged in structuring discussions to give them a sense of ownership. Inclusive language was used to ensure all voices were valued equally. This was done by using isiXhosa (the predominant language) in discussions to ensure comprehension and comfort.

Reflexivity means being open about the beliefs and values that shape the researcher's choices and reasons for using a particular method (Reid et al., 2018). It has to do with reflecting and acting during the whole research process. I engaged in ongoing reflexivity to ensure the trustworthiness of the research.

Similarly to Mayana's (2020) study, my Grade 11 learners had journals to document their thoughts, feelings, and decisions throughout the research process. These learner journals assisted me with ensuring that they still felt comfortable with being participants in the study and that their ideas were respected. It made it possible for me to reflect on how my positionality might influence social interactions (Vygotsky, 1978). I was transparent with participants about the goals and processes of the study and openly accepted their positions in the research process. I shared preliminary findings with them to ensure that their perspectives were accurately represented. I actively listened to and incorporated participants' feedback. I recognised and respected the knowledge that the Grade 11 learners came with as well as the two IKCs' contributions.

For the primary school learners who served as my IKCs in this study, I used an environment where they felt safe and empowered to share their experiences of the mountain sliding game (*umtyibilizi*). The primary schoolyard had a slope, so I requested to use it (see Figure 3.2 below). This served as an easily accessible resource as espoused by Asheela et al. (2021).

I was willing to modify the approach based on ongoing reflections and feedback from participants. For example, the Grade 11 learners requested to present as groups instead of having one person representing the group and that was granted. This flexibility ensured that the methods remained ethical and effective. I also consulted with the participant's parents to ensure ethical considerations were met and that the research aligned with cultural norms.

1.5 Statement of the Problem

Learners seem to perform poorly in science and that can be observed in the Trends in International Mathematics and Science Study document as South Africa ranks as one of the lowest in international science achievement (Mullis et al., 2019). This could be partly because science is taught in decontextualised ways as alluded to earlier. As a result, South African learners seem to find it difficult to understand WS and have no way of relating it to their everyday lives (Gwekwerere, 2016).

Studies by Mullis et al. (2019) and Gwekwerere (2016) seem to show that decontextualised teaching methods might make it difficult for learners to understand and apply scientific concepts like Newton's second law which is the focus of this study. This could be because the learners see WS as very abstract and that leads to them being unable to apply their knowledge and reason scientifically about some aspects such as Newton's second law. For instance, Newton's second law states that when a net force acts on an object, the object will accelerate in the direction of the force and the acceleration is directly proportional to the force and inversely proportional to the mass of the object (Department of Education, 2011).

The definition of Newton's second law provided (Department of Education, 2011) raises a few potential difficulties or areas of confusion, particularly for learners:

1. Ambiguity in 'net force': The term 'net force' is ambiguous for some. It refers to the vector sum of all forces acting upon the object, but learners who do not understand vector addition may not fully grasp this concept.
2. Understanding proportionality: There is a need for the learners to understand mathematics. Additionally, a learner who does not have a good understanding of proportional relationships may be confused by the phrase 'directly proportional to the force and inversely proportional to the mass'. They may not be able to apply this relationship to the equation.
3. Direction of acceleration: While the definition says that acceleration is 'in the direction of the force', the learner might be confused by how it works in two or three dimensions, especially when he is set before opposing or angled forces.
4. Reference frames: The law assumes the motion is in an inertial reference frame. Had this not been specified, then learners might attempt to apply the law in non-inertial (accelerating) reference frames in which additional 'forces' would be involved (e.g., fictitious forces).
5. Mass and resistance to acceleration: Here, the definition presupposes that mass is understood to mean a measure of resistance to acceleration. For novices, this connection between mass and inertia is not self-evident.
6. Application to real-life situations: Without further explanation, learners might struggle in applying this law to real-life examples involving objects that contain friction, air resistance, or even multiple forces.
7. Misinterpretation: Possible misunderstanding of 'force' to mean the existence of a single force acting on the body, rather than the resultant force, which may lead to confusion in any analysis involving multiple forces.

To address this problem, the South African Physical Sciences curriculum states that IK should be integrated into the lessons to help learners better understand their work. This is reflected in the general aim of the South African curriculum which states that the curriculum "promotes

knowledge in local contexts” (Department of Education, 2011, p. 4). In addition, the department states that it recognises and appreciates the Indigenous Knowledge Systems (IKS) of South Africa. However, the Curriculum Assessment and Policy Statement (CAPS) document only gives one example of IK, which is how the first people used friction to make fire (Department of Education, 2011). Furthermore, the CAPS document fails to address how the IK example should be integrated into WS. Such an omission might pose a significant disadvantage to learners, especially from rural schools, because some teachers might not even know what IK is, let alone how to integrate it into their science lessons (Mdleleni & Ngcoza, 2025).

For example, a Physical Science teacher might state that a skier slides down the slope, which might be difficult for a rural learner to understand because they have no idea what skiing is. Instead, the mountain sliding game, ¹*umtyibilizi*, played by children in the rural Eastern Cape can be used to explain the skier example in a context that the learners would understand (see Figure 3.2 below). It is against this backdrop that this interventionist study investigated the efficacy of integrating a gamified approach, specifically *umtyibilizi*, to enhance Grade 11 learners’ talk and sense making of Newton’s second law.

1.6 Purpose and Significance of the Study

This study sought to find out the efficacy of integrating a gamified approach, specifically *umtyibilizi*, to enhance Grade 11 learners’ talk and sense making of Newton’s second law. Essentially, the focus was on understanding how the integration of IK might affect the Grade 11 Physical Sciences learners’ ways of understanding and learning. In addition, integrating IK into science has the potential to create a holistic approach to education. Such a holistic approach can be achieved by appreciating the multiple ways of knowing (Seehawer & Breidlid, 2021).

Against this backdrop, the study attempted to shed light on how an Indigenous game can be mobilised to enhance the learners’ talk and sense making of the forces that act on an object, for example on an incline. In addition, changing the topic from something abstract to a real-life

¹ Notable is that *umtyibilizi* is referred to as *mutserendende* in Tshona and *kupwemuruka* in Rukwangali.

example helped make the concept more relatable and easier for learners to understand. Hopefully, this might also enlighten other science teachers who would like to integrate IK examples into their lessons. At a personal level, this might help me improve my teaching while also clearing up some misconceptions that I might have – in this way, becoming a better science teacher would improve my students' performance.

1.7 Research Goal, Objectives and Research Questions

In this section, I discuss the research goal, objectives and research questions of the study.

1.7.1 Goal of the study

This interventionist study sought to investigate the efficacy of integrating a gamified approach, specifically *umtyibilizi*, to enhance Grade 11 learners' talk and sense making of Newton's second law. To achieve this, the following research objectives and questions were addressed.

1.7.2 The research objectives

1. (a) To determine what enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton's second law before the intervention.
(b) To determine what Grade 11 Physical Sciences learners know from their community about *umtyibilizi* and Newton's second law.
2. To determine how Grade 11 Physical Sciences learners talk, interact and participate during the presentation by the Indigenous Knowledge Custodians on the traditional way forces are used during *umtyibilizi*.
3. To determine how Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of the practical demonstration of *umtyibilizi* by the Indigenous Knowledge Custodians.

4. To determine how Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of using an exemplar lesson that integrates learners' local knowledge (*umtyibilizi*) when learning about Newton's second law.

1.7.3 Research questions

1. (a) What enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton's second law before the intervention?
(b) What do Grade 11 Physical Sciences learners know from their community about *umtyibilizi* and Newton's second law?
2. How do Grade 11 Physical Sciences learners talk, interact and participate during the presentation by the Indigenous Knowledge Custodians on the traditional way forces are used during *umtyibilizi*?
3. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of the practical demonstration of *umtyibilizi* by the Indigenous Knowledge Custodians?
4. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of using an exemplar lesson that integrates learners' local knowledge (*umtyibilizi*) when learning about Newton's second law?

1.8 Data-Gathering Methods

The study used four data-gathering methods, and these methods were:

- Focus group interviews (sharing circles);
- Group activities;

- Observations (participatory and lesson observations); and
- Learners' reflective journals.

1.9 Theoretical and Analytical Frameworks

The theory that frames this study is Vygotsky's (1978) sociocultural theory. Vygotsky's (1978) sociocultural theory is centred on the idea that learning takes place as a result of social interactions. Moreover, it is a learning theory concerned with how learners learn. It is thus centred on the idea that learning takes place because of social and cultural influences. Our everyday tasks and the people that we interact with shape our higher mental capabilities. As stated by Vygotsky (1978), the sociocultural theory is defined by the concepts used in this study, even though they are not exhaustive. Concepts from the theory were used to analyse the data.

1.10 Key Concepts Used in the Thesis

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

1.10.1 Physical Sciences

Physical Sciences investigates physical and chemical phenomena. This is done through scientific inquiry, the application of scientific models, theories, and laws in order to explain and predict events in the physical environment (Department of Education, 2011).

1.10.2 Newton's second law

Newton's second law states that when a net force acts on an object, the object will accelerate in the direction of the force and the acceleration is directly proportional to the force and inversely proportional to the mass of the object (Department of Education, 2011).

1.10.3 Indigenous Knowledge

Indigenous Knowledge (IK) represents a legacy of knowledge and skills that are unique to a particular Indigenous culture. This form of knowledge encompasses wisdom that has been developed and passed down through generations (Kibirige & Van Rooyen, 2006).

1.10.4 Indigenous Knowledge Custodians

Rural practitioners of IK are individuals with little or no formal education who rely on traditional knowledge in their daily lives to address everyday challenges (Mathibela et. al., 2015).

1.10.5 Ubuntu

Ubuntu is the essence of humanity, sharing, caring, respect and compassion that allow individuals to live harmoniously and in a community with a sense of family (Seehawer, 2023).

1.10.6 Sociocultural theory

Social interactions are ways in which individuals engage and connect with one another – learning and development take place through these interactions (Vygotsky, 1978).

1.11 Thesis Outline

The study was conducted with 10 Grade 11 Physical Sciences learners, in the rural schools of Mqanduli (O.R. Tambo Inland), in the Eastern Cape, South Africa. The thesis consists of seven chapters.

Chapter One: The study is introduced in this chapter, which includes a discussion of the background of the study, situating myself in the study, positionality and reflexivity, the statement of the problem, and the purpose and significance of the study. Also, the research goal, objectives and research questions are stated. The data-gathering methods that were used are highlighted, viz., focus group interviews (sharing circles), group activities, observations (participatory and lesson observations) and learners' reflective journals. Lastly, a summary of the theoretical framework used to frame the study is discussed.

Chapter Two: In this chapter, literature about integrating IK into science is reviewed, both proponents of IK integration into science and those who are against its integration. Furthermore, literature on the topic of forces and Newton's laws, and learners' potential benefits on the integration of IK into Newton's laws are discussed.

Chapter Three: This chapter explores the theory used in this study, namely Vygotsky's (1978) sociocultural theory. Within Vygotsky's sociocultural, these concepts – mediation of learning, culture and language, social interactions, and the Zone of Proximal Development (ZPD) (not exhaustive) were used as an analytical lens.

Chapter Four: Chapter Four discusses the research methodology that informed this study, the research paradigms underpinning this study and the research design employed in the study. The study was underpinned by the interpretivist and the Indigenous research paradigms. Within the Indigenous research paradigm, I used the Ubuntu perspective. The research design consisted of a case study, research goal and research questions, my positionality and reflexivity, research sites and participants, data-gathering methods, data analysis, validity and trustworthiness and ethical considerations.

Chapter Five: In this chapter, the qualitative data generated from the group activities and IKC presentations are analysed and discussed with reference to Vygotsky's sociocultural theory.

Chapter Six: In this chapter, the qualitative data generated from the focus group interviews (sharing circles), observations (participatory and lesson observations) and learners' reflective journals are analysed and discussed with reference to Vygotsky's sociocultural theory.

Chapter Seven: In this chapter, a summary of the findings in relation to the two research questions is discussed. In addition, recommendations, limitations, possible areas of future research and reflections are provided. Lastly, the conclusion of this study is provided.

1.12 Chapter Summary

Chapter One laid the foundation for the study by introducing the integration of IK into science education, specifically through the Indigenous game *umtyibilizi* to enhance Grade 11 learners' understanding of Newton's second law. The chapter highlighted the challenges learners face in grasping scientific concepts due to decontextualised teaching methods and the limited guidance in the South African Physical Sciences curriculum on integrating IK. It established the study's purpose, which was to explore how the use of local knowledge and culturally relevant examples can improve learners' sense making and engagement in science. The chapter also presented the

research objectives, questions and data collection methods, while situating the researcher's positionality and reflexivity to address potential biases.

The chapter further explored the theoretical framework underpinning the study, Vygotsky's sociocultural theory, which emphasises learning as a socially mediated process influenced by cultural and contextual factors. This framework was crucial for analysing how learners' understanding evolved through collaborative activities and the integration of their everyday knowledge into formal education. The inclusion of reflective tools such as learner journals and participatory observations ensured an ethical and collaborative research approach. The study's methodology was designed to capture shifts in learners' interactions and understanding as they engaged in the game of *umtyibilizi*.

Finally, the chapter outlined the thesis structure, providing a roadmap for subsequent chapters. It included a review of the literature on integrating IK into science (Chapter Two), a detailed exploration of Vygotsky's sociocultural theory (Chapter Three), and an explanation of the research design and methodology (Chapter Four). Data analysis and findings are discussed in Chapters Five and Six, while Chapter Seven concludes with key insights, recommendations and reflections. This comprehensive structure ensures that the study's objectives and questions are addressed systematically.

In the next chapter, the literature relevant to the study is reviewed and discussed.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

A literature review is one of the components of research which allows the researcher to portray their understanding of works previously published in the chosen field of study relating to the problem under investigation (Bertram & Christiansen, 2020). It also is a process of identifying relevant information and theories pertaining to the study (Bertram & Christiansen, 2020).

This review examines the research that is relevant to the study which is on the integration of IK into the topic of Newton's laws. It looks at what is prior knowledge and how it affects the way in which learners learn while also looking at the nature of science and that of Indigenous Knowledge. The review also looks at the ways in which hands-on practical activities and visualisation can enhance teaching and learning. It also looks at how learners talk and make sense of Newton's laws.

2.2 Literature Relevant to the Curriculum and the Study

Forces and Newton's laws are rooted in the ground breaking work of Sir Isaac Newton. The literature review examines the practical application of these laws while highlighting the emerging importance of integrating IK into the understanding of Newton's laws.

The historical development of Newton's laws of motion represented a significant milestone in the field of physics and scientific understanding. From Sir Isaac Newton's ground-breaking work in the 17th century to contemporary advancements in physics education, the study of forces and Newton's laws has evolved tremendously (Chang et al., 2014). Exploring the pedagogical aspects of teaching Newton's laws can uncover innovative approaches and suggestions for content delivery. Chang et al. (2014) state that this journey through history not only enhances our appreciation for the contributions of Newton but also highlights the evolving methods and

strategies for teaching these fundamental principles. Moreover, it ensures that these methods and strategies are comprehensible and engaging for current and future generations of science learners.

Newton studied various laws but for this study, I focused on Newton's second law. Newton's second law states that when a net force acts on an object, the object will accelerate in the direction of the force and the acceleration is directly proportional to the force and inversely proportional to the mass of the object (Department of Education, 2011). Newton's second law can be represented by the following mathematical equation: $F_{net} = ma$ where F_{net} is the net force, m is the mass and a is the acceleration.

Various authors aimed to identify and address misconceptions among learners related to the topic of Newton's laws (Handhika et al., 2016; Rahmawati et al., 2020). For instance, Rahmawati et al. (2020), in a study conducted in Indonesia, employed an isomorphic multiple-choice test, which consisted of questions that present different but structurally similar scenarios to assess whether learners apply the correct scientific concepts consistently. The study examined the misconceptions held by learners and aimed to provide insights into the effectiveness of using isomorphic testing in diagnosing these misconceptions. The study revealed that one of the misconceptions is created by learners' lack of understanding of concepts (Rahmawati et al., 2020). In contrast to Rahmawati et al. (2020), this study sought to use IK to enhance Grade 11 learners' talk and sense making of Newton's second law, which might help learners to better understand concepts.

Essentially, misconceptions arise due to learners not understanding physics concepts (Handhika et al., 2016) and the effect of the normal force on objects (Rahmawati et al., 2020). For example, normal force and gravity eliminate each other, stationary objects do not have a force and so on. In addition, detecting misconceptions among learners at an early stage is essential to prevent learning difficulties (Mavhunga & Rollnick, 2013). However, these studies seem to fail to address ways to help learners clear up the misconceptions and understand Newton's laws better.

Analysing learners' scientific literacy regarding Newton's laws and their application in living systems is a crucial aspect of science education (Budiarti & Tanta, 2021). Scientific literacy regarding Newton's laws refers to having a basic understanding of the concepts of forces and how

these forces act on an object (Yuberti et al., 2020). This research sought to understand the depth of learners' knowledge and assist them in applying Newton's laws of motion to various contexts.

In their study conducted in Indonesia, Budiarti and Tanta (2021) revealed that scientific literacy competencies are generally low, with moderate knowledge in concepts of motion, reflected in various competency percentages and cognitive scores. However, this study fails to address how scientific literacy could be improved. In contrast, my study mobilised the Indigenous mountain sliding game (*umtyibilizi*) to try and improve learners' talk and understanding of Newton's second law. Syah et al. (2020) looked at creating TikTok-based educational videos, a study conducted in Indonesia, focused on character education within the context of Newton's laws as an innovative approach to engage the technologically savvy generation in science and ethics. It was found that TikTok can enhance physics learning on Newton's laws. This might be due to learning becoming more relevant and relatable for this audience (Ishaq et al., 2022).

Rider (2019) investigated, in Arizona, the use of teaching learners Newton's second law by letting them play ²Classcraft. The study showed that learners were more engaged in the physics content while playing Classcraft, and they seemed to be paying more attention (Rider, 2019). Explaining the game and allowing the learners to play is one of the ways that has the potential to help them understand Newton's laws better. Normandt (2023) concurs that since implementing gamification in the science classroom there has been remarkable progress and enlightening (*aha!*) moments for the learners. Mohammad et al. (2023) also used a game to teach the concept of free-body diagrams which applies to Newton's laws. Free-body diagrams include all the forces that act on an object. It was discovered that introducing board games (Quantum, Gravity Maze, and Physics Fluxx) in a class prevented learners from being bored even though using digital games can have difficulties, that is procedure and game design (Mohammad et al., 2023). These digital games must balance the gameplay with the learning objectives and teachers would need to be trained.

² Classcraft is an educational gaming platform where learners can create avatars, earn experience points, lose health points, compete with one another, and use power-ups to gain classroom privileges.

The abovementioned studies discussed using technology to help learners understand Newton's laws. However, some learners in rural areas in Africa do not have access to these devices. Therefore, this gap can be mitigated by integrating Indigenous games into science, in which Newton's second law can be made more relatable to African learners.

Rahmawati et al. (2021) further studied an Indonesian dance called *dadhak merak* related to Newton's laws. This dance, which is passed on from one generation to the next as reiterated by Kibirige and Van Rooyen (2006), was used by science teachers in the study to help explain Newton's first, second and third laws. It was used to explain the acceleration in terms of Newton's laws. Videos and images of the dance were analysed using the six stages of analysis by Krippendorff (2004). The different movements within the dance were used to explain each of the laws. The study by Rahmawati et al. (2021) showed that dance can give an idea of how to explain the acceleration relationship in Newton's second law. The dance still has other movements that need to be studied to help learners understand physics concepts better.

The work by Mashoko (2022) expanded on the work by Govender and Mudzamiri (2022) to demonstrate that IK can be integrated into physics in Zimbabwean schools. This study employed Vygotsky's (1978) sociocultural framework. Moshoko (2022) further states that the integration of IK into physics has the potential to create a sense of cultural belonging for learners. In addition, the study revealed that cultural tools and ways of knowing can provide both theoretical and practical knowledge. Moshoko (2022) also agrees that school science should not be separated from the learners' culture. Furthermore, IK can also help one to promote contextual lessons when the Indigenous items can be used in areas where there is a lack of official resources to carry out a lesson (Govender & Mudzamiri, 2022). This would ensure that the learners are not disadvantaged because they are at a school with limited resources.

In the Eastern Cape, learners seem to face challenges in understanding forces on inclined planes, as identified by Mapfumo (2016). This study aimed to bridge this gap by exploring the potential of Indigenous games like *umtyibilizi* to enhance Grade 11 learners' talk and sense making of Newton's second law. I contend that while digital platforms have been used in previous studies to enhance learning, they may not be accessible to learners in some rural parts of the Eastern Cape such as where I currently teach.

Understanding Newton's second law is crucial in Physical Sciences since it helps with understanding Grade 12 topics such as work, energy and power (Mapfumo, 2024). However, the lack of access to resources (digital platforms) limits the learners' talk and comprehension of scientific concepts. In this regard, this study contends that the Indigenous game, *umtyibilizi*, has the potential to offer a promising alternative because it is often readily available (Asheela et al., 2021; Shinana et al., 2021) and culturally relevant (Haimene, 2023; Mhakure & Otulaja, 2017).

2.3 Learners' Prior Knowledge

The foundation of a new topic that the learners are being taught is always based on their prior knowledge, be it from the work done in the previous grades (Mavhunga & Rollnick, 2013) or from their everyday life experiences (Kuhlane, 2011). Learners come to class having diverse prior knowledge gathered from their culture, experiences and knowledge and skills gathered from their previous years of schooling. Hailikari (2010) describes prior knowledge as a combination of knowledge that can be used in other learning areas. Understanding the learners' prior knowledge is crucial in the teaching of ideas and new knowledge.

According to Piaget (1973), the development of one's mental structures happens through a process of assimilation and accommodation which depend on the pre-existing knowledge. If one can make links between the learners' everyday knowledge, which includes experiences and scientific concepts, then science will stop being seen as an abstract thing that is hard to grasp and relate to (Gwekwerere, 2016). The learners might draw knowledge from their long-term memory enabling them to make necessary connections to help them understand their work better (Piaget, 1973). Prior knowledge is only beneficial if the learners can activate their long-term memory and make these connections. The prior knowledge in this case works as a catalyst to help the learners improve in their work. Rivet and Krajcik (2008) also drive the idea that some researchers have about connecting the science curriculum to the lives of the students so that it is made more relevant.

2.4 Nature of Science and Nature of Indigenous Knowledge

Western Science (WS) is the science that is taught in a formal setting, for example, schools (Seehawer & Breidlid, 2021). It follows a certain curriculum, and it is taught in a specified period.

Things that happen all around us are explained using scientific explanations that have usually been tested and proven.

Glasson et al. (2010) state that in science subjects one typically monitors success through standardised tests that evaluate the understanding that the learners have of various science concepts. The evidence from the Trends in International Mathematics and Science Study tests for South Africa shows that on average, learners seem to be struggling with understanding science and mathematics (Mullis et al., 2019). TIMSS reports that 80% of science learners have only a limited understanding of the subject and its foundational knowledge (Mullis et al., 2019). Understanding WS seems to be more of a struggle in the African science classroom and that is clearly depicted in the TIMSS document with the African countries being last in the country's achievements in mathematics and science. This could have many causes, such as overcrowded classrooms, poor literacy and unqualified teachers. But this could also be due to the decontextualised ways in which science is often taught – hence, my interest in exploring new ways of teaching, such as the integration of IK with Physical Sciences.

Indigenous Knowledge (IK) includes a range of knowledge that people might possess and IKS is a collection of knowledge developed within Indigenous communities (Taylor & Cameron, 2016). Thus, IK is intergenerational as it is passed from one generation to the next through their practices, shared beliefs, and stories (Kibirige & Van Rooyen, 2006; Vasudevan & Novoa, 2022). Taylor and Cameron (2016) explain IK in an African setting as the worldviews of the African people and their ways of knowing things. Hence, some scholars are proposing 'Two-Ways-Thinking' (Michie et al., 2023) and 'Two-Eyed-Seeing' (Hatcher et al., 2009) approaches. The concepts of 'Two-Ways-Thinking' and 'Two-Eyed-Seeing' emphasise the value of drawing from both Indigenous and Western knowledge systems, acknowledging their unique strengths and perspectives. It is against this backdrop that I contend that *umtyibilizi* has the potential to be an affordance for this.

Notwithstanding, McCarter and Gavin (2011) insist that integrating IK with science might overlook the richness and depth of IK (McCarter & Gavin, 2011). This implies that IK can be a subject on its own, with various terms used (traditional knowledge, native wisdom or local expertise) to refer to it. McCarter and Gavin (2011) argue for a different term to describe IK. They use traditional ecological knowledge. This term seems to better explain what IK is. It factors in the

idea that it is those cultural or traditional ways of doing things or know-how and also that the knowledge differs in different cultures and surroundings.

Different authors have studied the integration of IK with WS (Mukwambo, 2016; Onwu & Charles, 2020). These scholars based their studies in different African countries where different Indigenous practices are applicable. An individual African country has a variety of ways of 'know-how' by the people due to the different communities and ethnic groups. Similarly to Hatcher et al. (2009), Onwu and Charles (2020) use the 'Two-Eyed-Seeing' approach which is a way of studying science using the IK that the learners are already aware of. This approach ensures that IK and WS are used together to improve the teaching and understanding of science education (Seehawer & Breidlid, 2021).

Contextualised teaching and learning (CTL) is another approach to the integration of IK into WS (Mukwambo, 2016). It deals with ensuring that a teacher not only focuses on the subject matter but also uses real-life examples to help the learners understand better (Gwekwerere, 2016; Mukwambo, 2016). Similarly, situated learning emphasises the importance of context in the learning process (Khan et al., 2023). This might help the learners relate to science instead of viewing it as if it is abstract with no relation to their real worlds. One qualitative research project observed and interviewed trainee teachers to find out if they applied CTL (Mukwambo, 2016).

The work by Gwekwerere (2016) was primarily qualitative but test results of the control and experimental groups of learners were statistically analysed. The quantitative study focused on the learners and showed the improvement that the integration had on their understanding of their work. The qualitative study focused on the teachers and showed the rich explanations from the cultural groups and views from the reflections from the trainees which could help other teachers who read the article. These studies show how integrating the two knowledge systems (IK and WS) helps to benefit the learners as reiterated by Seehawer and Breidlid (2021) but seem to fail to show us the challenges or hurdles that need to be overcome to efficiently practice it.

Further studies have been carried out that not only show the integration of IK with WS but also mention the work that would need to be put into making such changes (Otulaja & Ogunniyi, 2017; Ogunniyi, 2007a). For instance, Ogunniyi (2007a) used the practical argumentation framework to

justify or reach an agreement within the data collected from questionnaires, tapes, interviews and reflective essays from the teachers. The study revealed that the teachers agreed with the need for integration between the two knowledge systems due to the awareness brought to them during the study (Ogunniyi, 2007a). According to Aikenhead and Jegede (1999), the integration between the two knowledge systems would allow the learners to easily switch between their cultural knowledge and school knowledge.

This idea is also shared by Otulaja and Ogunniyi (2017) and Aikenhead and Jegede (1999) refer to this phenomenon as border crossing. In contrast, Godlo (2024) refers to this as a river crossing emphasising that in her context or setting there are no borders. Instead, schools and communities are separated by rivers. The two studies do not only end there but further portray how more work must be done to come up with strategies and enable a smooth transition into the new curriculum for the teachers, learners and the community at large. Ensuring the learning between the Indigenous and modernised science goes hand in hand, the teachers would need to be trained on the changes with the help of the community members who could help with examples that could be used in the new curriculum.

Some authors believe that IK is better off as standalone knowledge instead of being integrated into science (Cobern & Loving, 2001; Horsthemke & Schafer, 2007). These scholars believe that it would be better to understand IK as an important type of knowledge without it being integrated into science. They share the idea that IK will always be overshadowed by WS. Seemingly, science incorporates broader knowledge that can easily be explained by facts while IK does not.

However, some proponents of IK also caution against romanticising IK (Afonso-Nhelevilo, 2013; Mhakure & Otulaja, 2017; Mukwambo et al., 2014; Ogunniyi, 2007a). It is important to see IK as not superior to science because it will create the same boundary as when science was viewed as superior, instead of creating harmony between the two knowledge systems (Seehawer & Breidlid, 2021). Such harmony could further be harnessed in that Indigenous practices could be in the form of hands-on practical activities (Asheela et al., 2021; Shinana et al., 2021), enabling the visualisation of science concepts embedded in them.

2.5 Hands-on Practical Activities

Hands-on practical activities are important in ensuring that learners get to have a feel of what is being taught. Asheela et al. (2021) define practical activities as the use of action to create a link between what we see being done and what is taught in class. These activities help the learners to develop a level of skill and knowledge that is beneficial to their understanding.

According to Whyte et al. (2008), objects play a significant role in portraying meaning during teaching and learning. Making sense of something is easier when one can actually see what is being taught. This is how visualisation can be explained, as representing difficult concepts by using artefacts to help the learners understand better (Fadiran et al., 2018; Shinana et al., 2021). These visual representations help learners to have an idea about what the teacher is talking about. This could even be more helpful in rural schools where learners might not know what the teacher is talking about and hence the concepts end up not making sense. Visualisation allows for a better understanding of the various concepts. This is where the Indigenous game fits in.

2.6 Learner Talk and Sense Making

Learners' talk and sense making are critical components of effective science education, fostering a deeper understanding of complex concepts like Newton's second law. Engaging learners in discussion allows them to articulate their thoughts, question their assumptions, and build on each other's ideas, thereby enhancing their cognitive processes. Affolter (2020) states that learners deepen their understanding of science through collaborative dialogue, engagement in science practices and complex reasoning. This interactive approach promotes active learning, whereby learners collaboratively construct knowledge rather than passively receiving information. Sense making, in this context, involves interpreting and integrating new information with existing knowledge to form coherent understanding. Through dialogue, learners negotiate meanings, clarify misunderstandings and refine their conceptual frameworks, leading to a more robust grasp of scientific principles (Affolter, 2020).

Integrating the Indigenous game of mountain sliding provides a culturally relevant and engaging platform for learners to explore Newton's second law. This hands-on activity contextualises abstract physics concepts within a familiar and enjoyable experience, making them more accessible (Asheela et al., 2021). As learners participate in the game, they naturally engage in discussions about the forces at play, such as gravity, friction and acceleration. These conversations facilitate sense making as learners observe, hypothesise and reason through their experiences. The game serves as a bridge between theoretical knowledge and practical application, enabling learners to see the real-world relevance of Newton's second law while honouring Indigenous Knowledge and traditions.

2.7 Chapter Summary

This chapter reviewed relevant literature on integrating IK into the teaching of Newton's second law, exploring its potential to enhance learner understanding and engagement. It began by examining the historical and pedagogical significance of Newton's laws, focusing on common misconceptions and challenges in teaching the subject. Research indicates that learners struggle with concepts such as force and motion due to a lack of resources, decontextualised teaching methods and limited scientific literacy. While previous studies have incorporated digital tools and games to address these issues, this chapter highlights the gap for resource-limited rural settings, suggesting Indigenous games as an alternative approach.

The chapter delved into the interplay between learners' prior knowledge, the nature of science (WS), and Indigenous Knowledge, emphasising the importance of bridging the gap between these frameworks. Theories such as Vygotsky's sociocultural framework and Piaget's concepts of assimilation and accommodation were used to show how connecting IK to science education can make learning more relatable and meaningful. However, debates around integrating IK into WS highlight the need for careful balance, ensuring IK is not overshadowed or romanticised but instead harmonised with formal science education. The study underscores the potential of Indigenous games, like *umtyibilizi* (mountain sliding), to contextualise abstract concepts and foster a sense of cultural belonging among learners.

In addition, the chapter explored the role of hands-on practical activities and learner talk in enhancing sense making. Practical activities using Indigenous games provide a visual and interactive platform for learners to grasp Newton's second law, fostering active learning and collaborative discussions. These activities help learners connect theoretical concepts to real-life experiences, enabling them to better understand forces like friction and gravity. Overall, the review demonstrated that integrating IK, particularly through culturally relevant activities, can transform science education into a more inclusive and effective learning experience.

In the next chapter, the theoretical framework underpinning the study is discussed.

CHAPTER THREE: THEORETICAL FRAMEWORKS

3.1 Introduction

The goal of this interventionist study was to investigate the efficacy of integrating a gamified approach, specifically *umtyibilizi*, to enhance Grade 11 learners' talk and sense making of Newton's second law. It sought to do this by exploring the potential of Indigenous games like *umtyibilizi* (mountain sliding game) to enhance learner talk and sense making of Newton's second law.

3.2 Theoretical Framework

A theoretical framework provides a structured approach to addressing a problem while influencing how data is analysed (Bertram & Christiansen, 2020). In this study, Vygotsky's (1978) sociocultural theory served as the analytical lens. Sociocultural theory, rooted in the idea that learning is fundamentally shaped by social and cultural influences, provides an essential perspective for exploring the dynamics of learning. Vygotsky (1978) argued that our daily interactions and activities are pivotal in shaping our higher mental functions. This theory offers a framework to examine learning, particularly in the context of learners.

Central to sociocultural theory is the notion that learning occurs within social contexts, emphasising the importance of cultural tools, mediation and interaction. Vygotsky (1987) highlighted the dynamic interplay between learners and their environments, focusing on how teachers and learners engage in shared activities to promote cognitive development. This interaction, often referred to as the Zone of Proximal Development (ZPD), underscores the potential learners achieve through guidance and collaboration with more knowledgeable others.

According to Allahyar and Nazari (2012), this framework is particularly relevant in the study of teaching and learning processes in education. Their review of Vygotsky's work supports the idea that learners' interactions are vital for effective learning in English as a foreign language classrooms. This highlights one of the key principles of sociocultural theory; that learner engagement and participation in social contexts are essential for cognitive and linguistic development.

Pathan et al. (2018) emphasise the profound impact of sociocultural theory on second language acquisition. They describe language learning as a process deeply embedded in socially mediated activities. In this view, participation in collaborative tasks and culturally relevant experiences becomes a cornerstone of effective learning. Vygotsky's framework shifts the focus from isolated knowledge acquisition to the importance of creating meaningful and relevant educational experiences.

This sociocultural perspective also recognises the significance of historical, cultural and institutional contexts in shaping learning outcomes. Vygotsky (1987) argued that the social dimension of consciousness precedes the individual dimension, illustrating how cultural and social artefacts mediate cognitive processes. Consequently, the interaction between teachers and learners and the broader cultural environment is central to learners' development and potential performance (Pathan et al., 2018).

Social interaction plays a pivotal role in Vygotsky's sociocultural theory. As Scott and Palincsar (2013) note, this perspective seeks to explain how individual mental functioning is inextricably linked to the cultural and historical contexts in which individuals live. Learning, therefore, is not an individual activity but a socially constructed process that evolves through participation in culturally organised activities and interactions.

Daneshfar and Moharami (2018) expanded on this idea by emphasising the role of the social environment in shaping learners' development. They argue that no individual is born as a culturally proficient member of society; rather, cultural practices must be taught through active engagement in social interactions. This underscores the necessity of integrating IK when teaching learners WS because they have environments rich with cultural and interpersonal experiences.

The sociocultural theory provides valuable insights into teaching practices, particularly in language education. Pathan et al. (2018) suggest that education should focus on helping learners 'learn to learn' by creating meaningful and relevant learning experiences. This aligns with Vygotsky's emphasis on the significance of scaffolding and guided participation in facilitating learners' cognitive and language development.

For teachers, this theoretical lens emphasises the need to create learning environments that prioritise collaboration, interaction and cultural relevance. By fostering social connections and leveraging cultural tools, teachers can create opportunities for learners to achieve higher levels of understanding and performance. The sociocultural theory thus offers a comprehensive framework for addressing the complexities of learning and teaching processes, particularly in multilingual and multicultural contexts.

While much of the foundational work in sociocultural theory originates from Vygotsky's writings, subsequent scholars have extended and refined his ideas. Contemporary research continues to explore the intersections of culture, cognition and social interaction in diverse educational settings. Scott and Palincsar (2013) highlight the ongoing relevance of sociocultural theory in understanding how participation in socially mediated activities influences psychological development.

In sum, Vygotsky's sociocultural theory provides a powerful framework for analysing the interplay between social, cultural and historical influences on learning. By emphasising the role of social interactions, cultural tools and meaningful experiences, this theory offers valuable insights into how learners learn. As stated by Vygotsky (1978), the sociocultural theory is defined by the concepts below, even though they are not exhaustive.

3.2.1 Mediation of learning

Mediation is when learners work together with the monitoring of the teacher to support each other's learning, as explained by Vygotsky (1978). It involves the use of tools, structured activities and social interactions to help learners make sense of their environment and tasks. Mediation provides opportunities for individuals to connect with the material, build understanding, and

develop their cognitive and social skills (Vygotsky, 1978). For instance, teachers often use strategies like asking students to explain concepts in their own words or engaging them in practical exercises. An example could be a game of tug-of-war, which helps learners experience and understand the effect of forces. Such activities encourage learners to form meaningful connections between theoretical concepts and real-world applications.

Mediation is not only about external activities but also the internal processes they trigger. According to Vygotsky (1978), mediation occurs in two stages. First, human actions are influenced by interactions with their surroundings. Then, these actions develop internally as psychological processes. This dual nature of mediation highlights its role in shaping both external behaviours and internal thought processes.

There has been a growing interest in how mediation affects the way that various learners learn in their particular contexts. Vygotsky (1978) emphasises that mediation involves inserting tools or objects between humans and their environment to facilitate understanding and learning. These tools can be physical, like books or educational games, or symbolic, such as language and social interactions. Through mediation, learners gain a deeper understanding of the tools they use and the concepts they apply.

One well-researched framework for mediation is peer-assisted learning strategies (PALS). According to Zayyad (2020), PALS involves structured peer interactions where learners work together to support each other's learning under the guidance of an expert teacher. In this approach, learners alternate roles as tutors and tutees, engaging in structured activities that include immediate feedback and correction. This continuous exchange ensures that learners are actively involved and benefiting from the process.

Unlike traditional teacher-led instruction, which often limits opportunities for practice and interaction, PALS keeps learners engaged throughout the lesson (Zayyad, 2020). Mediation of learning incorporates verbal interactions and corrective feedback, enabling learners to refine their understanding and skills in real time. Teachers play a critical role in this process by supervising the sessions, ensuring the strategies are correctly applied, and providing feedback and rewards for effective teamwork and accurate responses.

According to Zayyad (2020), students in PALS programmes spend most of their learning time actively engaged, benefiting from frequent opportunities for verbal interaction and immediate corrective feedback. These interactions help clarify misunderstandings and reinforce correct concepts, ensuring consistent progress for both tutors and tutees. This dynamic approach contrasts with traditional methods, where learners may spend more time passively listening and less time actively engaging with the material.

The benefits of mediated learning extend beyond cognitive development. Alkudiry (2022) highlights that high levels of peer interaction lead to higher academic success rates. By working collaboratively, learners develop essential social skills, such as communication, teamwork and problem solving. These skills are critical for academic achievement and preparing learners to navigate real-world challenges.

Mediation also fosters a deeper understanding of tools and their purposes. Dalsgaard (2020) explains that mediation enables learners to connect tools with their intended outcomes, creating a more profound sense of understanding. For example, in a science lesson, students might use a simple machine to explore the principles of mechanics. Through mediated activities, they not only learn the theoretical concepts but also understand how these tools function in practical scenarios.

Another essential aspect of mediation is the teacher's role. Neto (2020) emphasises that teachers must provide direct support, guiding learners through the entire process. This involves moderating learning strategies, prompting learners to apply them accurately and ensuring that corrective feedback is immediate and constructive. Teachers should also encourage positive behaviour and teamwork by recognising and rewarding collaborative efforts.

In conclusion, mediation is a powerful tool for fostering cognitive development and social skills. It helps learners build connections between concepts and their practical applications while promoting active engagement and collaboration. Frameworks like PALS demonstrate how structured interactions, guided by expert teachers and peers can transform the learning experience. By ensuring continuous engagement and immediate feedback, mediation enhances academic success and equips learners with essential life skills. As Dalsgaard (2020) notes, mediation creates

meaningful learning experiences by linking tools to their intended purposes, making it a cornerstone of effective education.

3.2.2 Culture and language

Culture and language play critical roles as tools in the learning process. According to the sociocultural theory, learning is inherently a social activity influenced by cultural contexts and interactions (Vygotsky, 1978). Language, especially second language acquisition, is a significant challenge for learners, particularly in rural South Africa. Here, learners face the concept of “border crossing” as defined by Aikenhead and Jegede (1999), which involves switching between the distinct cultural and linguistic environments of their homes and schools.

This divide highlights the lack of synergy between schoolwork and learners’ home cultures or languages, creating barriers to effective learning. Teachers must consider the diverse cultural and linguistic backgrounds of their learners when planning lessons. Integrating culturally responsive teaching methods ensures that learning materials are relatable and accessible to learners from different cultural contexts (Mavuru & Ramnarain, 2020). Bridging this gap fosters a learning environment where learners can connect their cultural experiences with academic content, reducing the alienation they may feel in school settings.

Learning an additional language goes beyond mastering grammar and vocabulary – it involves immersing oneself in the culture of that language. As Kim (2020) points out, language learning is a pathway to experiencing another culture, promoting empathy and enriching one’s understanding of diverse human experiences. Successful language learners often integrate cultural understanding with language acquisition, as teaching language and culture are inseparable.

For language to be meaningful, it should be contextualised within cultural practices, values and perspectives. This cultural immersion allows learners to gain insights into the lives of others, fostering understanding and bridging social and political divides. Teachers should adopt approaches that view language as a means to engage with people rather than treating it as a set of mechanical skills. This perspective enhances learners’ ability to see language as an extension of

real-life interactions, furthering their ability to navigate and appreciate cultural diversity (Kim, 2020).

Language is central to learning and cultural transmission. Vygotsky (1987) emphasised that language is improved through social interactions aimed at communication. These interactions expose learners to diverse cultures and perspectives, helping them make sense of the world. Similarly, Erbil (2020) underlines that language is a vital tool for transmitting culture, enabling learners to connect their personal and educational experiences to broader cultural contexts. Caronia (2021) elaborates that language mediates how individuals perceive and understand the social, material and cultural world around them. It allows learners to move beyond immediate circumstances, engage with abstract ideas and discuss events displaced in time and space. As Rahmatirad (2020) explains, language gives both the teachers and the learners a unique ability to think and communicate about hypothetical entities and future possibilities. By teaching language in a way that embraces its cultural dimensions, educators empower students to not only succeed academically but also connect meaningfully with the world.

3.2.3 Social interactions

From the time children are born, they begin learning through interactions with their environment and the people around them (Bodrova, 1997). These early interactions lay the foundation for their cognitive and social development. Teachers play a crucial role in bridging the gap between the knowledge learners have already gathered through their experiences and the new concepts being taught in class. By building on learners' prior knowledge and life experiences, teachers can help learners understand rather than simply memorise information (Gwekwerere, 2016; Turuk, 2008). This approach encourages meaningful learning and strengthens connections between existing knowledge and new ideas.

Evidence shows that even young children, as early as three years old, can engage in argumentation and counter-argumentation in various settings, such as at home or school (Rapanta, 2023). These conversations, which are often practical, aim to persuade, discuss and negotiate rather than achieve a specific learning goal. Such interactions help children become aware of social situations and

develop skills to argue effectively. Even if they end up agreeing to disagree, arguing encourages active thinking and teamwork (Rapanta, 2023).

Vygotsky (1978) emphasised that learning is fundamentally a social activity. His theory postulates that learners develop new skills and behaviours through social interactions. Observing and communicating with peers or mentors with more advanced knowledge helps learners solve problems and progress in their development. Activities like role play, teamwork, group work and simulations provide opportunities for this type of social learning, allowing students to benefit from others' experiences and skills (Zhou, 2020).

Erbil (2020) further highlights the “learning together technique,” where learners are assigned specific roles in heterogeneous groups. Each group member contributes by completing a designated part of the task, fostering collaboration and collective achievement of group objectives. This social interaction method enhances learners' ability to engage with one another and learn effectively in a classroom setting.

By promoting direct discussion, teamwork and interactive activities, teachers can create a dynamic learning environment where students are active participants in their own education. This approach not only develops critical thinking and problem-solving skills but also prepares learners to collaborate and adapt in diverse social and academic contexts.

3.2.4 Zone of proximal development

According to Vygotsky (1978), learning takes place within the ZPD. Vygotsky describes the ZPD as “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (1997, p. 33). Zaretsky (2021) supports this by stating that teachers should be aware of the space where a child can solve problems with adult help but cannot yet do so independently. The fundamental feature of teaching and learning consists in the formation of a ZPD. Teaching thus gives birth to, awakens and animates in the child a whole series of internal developmental processes, which, at a given moment, are only accessible to them

within the framework of communication with the adult and of collaboration with peers, but which, once internalised, will become the child's own conquest (Schneuwly & Leopoldoff, 2022).

In other words, the ZPD is the area or zone where learning takes place. When a learner requires the assistance of a more knowledgeable other (MKO) to complete a task, it helps them to develop their mental structures so that in the future they might be able to apply the strategies they learned without any assistance. The learner can also end up being the MKO when they start understanding their work and help explain it to other learners (Stott, 2016). The ZPD is not the same throughout an individual's life because a child changes and goes through different developmental stages.

The role of the teacher is to mediate this development to help the learners improve in the context of this study. This could be done by breaking down the lesson into smaller manageable units and assisting when required, referred to as scaffolding (Bruner, 1960). When teachers create a favourable learning environment, learners are easily supported to move to the next developmental stages enabling them to do better in science. This would enable the learners to have the ability to self-regulate or learn on their own (Vygotsky, 1978). Vygotsky's sociocultural theory (1978) helps us understand how people learn, however, it does have its limitations. Ameri (2020) states that Vygotsky (1978) does not consider that some children, such as gifted children, can rise above social norms in their ability to understand what is being said.

3.3 Whose Sociocultural Context Do We Consider?

From the perspective of Vygotsky's sociocultural theory, the question arises: is it fair to teach learners in rural parts of the Eastern Cape who have never experienced snow about Newton's second law using an example of a skier sliding down a snowy slope – something entirely removed from their lived experience? Learning, according to this theory, is deeply rooted in the cultural and social contexts of the learner, mediated through cultural tools that resonate with their environment.

When the examples used in teaching are disconnected from the realities of learners' daily lives, do we not risk creating a barrier to understanding, rather than a bridge? By failing to leverage familiar concepts, such as pushing a wheelbarrow, rolling a tyre down a hill or playing *umtyibilizi* – an

Indigenous game played by children in this region, we may inadvertently alienate learners from the very knowledge we aim to make accessible.



Figure 3.1: Skier sliding down the slope (<https://images.app.goo.gl/wJhjwaCuHKYhEBXk6>)
 Figure 3.2: A learner playing umtyibilizi (mountain sliding game)

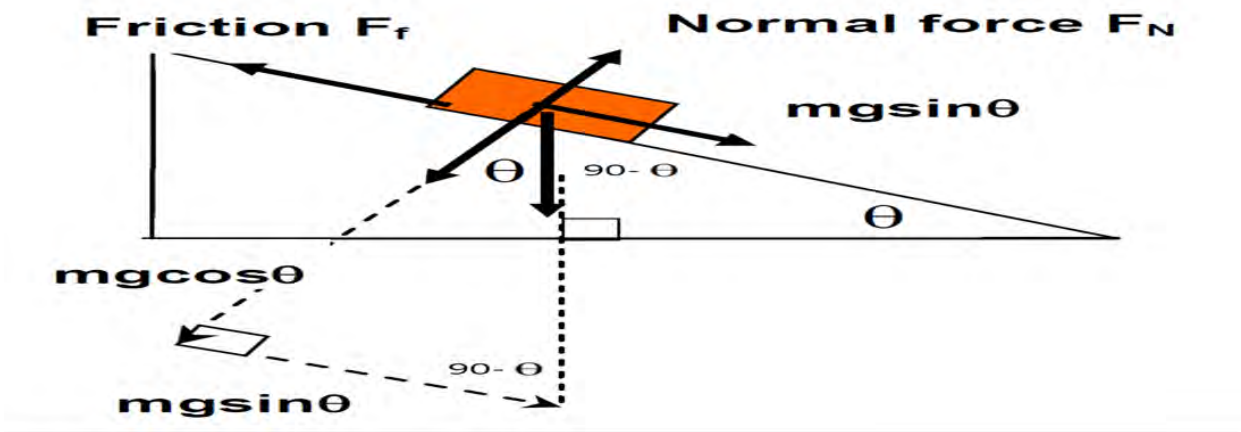


Figure 3.3: Resolved forces on an inclined plane
 (<https://images.app.goo.gl/GnQBaNc6RYJKPYuu5>)

Teaching through unfamiliar contexts raises a deeper ethical question: Does this approach truly respect the learners’ lived realities?

3.4 Chapter Summary

This chapter explored the integration of IK into teaching Newton’s second law through Indigenous games like *umtyibilizi* (mountain sliding). The study is grounded in Vygotsky’s sociocultural theory, which emphasises the influence of social interactions, cultural tools and the ZPD in learning. The chapter underscored the dynamic relationship between learners and their

environment, highlighting how culturally relevant educational practices foster understanding and cognitive growth. By examining the sociocultural underpinnings of teaching and learning, the study argues for the meaningful inclusion of learners' cultural contexts to bridge the gap between traditional knowledge systems and formal science education.

The chapter elaborated on four key concepts of Vygotsky's theory which are the mediation of learning, the role of culture and language, social interactions and the ZPD. Mediation is a structured process where teachers and peers facilitate learning using tools, activities, and social exchanges, encouraging learners to connect theoretical concepts with real-life applications. Language and culture emerge as critical components, as they shape how learners interpret and engage with their world. The chapter highlighted the challenges learners face in navigating linguistic and cultural divides, particularly in rural South African contexts, and emphasised the need for culturally responsive teaching practices.

Social interactions and the ZPD are central to understanding learners' cognitive development. Through collaborative activities and peer engagement, learners can internalise new concepts and build upon prior knowledge. Teachers play a critical role by scaffolding lessons, providing guidance and creating environments conducive to growth. The chapter concluded by acknowledging the limitations of sociocultural theory, such as its limited consideration of individual learners' abilities, while emphasising its value in creating culturally relevant, interactive and learner-centred educational practices.

In the next chapter, the research methodology of the study is discussed.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

The research methodology communicates the steps or processes carried out during the study and the reasons behind them. Creswell (2012) also sees the methodology as a pathway that provides the evidence that enables one to answer the research questions. Concurring, Bertram and Christiansen (2020) describe it as a section that provides detail on the tools used to gather data while also giving reasons why the selected approach is used. These tools and reasons provide a valid way for the researcher to gather information that may be used to answer the research questions.

The research methodology consists of two components, namely, the research paradigm(s) and the research design. The research paradigms that speak to this study are the interpretivist and Indigenous research paradigms, which are looked at in detail below. The research paradigms give direction for the best possible research design that was suitable for the nature of this study. The two components, namely the research paradigm(s) and the research design are discussed below.

4.2 Research Paradigms

Fazlıoğulları (2012) states that paradigms tell the researcher what is important, legal and sensible. Paradigms help one to have a way of understanding a problem while also bringing about a broad understanding of steps to take to try to solve the problem. Cohen et al. (2018) concur that it is a way of looking at the world and using the way humans interact to try and get a sense of shared beliefs and values. I now discuss the paradigms that I used in this study.

4.2.1 Interpretivist paradigm

This paradigm deals with trying to interpret aspects of research. According to Chilisa and Kawulich (2012), this paradigm works to try to understand human nature. The assumptions of the interpretivist paradigm according to Bertram and Christiansen (2020, pp. 57–61) are:

1. Ontology – the assumption is that reality is socially constructed. The reality that one has is shaped by things like their context, so there are multiple realities.
2. Epistemology – knowledge is subjective because it is socially constructed. Belief systems and spiritual claims can be different for different communities.
3. Methodology – the purpose is to understand the experiences that people have. In order for one to understand people’s experiences, the research should take place where the participants live. This results in the researchers using methods such as case studies, phenomenology and ethnography to try and interpret the participant’s experiences.

The interpretivist believes that the world can be understood from the perspective of the individuals who are part of the study. That is, people’s lived experiences are central, and people define and describe the meaning of a particular situation they are in. However, one of the criticisms of the interpretivist paradigm is that its focus is on descriptions of situations at the expense of explanations thereof. It is against this background that in this study I complemented it with the Indigenous research paradigm (Chilisa, 2012).

4.2.2 Indigenous research paradigm

This research paradigm looks at the views of and tries to understand non-Western experiences and ways of doing things. Chilisa and Kawulich (2012) explain post-colonial Indigenous research as a worldview that looks at the previously disempowered and exploited racial groups. The assumptions of the Indigenous research paradigm according to Chilisa and Kawulich (2012, pp. 13–14) are:

1. Ontology – reality is socially constructed, it is shaped by the relations that people have with each other and the environment. There are multiple realities;

2. Epistemology – knowledge includes the Indigenous Knowledge passed from generations; and
3. Methodology – involves observing people in their natural setting through, stories, talk circles and Indigenous Knowledge Systems.

Within the Indigenous research paradigm, the Ubuntu perspective was used (Ogunniyi, 2018; Seehawer, 2023). Ubuntu is symbolised by the togetherness in the way people interact with each other and the environment. Seehawer (2023) describes Ubuntu as the understanding that our lives are dependent on the lives of other people. Ubuntu was used as a tool in conducting this study, during and after the interviews to continuously portray humaneness, interconnectedness and mutual respect for others. This was done by preparing the participants by explaining the purpose of the study, ensuring informed consent and addressing any concerns or questions they may have. In addition, allowing the participants to express themselves fully without interruption or judgement created a sense of trust and collaboration.

These paradigms seemed to work well together in this study because the interpretivist paradigm helped to deeply understand the subjective experiences of the learners, while the Indigenous research paradigm ensured that these experiences were interpreted within the context of IK and cultural perspectives. Together, they had the possibility of offering a richer and more comprehensive understanding of how integrating a gamified approach like *umtyibilizi* can enhance learners' talk and sense making of Newton's second law in a culturally relevant way.

4.3 Research Design

A research design is a detailed outline of how the research (study) will take place. The research design includes how data will be generated, what tools will be used and how the generated data will be analysed (Bertram & Christiansen, 2020). My research design was a case study, which is appropriate because it allows for an in-depth exploration of a specific phenomenon within its real-life context (Bertram & Christiansen, 2020). In this study, the case was the integration of IK through the *umtyibilizi* game to enhance Grade 11 learners' talk and sense making of Newton's second law. The unit of analysis was the learning process and experiences of the learners, focusing on their interactions, reflections and understanding of scientific concepts through participatory activities and demonstrations.

I asked for permission to work with learners from the primary school to do practical demonstrations on *umtyibilizi*. These learners were regarded as the IKCs in this study as they had expertise in this game. I also asked for permission to work with the Grade 11 Physical Sciences learners for an hour after school, once every week, to share their reflections on the process. Data generation methods involved focus group interviews (sharing circles), group activities, observations (participatory and lesson observations), and learners' reflective journals. I elected to choose an isiXhosa teacher to be my critical friend. Below are the components of the research design and how they were influenced by the paradigms.

4.3.1 Research approach

In this study, a qualitative participatory case study approach was employed and 10 Grade 11 learners in Mqanduli, Eastern Cape, voluntarily participated. This approach allowed for detailed insights within a real-life context. The main aim of qualitative methods was to try and understand the interactions of people through the participants involved (Szyjka, 2012). This interventionist study investigated the efficacy of integrating *umtyibilizi* to enhance Grade 11 learners' talk and sense making of Newton's second law. The research approach involved learners who still played *umtyibilizi*. These presentations shed light on IK techniques used that apply Newton's second law. Following these presentations, an open discussion session with the learners was conducted.

4.3.2 Research goal, objectives and research questions

In this section, I discuss the research goal and research questions of the study.

4.3.2.1 Goal of the study

This interventionist study sought to investigate the efficacy of integrating a gamified approach, specifically *umtyibilizi*, to enhance Grade 11 learners' talk and sense making of Newton's second law. To achieve this, the following questions were addressed.

4.3.2.2 The research objectives

1. (a) To determine what enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton's second law before the intervention.

- (b) To determine what Grade 11 Physical Sciences learners know from their community about *umtyibilizi* and Newton's second law.
2. To determine how Grade 11 Physical Sciences learners talk, interact and participate during the presentation by the IKCs on the traditional way forces are used during *umtyibilizi*.
 3. To determine how Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of the practical demonstration of *umtyibilizi* by the IKCs.
 4. To determine how Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of using an exemplar lesson that integrates learners' IK (*umtyibilizi*) when learning about Newton's second law.

4.3.2.3 Research questions

1. (a) What enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton's second law before the intervention?
(b) What do Grade 11 Physical Sciences learners know from their community about *umtyibilizi* and Newton's second law?
2. How do Grade 11 Physical Sciences learners talk, interact and participate during the presentation by the IKCs on the traditional way forces are used during *umtyibilizi*?
3. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of the practical demonstration of *umtyibilizi* by the IKCs?
4. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of using an exemplar lesson that integrates learners' local knowledge (*umtyibilizi*) when learning about Newton's second law?

4.3.3 Research site, participants and sampling

The study took place at Intaba Secondary School (pseudonym) in the rural town of Mqanduli in the Eastern Cape, South Africa, serving approximately 400 learners from grades 8 to 12, who are primarily isiXhosa speakers. The sampling method combined convenience and purposive sampling (Bertram & Christiansen, 2020). Convenience sampling involves selecting participants who are easily accessible or available to the researcher, while purposive sampling entails deliberately choosing participants based on specific characteristics or criteria relevant to the study (Bertram & Christiansen, 2020). By combining both methods, it was hoped that this would ensure practicality while focusing on participants who could facilitate valuable insights for the research. The choice of this school was convenient for my research because it is where I work as a Physical Sciences teacher.

The 10 Grade 11 Physical Sciences learners (who formed all learners in the class) from the school where I teach were invited to participate in my study. I deemed it ethical to include all the learners; however, they were allowed to participate voluntarily in this process so that they did not miss out on this innovative approach. So, the learners chose two groups of five learners each to participate in the sharing circle. This helped foster familiarity and ease of interaction with potential participants. To enhance the research process, a critical friend, who is a science teacher at the school was invited to collaborate with me and provide reflections throughout the study.

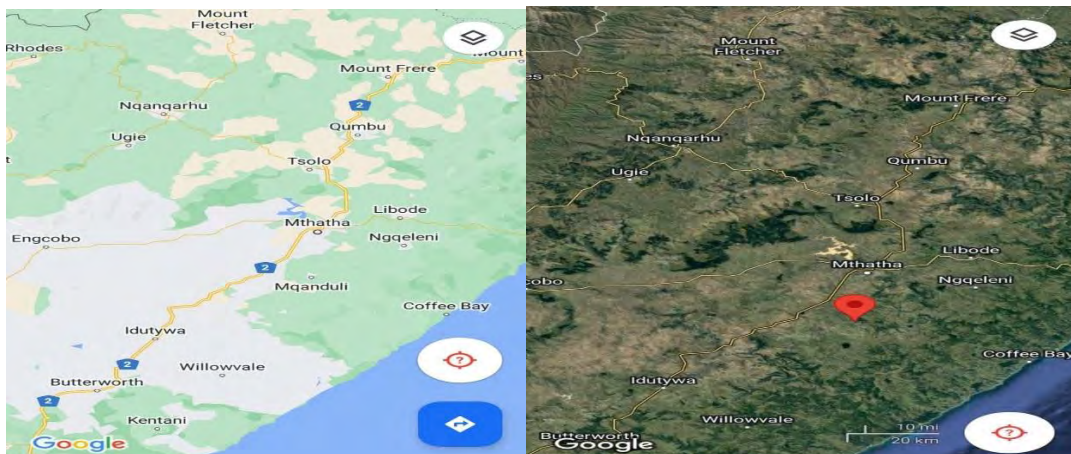


Figure 4.1: Map of the area of Mqanduli (<https://maps.app.goo.gl/cfWKGvWbo4hkCUXq9>)

4.3.4 Data-gathering methods

On the first day of data collection, the day the learners came into the venue for their Physical Sciences class, they looked confused and concerned. They seemed not to know what was expected of them, so I took some time to explain the process. They did appear to relax a bit after my explanation but remained reserved. The situation changed when one learner asked if they could speak in isiXhosa. This allowed them to feel more comfortable with each other, and they began sharing.

One was willing but had a sore on her face. She requested that she not be included in the pictures, which I respected. As it healed later, she then wanted to be part of the pictures, and I also respected that. The two lessons were an hour each, the focus group interviews (sharing circles) took 25 minutes for the pilot study and 20 minutes for the main study, and practical demonstrations took two hours. Since learners from the primary joined in during this, the critical friend and I had to manage a larger group of learners, making sure that we were still working instead of just having fun.

Overall, it went well, but what worked for me, like making accommodations for isiXhosa and deference to requests on personal matters, created an atmosphere of ease that contributed positively during the data-gathering process. The data-gathering methods which were used are discussed below.

4.3.4.1 Focus group interviews (sharing circles)

I had direct contact with the participants; therefore, a focus group interview was employed. These focus group interviews were conducted with the voluntarily participating Grade 11 learners, using an Indigenous methodology known as the sharing circle. Sharing circles were used as a cultural tool to capture the experiences of learners (Chilisa, 2012; Lavalley, 2009). They offered advantages such as the ability to explore specific responses, repeat questions if needed and discover new avenues for gathering in-depth information, as noted by Bertram and Christiansen (2020). This approach allowed me to efficiently gather the perspectives of multiple participants

simultaneously (Barrett & Twycross, 2018). In addition, it encouraged the participants to freely express their views, although it was worth noting that interviews can be time-consuming.

Two sharing circles were conducted – one was to see the loopholes that could be fixed. The pilot sharing circle showed that some learners tended to overpower others when talking. This gave rise to the idea of using a sharing stick for the second sharing circle. The sharing stick made it possible for the learners to all have an equal chance to talk. There was one learner during the pilot sharing circle who opted to sit on the side because she had sores on her face. Regardless of this she still shared her opinions.

4.3.4.2 Group activity

Similarly to Mayana's (2020) and Godlo's (2024) studies, this study employed group activities to create a welcoming classroom atmosphere, enabling learners to feel relaxed and express themselves freely. Group activities helped to identify learners' individual prior knowledge, providing valuable insights to address the research questions. Group activities promote active participation and social interactions and are in line with Vygotsky's (1978) sociocultural theory. In the group discussions, the Grade 11 learners and I discussed various questions on integrating IK into the topic of forces and Newton's laws (Appendix C3).

The learners seemed to all actively participate when sharing their information with their group members. Even the known shy learners seemed comfortable and outspoken. Initially, the learners had decided that the group members should co-present instead of selecting one learner. They then later decided that the two groups would co-present for MaNduli (critical friend) and me because they felt that would ease the pressure.

4.3.4.3 Participatory and lesson observations

The Grade 11 learners observed the IKCs' (learners from primary school) presentations on the Indigenous game. Each learner had the opportunity to present how the game was played while others observed the forces that were at play. The learners were also observed during the IK exemplar lesson and activities. The observations allowed me to understand the context better,

identifying details often missed during interviews and uncovering hidden information (Creswell, 2016).

During this research process, I positioned myself as a co-learner and let my critical friend (another teacher) encourage the learners to express their thoughts and opinions freely and validate their input. My critical friend obtained assent to reduce perceived pressure. Two lessons were conducted, one before the demonstration by the IKCs and the second after the demonstration. Where appropriate, I involved the learners in question formulation to give them a sense of ownership and reduce the hierarchical gap. The lessons were observed and videotaped by MaNduli, a critical friend. During the first lesson, the learners were very reserved, and it was difficult to get any responses. As a result, the first lesson was shorter than the second lesson, where the learners had more to say.

4.3.4.4 Learners' reflective journals

Reflective journals serve as written records that learners can use to reflect on their understanding of various concepts, events or interactions over time, fostering self-awareness and learning (Dumlao, 2024). In this study, participants were encouraged to maintain reflective journals to record learning-related incidents and their thoughts about lessons. These reflective journals allowed learners to express their personal experiences, thoughts and emotions in their own words. This provided a deeper understanding of the learners' perspectives, challenges and achievements throughout the study. These entries helped me track changes in learners' attitudes, understanding and skills. In addition, they highlighted how learners evolved throughout the study, offering insights into the effectiveness of the methods and interventions used.

The learners were made aware that they could use any language that they were comfortable with when they were writing in the journals. Initially, the learners seemed to struggle to write sentences but as time went on, they were able to write freely. Some learners used only English or isiXhosa while others used both languages interchangeably.

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

Phase	Method to be used to gather data	Purpose	Research questions
Phase 1	Lesson Observation	To find out what enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton’s second law before the intervention	1
	Sharing Circles		
Phase 2	Group Activities	To find out what Grade 11 Physical Sciences learners know from their community about <i>umtyibilizi</i> and Newton’s second law	2
Phase 3	Presentations by IKCs	To find out how Grade 11 Physical Sciences learners talk, interact and participate during the presentation by the Indigenous Knowledge Custodians on the traditional way forces are used during “ <i>umtyibilizi</i> ”	3
Stage 4	Lesson Observations	To find out how Grade 11 Physical Sciences learners’ talk and sense making shift (or not) as a result of using an exemplar lesson that integrates learners’ local knowledge (<i>umtyibilizi</i>) when learning about Newton’s second law	4
	Reflective Journals		

4.3.5 Data analysis

In this study, data analysis was conducted through a combination of thematic analysis and concepts from Vygotsky's (1978) sociocultural theory as an analytical lens. Thematic analysis is employed to identify, analyse, and interpret patterns or themes emerging from the data (Merriam, 1998), allowing the research to remain grounded in participants' responses.

The analysis followed an inductive approach, as described by Proudfoot (2023), where the themes emerged from the data rather than being pre-determined. This ensured that the findings were closely tied to participants' perspectives and experiences. At the same time, a deductive element guided the interpretation, as the study was informed by key concepts from sociocultural theory, including the mediation of learning, MKO, social interaction and cultural context. Using Vygotsky's framework, the data was examined for evidence of:

1. Mediation of learning – Involves guiding learners to connect new information with their existing knowledge meaningfully.
2. Culture and language – Language reflects cultural norms, tools, or values influencing learners' experiences or behaviours and how they communicate.
3. Social interaction – The role of collaborative or interpersonal interactions in shaping experiences or outcomes.
4. The MKO – Instances where learners' learning or understanding was influenced by someone with more expertise or knowledge.

The phases of analyses were adapted from Lacey and Luff (2001) and Sgier (2012):

1. The initial phase involved reading and re-reading the data to gain a deep understanding of the content. Also transcribing some of the data was relevant.
2. Using thematic analysis, segments of the data were coded based on recurring ideas or concepts.
3. Codes were grouped to form broader themes that aligned with the research questions and theoretical framework.

4. Emerging themes were contextualised within existing literature to strengthen the interpretation.
5. The themes were refined and analysed in relation to sociocultural theory, ensuring theoretical alignment.

Throughout the process, reflexivity was maintained by considering my influence on data interpretation. This approach ensured that the findings were authentic and grounded in both the data and the theoretical framework. By using thematic analysis with Vygotsky's sociocultural theory, this study aimed to provide an understanding of the data, revealing insights into the learners' experiences within their sociocultural contexts.

4.3.6 Validity and trustworthiness

To triangulate data, I used different data-gathering methods, viz., focus group interviews (sharing circles), group activities, participatory and lesson observations, and learners' reflective journals. Member checking was done by giving the transcripts to my learners, which they reviewed and approved. I also gave them feedback on my findings.

I presented my research at the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE) on 15 January 2025 in Potchefstroom. I also presented at the Special SAARMSTE Eastern Cape Chapter colloquium on 21 January 2025. The feedback received from both conferences helped me improve my research.

4.4 Ethical Considerations

This section deals with the process of ensuring that the interests of the participants of this study were protected and recognised accordingly as stated by the university's Research Ethics Committee. In this section, I discuss some aspects of ethical considerations.

4.4.1 Respect and dignity

The study was guided by the perspective of Ubuntu, which focuses on the qualities of being human, sharing, caring, respect and compassion. Ubuntu creates a sense of community and ensures a qualitative and harmonious human experience (Seehawer, 2023). In line with these values, both

the learners and the IKCs were respected by using the names they chose for themselves. This approach helped to level power relations, treating all participants as equals and acknowledging their values, interests and needs. They were viewed as co-learners in the study. Accordingly, I invited both male and female IKCs to best avoid gender power relations or complexities.

Since this was an interventionist study, the final decisions on anonymity were left to the participants. I also obtained permission from them to allow me to video their presentations. Finally, I ensured that the information obtained would be confidential and not released to any third party, except my supervisor, without permission. The consent and assent forms signed by all were kept in a locked cabinet at home for privacy and security.

4.4.1.1 Transparency and honesty

Before the study had begun, the purpose of the study, why the site was chosen, and what would happen were clearly explained to the participants. The time involved was explained to them, reassuring them that the study would not interfere with their schooling because it would only take one hour a week, except for the demonstration, which was two hours.

I therefore asked participants to sign consent and assent forms, which were made available in both isiXhosa and English. What is more, I had to explain the study to the parents or guardians of the learners since they were minors, and I needed permission to involve their children in an out-of-school learning context. I also had to explain the study to the parents of the two IKCs' parents since they were minors.

4.4.1.2 Accountability and responsibility

The study followed the principles and policy guidelines for educational research. My responsibility was to ensure that all data was safely stored. Data collected in hard copy was stored securely in lockable cabinets, while data collected electronically in soft copy was protected with passwords to ensure confidentiality and security.

4.4.1.3 Integrity and academic professionalism

The ethical clearance letter from Rhodes University was received (see Appendix A1). This was after receiving the approval letter to conduct research from the Eastern Cape Department of Education (see Appendix A2). Letters were submitted to the principals of the two schools to allow me to conduct the interviews (see Appendix A3) and consent forms to the participants (see Appendix A4). I explained to the learners the aim of the study before they gave voluntary consent to participate. I also requested the learners to take audio recordings during the interviews. The learners who participated in the study were anonymised, and they were referred to by the names that they chose for themselves. The schools also remained anonymous. The pictures of the participants are not blurred because that is what they requested, as they were proud to be part of the study.

4.5 Chapter Summary

This chapter outlined the research methodology, which detailed the processes and tools employed in the study and their rationale. The methodology includes two primary components: research paradigms and research design. The interpretivist paradigm and the Indigenous research paradigm formed the basis for this study, allowing for a comprehensive exploration of learners' experiences. The interpretivist paradigm focuses on understanding subjective experiences, emphasising the importance of social and cultural contexts. The Indigenous research paradigm complements this by integrating IK and the Ubuntu perspective, which values interconnectedness, mutual respect and cultural heritage in the research process. Together, these paradigms provided a robust framework for understanding the learners' talk and sense making of Newton's second law through the culturally relevant game, *umtyibilizi*.

The research design employed a qualitative case study approach to explore the integration of *umtyibilizi* into Grade 11 Physical Sciences lessons. This approach involved various data-gathering methods, including focus group interviews (sharing circles), group activities, participatory observations and learners' reflective journals. These methods were designed to capture learners' experiences and interactions during the study, ensuring active participation and fostering a sense of ownership among participants. The research site, Intaba Secondary School in the Eastern Cape,

provided a familiar and accessible environment for the study, while purposive and convenience sampling ensured meaningful engagement with learners. A critical friend assisted during the research process to enhance reflection and validate findings.

Data analysis followed a thematic approach, guided by Vygotsky's sociocultural theory, to identify patterns and themes in the learners' experiences. Key elements such as mediation, social interaction, and cultural tools were examined to understand the impact of integrating *umtyibilizi* on learners' understanding of Newton's second law. Measures were taken to ensure validity and trustworthiness, including triangulation of data, member checking, and peer feedback through conference presentations. Ethical considerations, such as informed consent, anonymity and voluntary participation, were prioritised throughout the study. This methodology supported the study's goal of exploring how Indigenous games can enhance learning, promoting cultural inclusivity and academic engagement.

In the next chapter, the data analysis generated from the lesson observations, sharing circles and group activities is discussed.

CHAPTER FIVE: LESSON OBSERVATIONS, SHARING CIRCLES AND GROUP ACTIVITIES

5.1 Introduction

The primary goal of this interventionist study was to investigate the efficacy of integrating a gamified approach, specifically *umtyibilizi*, to enhance Grade 11 learners' talk and sense making of Newton's second law. This was done to promote the accessibility of science and its relevance to the life experiences of learners (Gwekwerere, 2016). In this chapter, I thus present, analyse and discuss data from the lesson observations and sharing circles. This was intended to answer the following research question:

1. (a) What enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton's second law before the intervention?

(b) What do Grade 11 Physical Sciences learners know from their community about *umtyibilizi* and Newton's second law?

5.2 Data Generated from Lesson Observation (1)

Kraus (2024) defines observation as the act of watching and mentally processing an ongoing activity, emphasising its importance in understanding and analysing complex processes. This definition aligns closely with the lesson observation process undertaken in this study. MaNduli, my critical friend, observed the two lessons I presented in class, not only to gain insights into the teaching and learning process but also to provide constructive feedback that could enhance future practices.

In this section, the data generated from the lesson and its associated activities, which focused on Newton’s second law and its integration with *umtyibilizi* (an Indigenous game) is discussed. The integration of *umtyibilizi* aimed to contextualise the scientific concept within learners’ lived experiences, fostering a deeper understanding of Newton’s second law through culturally relevant teaching methods (Mhakure & Otulaja, 2017). All lessons were video recorded with the participants’ informed consent to ensure adherence to ethical guidelines and to allow for detailed analysis of both teacher and learner social interactions as emphasised by Vygotsky (1978). This process was important in capturing the dynamics of the classroom and the effectiveness of the integrated teaching approach.

Table 5.1: Data-gathering tools and codes discussed in this section

Data-gathering tools and codes used	Codes used
Lesson before the demonstration by IKCs	LBD
Sharing circles interview	SCI
Learner-codes in sharing circles interview	L3, L4, L5, L8, L9
Learner journal reflections	L1, L2, L3, L6, L7

The Grade 11 learners had a lesson on practical activities before the practical demonstration where the baseline information was observed. The following day, the learners were taken to the primary school for the presentation by the IKCs. After the presentation by the IKCs, the second lesson integrating IK was taught and MaNduli (critical friend) observed.



Figure 5.1: Image of the learners walking into class for the lesson before demonstration by IKCs

5.2.1 Development of themes

Sub-themes emerged from the lesson observation analysis. From these sub-themes, themes emerged which in turn allowed for the literature and theory to surface.

Table 5.2: Themes that emerged from the lesson observations

Sub-themes	Themes	Literature/theory
Lesson before the demonstration by IKCs (LBD)		
Science activities that reflect learners' cultural backgrounds, making science more relatable and engaging	Connecting learner's cultural experiences to science through relatable learning activities	Vygotsky (1978); Kuhlane (2011); Fadiran et al. (2018); Shinana et al. (2021)
Cultural references to explain scientific principles; home languages to bridge and enhance comprehension of scientific content	Use of cultural and everyday language to make science more understandable	Vygotsky (1978); Asheela et al. (2021); Pathan et al. (2018)
Working together on scientific activities; reach a common understanding of scientific concepts	Teamwork and discussions to build shared knowledge and understanding	Vygotsky (1978); Scott and Palincsar (2013); Zayyad (2020)

Providing step-by-step support; see how IK and scientific methods complement each other	Guidance helps the learners to gradually connect IK to scientific ideas	Vygotsky (1978); Bruner's (1960)
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5.2.2 Lesson before the demonstration by IKCs

The introductory lesson module before the demonstration by the IKCs was to contextualise and prepare the learners for what they were going to be doing. It also sought to find out what enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton's second law.

- **Connecting learners' cultural experiences through relatable learning activities**

Before introducing Newton's second law, a lesson designed to use the learners' prior knowledge and lived experiences as a foundation for learning was planned (Kuhlane, 2011). The lesson revolved around *umtyibilizi*, an Indigenous mountain sliding game that many learners had played in their childhood. To mediate their learning, the learners were asked whether they still played *umtyibilizi* (Vygotsky, 1978). Grade 11 learners responded "No" in unison to that. However, when asked if they had ever played it, they unanimously said "Yes". This response confirmed that the game was part of their cultural experience, even if it was not currently practiced.

The learners were then asked to form pairs and discuss how they had played *umtyibilizi*. Each pair reported back to the class, describing their unique experiences. Some mentioned sliding on slopes covered with soil, while others preferred grassy slopes. They shared how different materials, such as broken canopies, cardboard or even old metal sheets, were used as sledges. These served as artefacts to help the learners understand the role of frictional force better (Fadiran et al., 2018; Shinana et al., 2021). L3 and L8 talked about seeking slopes with contours to mimic the sensation of flying, with L3 stating, "*ibangathi uyabhabha*" (feeling like you're flying). This discussion mediated their learning by connecting a shared cultural experience with the concepts we were about to explore in physics.

Despite this connection, the learners initially struggled to relate *umtyibilizi* to Physical Sciences. When asked which forces might be involved in the game, there was a long pause. After much thinking, only four of the 10 learners could identify frictional force and applied force. Of these, only L5 attempted to explain how the forces operated during sliding. This gap revealed the need for further mediation to bridge their cultural knowledge and scientific understanding.

- **Use of cultural and everyday language to make science more understandable**

Integrating *umtyibilizi* into the lesson was a deliberate choice to acknowledge and value the learners' cultural heritage. The learners described their experiences of the game in their own words, using informal language and cultural references. For instance, L3 described the motion of sliding as “*ingathi uyabhabha*” (feeling like you're flying), which hinted at their intuitive understanding of acceleration. Others emphasised the materials they used as sledges, describing their functionality and preferences. This Indigenous game provided a familiar context that could make abstract scientific concepts more relatable (Asheela et al., 2021).

This use of cultural and linguistic connections enriched the learning process. For instance, L7 asked, “*Singasisebenzisa isiXhosa?*” (Can we use isiXhosa?). An inclusive environment where they felt valued was created by allowing learners to express themselves in their preferred language and using examples they found relatable. This approach aligns with Vygotsky's (1978) assertion that language is a powerful tool for learning. Pathan et al. (2018) assert that language is indeed necessary for ensuring that learners have a meaningful education. It serves as both a medium for communication and a means of organising thought, enabling learners to transition from everyday understanding to scientific reasoning.

- **Teamwork and discussions to build shared knowledge and understanding**

By pairing learners to discuss their experiences of *umtyibilizi*, they were encouraged to engage in meaningful conversations about their shared cultural practices. Each pair had the opportunity to share their ideas with the class, fostering a sense of community and collective learning. It could be argued then that the structure of the lesson emphasised collaboration and dialogue, key components of Vygotsky's (1978) sociocultural theory.

During these discussions, learners built on each other's ideas, clarifying and refining their understanding. Scott and Palincsar (2013) highlighted that socially mediated activities influence the development of learners. For example, when one pair mentioned the role of friction in stopping the sledge, another pair added that the type of slope (grassy or sandy) influenced how quickly the sledge stopped. This exchange of ideas allowed learners to co-construct knowledge, a process that Vygotsky identifies as essential for cognitive development. Zayyad (2020) asserts that this form of learning through social interaction provides the learners with the opportunity to articulate their thoughts, hear alternative perspectives and develop a deeper understanding of the topic.

- **Guidance helps the learners to gradually connect IK to scientific ideas**

The learners' responses during the lesson revealed their ZPD, the range of tasks they could perform with guidance but not yet independently. Initially, most learners could not relate *umtyibilizi* to physics without prompting. Through carefully designed questions, such as "*What forces do you think are at play during sliding?*" The learner's thinking was scaffolded and this guided them towards identifying concepts like friction and applied force (Bruner, 1960).

Although only a few learners could explain these forces in detail, the activity set the stage for further exploration within their ZPD. By providing hints and encouraging peer discussions (Vygotsky, 1978), the learners were helped to move closer to understanding the scientific principles underlying the game. This process of scaffolding ensured that the learners were actively engaged and building their knowledge progressively.

Table 5.3: How Indigenous knowledge can be linked to scientific concepts

Theme	Indigenous Knowledge	Scientific Concept
<p>Connecting learner’s cultural experiences to science through relatable learning activities</p>	<p>Some mentioned sliding on slopes covered with soil, while others preferred grassy slopes</p>	<p>The type of surface affects the coefficient of friction. Grass typically has less friction than soil, which may allow for faster sliding. Also, the slope represents an inclined plane, and the steeper the slope, the greater the gravitational force component Fg_{\parallel} acting along the plane, increasing acceleration</p>
	<p>Different materials, such as broken canopies, cardboard or even old metal sheets, were used as sledges</p>	<p>Smooth materials like metal sheets reduce friction and air resistance, enabling faster movement compared to rough materials like cardboard</p>
<p>Use of cultural and everyday language to make science more understandable</p>	<p>“<i>ibangathi uyabhabha</i>” (feeling like you’re flying)</p>	<p>Sliding down a slope rapidly can give a sensation of flight due to the high acceleration and the reduced normal force acting on the body</p>

5.2.3 Summary

The lesson leveraged learners’ cultural experiences to introduce Newton’s second law by using the Indigenous game *umtyibilizi* as a foundation. Despite no longer playing the game, learners confirmed its significance in their childhood, establishing it as a shared cultural game. They discussed their experiences of sliding on grassy or sandy slopes with makeshift sledges made from various materials, which were used as artefacts to contextualise concepts like friction and applied force. While some learners struggled initially to connect the game to physics, the activity revealed gaps in their understanding and highlighted the need for further mediation to bridge cultural knowledge with scientific concepts.

To make the lesson relatable, learners were encouraged to describe *umtyibilizi* using their own words and preferred languages, including isiXhosa. This approach fostered an inclusive environment, allowing them to articulate intuitive understandings, such as L3's comparison of sliding to "feeling like you're flying," hinting at acceleration. The use of everyday language and cultural examples aligned with Vygotsky's emphasis on language as a learning tool, enabling learners to transition from informal understanding to formal scientific reasoning while feeling valued for their contributions.

Collaboration and guided discussions further enriched the learning process. Pairing learners to share experiences fostered community and co-construction of knowledge, as they built on each other's ideas, such as linking friction, acceleration and slope type to sliding motion. These social interactions, central to Vygotsky's sociocultural theory, revealed the learners' low ZPD. Through scaffolding and strategic questioning, learners gradually connected *umtyibilizi* to physics concepts, engaging more deeply with the material and setting a foundation for further scientific exploration.

5.3 Data Generated from Focus Group Interviews (Sharing Circles)

Sharing circles are similar to focus groups, but they focus on learning through discussions (Chilisa, 2012). In this study, sharing circles were used to understand how learners felt about using IK to learn about Newton's second law of motion. After the lesson before the demonstration by IKCs, the learners had to find information from their communities about Newton's second law. The learners' findings were discussed during the sharing circles. During the first trial of the sharing circle, a group of five learners was chosen by their peers to represent them. However, it became clear that some learners were dominating the discussions, while others struggled to share their thoughts.

To solve this problem, we introduced a 'sharing stick' in the second sharing circle. The stick was passed around, and only the person holding it could speak. Once they were done or if they had nothing more to say, they passed it to the next person. This method ensured that everyone had an equal opportunity to contribute to the study.



Figure 5.2: Learners in a sharing circle and a learner after finding the sharing stick used

One of the learners, identified as L3, explained why they were chosen to represent the group. L3 said, “*bandi-choose-e because bayayazi uba andinantloni*” (they chose me because they know that I am not shy). This response highlights the importance of confidence and trust within the group.

The use of sharing circles connects well with cultural practices. People in many communities used to gather in circles, especially around a fire, to tell stories and share knowledge (Liveve, 2022). Sitting in a circle creates a sense of equality and allows everyone to feel comfortable expressing their views. This approach reduces power dynamics and encourages open discussions.

The sharing circle method also aligns with the concept of Ubuntu. Ubuntu emphasises treating everyone with respect and recognising their values, needs, and opinions (Ogunniyi, 2018; Seehawer, 2023). By using this method, learners were able to share their knowledge and thoughts in a non-threatening and respectful environment. To further build trust, clan names were used during these discussions. This strategy ensured the environment was more relaxed and encouraged learners to participate freely while respecting each other’s views.

Overall, the sharing circle method seemed to be an effective way to gather learners’ experiences. It not only promoted equality and respect but also provided a platform for learners to connect their IK with the scientific concept of Newton’s second law.

5.3.1 Development of themes

Sub-themes emerged from the focus group (sharing circle) data. From these sub-themes, themes emerged which in turn allowed for the literature and theory to surface.

Table 5.4: Themes that emerged from the sharing circles

Sub-themes	Themes	Literature/ Theory
Learners' cultural experiences and identities into the curriculum; use of everyday knowledge to make new concepts more accessible and meaningful	Learners' experiences and implication for teaching	Vygotsky (1978); Fadiran et al. (2018); Shinana et al. (2021); Seehawer & Breidlid (2021)
Connecting lessons to learners' lives, enhancing relevance and engagement; helping learners construct knowledge	Learners' experiences and teaching implications	Vygotsky (1978); Otulaja & Ogunniyi (2017); Aikenhead & Jegede (1999)
Effective communication in the learning process; interactive teaching strategies	Social interactions and teaching implications	Vygotsky (1987); Allahyar & Nazari (2012); Daneshfar & Moharami (2018)
Providing structured guidance that builds on learners' prior experiences; encouraging growth	Learners' experiences and guidance	Vygotsky (1978); Pathan et al. (2018); Schneuwly & Leopoldoff (2022); Stott (2016)

Vygotsky (1978) argued that learning is a collaborative process mediated by cultural tools and social interactions. Extending on Vygotsky's seminal work, Brunner (1960) coined the concept of scaffolding to emphasise the importance of learning during activities. Central to this theory are four key principles: mediation of learning, culture and language, social interactions and the ZPD.

This analysis used the responses of Grade 11 learners sharing circle to explore how these principles manifest in their experiences of learning Physical Sciences, particularly Newton's second law.

5.3.1.1 Learners' experiences and implication for teaching

The learners highlighted the importance of their teacher in simplifying complex concepts. L4 mentioned, "*Xa utitsha uNewton's second law, kuzoqala kubekho isurface ibe-rough... kuapplawe iforce*" (When you are teaching Newton's second law, there is first a rough surface ... and force is applied). This indicates that teachers should employ practical demonstrations to bridge the gap between theoretical concepts and real-world applications. Mediation refers to the process whereby tools and resources are used to facilitate learning. According to Vygotsky (1978), individuals do not learn directly from their environment but through mediation by cultural tools in the environment such as language, diagrams, experiments, and teacher explanations (Fadiran et al. 2018; Shinana et al., 2021).

In this regard, Seehawer and Breidlid (2021) stated that this integration of IK benefits the learners since there is a dialogue between IK and WS. L5 also noted that the concepts seem straightforward during instruction but become challenging when applied independently: "*Ibalula xa siyititshwa but xa kufuneka sizenzele ngokwethu ibanzima*" (It is easy when we are being taught but when we have to do it on our own then it becomes difficult).

The teacher's role as a mediator is crucial in helping learners navigate abstract concepts. However, the learners' difficulties with independent tasks suggest that the mediation process could be enhanced in several ways:

1. Physical experiments allow learners to actively engage with concepts rather than passively observing them. For instance, using objects to demonstrate forces can make Newton's second law more relatable.
2. Visual aids, such as force diagrams, can help learners internalise abstract ideas more effectively.
3. Teachers should guide learners through increasingly complex tasks, gradually reducing support as learners develop competence.

By strengthening mediation, the teacher can ensure that the learners not only grasp concepts during instruction but are also equipped to apply them independently.

5.3.1.2 Learners' experiences and teaching implications

The learners' responses revealed the significant role of bilingualism in their learning process. They expressed themselves in a mix of isiXhosa and English (Mapfumo, 2024), as seen in phrases like L9: "*Si-understand-a uba uNewton second law noba ugqibo kwenza ntoni kodwa uba kulento uyenzayo uno-apply-a iforce*" (We understand that in Newton's second law, whatever you finish doing but as long as you apply a force) and L8: "*Xa ititshwa ivakala ilula*" (When it is being taught, it seems easy). This code switching demonstrates how learners rely on their native language to grasp foundational ideas while using English to engage with scientific terminology. The use of isiXhosa provided a culturally relevant framework for understanding, while English connects them to formal scientific discourse. In this regard, Vygotsky (1978) emphasised that culture and language are central to learning because they shape how individuals interpret and interact with the world. Language is both a tool for communication and a medium for cognitive development.

The teacher should continue using both isiXhosa and English to bridge the gap between learners' everyday experiences and lesson content. This is referred to as border crossing (Aikenhead & Jegede, 1999; Otulaja & Ogunniyi, 2017). Explaining complex ideas in isiXhosa before introducing English terms can offer a deeper understanding to the learners. In addition, encouraging learners to explain scientific concepts in both languages reinforces their comprehension and prepares them for exams conducted in English. This process of relating scientific concepts to learners' cultural and daily experiences, such as traditional tools or local phenomena, can enhance engagement and understanding. By acknowledging and integrating the learners' linguistic and cultural backgrounds, a more inclusive and effective learning environment can be created.

5.3.1.3 Social interactions and teaching implications

L8 observed that concepts feel manageable when explained by the teacher but become difficult when attempted independently: "*Xa ititshwa ivakala ilula kodwa xa kufuneke ubhalile*" (When it

is being taught it is easy but when you must calculate). This indicates that learners rely on social support to bridge gaps in understanding (Daneshfar & Moharami, 2018). The shared laughter during the discussion also suggests that learners benefit from collaborative engagement, where they feel comfortable expressing challenges and exploring solutions together. Vygotsky (1987) viewed social interactions as fundamental to cognitive development. Learning occurs first on a social level, through collaboration and communication, before becoming internalised at an individual level. The responses highlight the importance of both teacher–learner and peer interactions in the learning process (Allahyar & Nazari, 2012).

Group activities where learners solve problems together can foster peer-to-peer support and shared knowledge construction. For example, learners could work in pairs to calculate forces in structured scenarios. Also, open discussions about challenging concepts can help learners clarify misunderstandings and reinforce their understanding through dialogue by facilitating interactions, asking probing questions and encouraging learners to articulate their thought processes (Allahyar & Nazari, 2012). Through meaningful social interactions, learners can co-construct knowledge and gradually internalise new concepts.

5.3.1.4 Learners' experiences and guidance

The learners' struggles with specific aspects of Newton's second law, such as force components at an angle, highlight the presence of their low ZPD. For instance, L5 noted that, "*Uba funeke ufake iforce applied yhoo iyandixaka shem*" (When you have to add force applied, yhoo it challenges me) indicating that they understand the concept when guided but struggle to apply it independently. This is a clear example of a task within the ZPD, challenging, yet achievable with support. This task has a potential of improving learner understanding and performance (Pathan et al., 2018). The ZPD is the range of tasks that a learner can complete with guidance but not yet independently (Vygotsky, 1978). Vygotsky argued that effective teaching occurs within the ZPD, where scaffolding helps learners progress to higher levels of competence.

This process involves providing step-by-step guidance for challenging topics, such as breaking down forces into components and demonstrating how to calculate them. It would start with teacher-led examples, transitioning to group practice, and eventually moving to independent tasks which

would help learners build confidence and competence (Schneuwly & Leopoldoff, 2022; Stott, 2016). Also, revisiting difficult concepts through repeated exposure will ensure that learners consolidate their understanding over time. By focusing on the ZPD, teachers can help learners master tasks that initially seem daunting, ensuring steady progress in their cognitive development.

5.3.2 Summary

Using Vygotsky's (1978) sociocultural theory, the learners' experiences with Physical Sciences reveal the critical role of mediation, language, social interactions and scaffolding within the ZPD. While the learners benefit from the teacher's demonstrations and bilingual instruction, they face challenges in applying concepts independently, particularly in tasks involving force components.

To address these challenges, the teacher should strengthen mediation through hands-on experiments, visual aids and step-by-step scaffolding. Bilingual instruction should be leveraged to connect scientific concepts to learners' linguistic and cultural contexts. Collaborative activities and guided practice should be prioritised to support learners within their ZPD, gradually enabling them to tackle tasks independently.

By aligning teaching strategies with Vygotsky's principles, the teacher can create an engaging and supportive learning environment where learners not only understand Newton's second law but can confidently apply it in various contexts. This approach ensures that learners are not only prepared for academic success but are also equipped with the skills to navigate and interpret the physical world effectively.

5.4 Summary of the Qualitative Data Generated During Group Activities

The information in Table 5.1 below offers a clear demographic breakdown of the participants involved in the study, which is important for understanding the context and the potential implications of the findings. One of the learners was a 31-year-old female who decided to go back to school after realising that promotions at work were passing her because she did not have a Grade 12 certificate. The ages of the rest of the learners were between 17 and 21.

Table 5.5: Learners' profiles

Biographical Information	Categories	Learner Names (L – Learner)	Total Number
Age	17-31	L1, L2, L3, L4, L5, L6, L7, L8, L9, L10	10
Gender	Female	L1, L2, L3, L4, L5	05
	Male	L6, L7, L8, L9, L10	05
Mother Tongue	IsiXhosa	L1, L2, L3, L4, L5, L6, L7, L8, L9, L10	10
Groups	Group 1 (G1)	L1, L3, L5, L7, L9	05
	Group 2 (G2)	L2, L4, L6, L8, L10	05

During the group activities, the Grade 11 learners were divided into two groups consisting of five learners each. Similarly to Mayana's (2020) study, the learners were given guiding questions to use for their group discussions (see Appendix C3). This helped to ensure that the data generated from the group activity was relevant to the study. Moreover, the learners had time in class to discuss their data in groups and then record their conclusions on newsprints. They worked on the newsprints on one day and presented their group activity the following day. We had arranged two consecutive days that we could use to work for that week.



Figure 5.3: The two groups preparing their newspapers for their presentations



Figure 5.4: The two groups preparing for their presentations

5.4.1 Development of themes

The responses from the group presentations were colour-coded according to their answers to form sub-themes. From those sub-themes, themes emerged which in turn allowed for the literature and theory to surface.

Table 5.6: Themes that emerged from the group presentations

Sub-themes	Themes	Literature/Theory
The amount of force needed to move an object depends on its weight and how fast	Newton's second law in daily activities	Vygotsky (1978); Dalsgaard (2020); Pathan

you want it to move; how acceleration changes based on the force applied		et al. (2018); Zayyad (2020)
The more force is required to accelerate it; how force and mass influence motion in practical, everyday tasks	Traditional practices illustrating Newton's second law	Vygotsky (1978); Aikenhead & Jegede (1999); Pathan et al. (2018); Scott & Palincsar (2013); Daneshfar & Moharami (2018); Mavuru & Ramnarain (2020)
Description of <i>umtyibilizi</i> ; context of education or cultural understanding	Description of <i>umtyibilizi</i>	Vygotsky (1978); Vygotsky (1987); Gwekwerere (2016); Turuk (2008); Zayyad (2020); Zhou (2020)
Show how Newton's second law applies in everyday situations; how <i>umtyibilizi</i> is played	Learning through demonstration of Newton's second law	Vygotsky (1978); Zhou (2020); Bruner (1960); Zaretsky (2021); Stott (2016)

Vygotsky's (1978) sociocultural theory with its emphasis on mediation, culture and language, social interaction and the ZPD provides a comprehensive framework for understanding the teaching and learning of Newton's second law through learners' lived experiences and community practices. The group's responses highlight the importance of these concepts, providing valuable insights into how theoretical knowledge can be made relatable and meaningful.

As alluded to earlier, Newton's second law of motion explains how force, mass and acceleration are interrelated. This principle is evident in various everyday activities, cultural practices and even games within communities. The research question aimed to understand what the Grade 11 Physical Sciences learners know from their community about *umtyibilizi* and Newton's second law. By analysing responses from the two groups, G1 and G2, I analysed how learners perceive and apply this scientific principle in their daily lives and contexts. I now present these themes below.

5.4.1.1 Newton's second law in daily activities

The group's responses about Newton's second law, such as pushing a wheelbarrow or lifting a coffin, serve as examples of how learners use familiar contexts to make sense of abstract principles. Mediation is central to learning, involving the use of tools, structured activities, and social interactions to facilitate understanding (Vygotsky, 1978). This agrees with Pathan et al. (2018) that education should have an objective of helping learners to learn by creating meaningful and relevant learning experiences. For instance, G1 stated, "*We see and experience Newton's second law when pushing a wheelbarrow – The force you apply the handle of the wheelbarrow (F) propels it forward. The mass of the wheelbarrow and its contents (m) determines how much force is required to achieve a certain acceleration (a)*". G1 described how the force applied to a wheelbarrow overcomes resistance and causes acceleration, emphasising the relationship between force, mass and acceleration ($F = ma$). Mediation occurred because learners used their everyday experience of using a wheelbarrow to understand and explain these scientific concepts more meaningfully.

G1 further stated, "*When lifting a coffin, Newton's second law is needed at work*". Here, the force applied by pallbearers must counteract the mass of the coffin and its contents. The acceleration as the coffin is lifted reflects how much force is applied relative to its weight. G2 provided relatable examples, such as stopping a rolling ball or pushing a car. They described how mass affects the amount of force needed to move an object. A larger mass requires more force for a similar acceleration. Another example by G2 was "*One's body movement to the side when a car makes a sharp turn*". This demonstrates the relationship between inertia, force and acceleration.

As Dalsgaard (2020) notes, mediated learning creates meaningful experiences by linking tools to their intended purposes, making it important for effective education. G1 described the thrill of sliding down a hill using makeshift sledges, with both groups explaining how gravity, frictional force and air resistance interact to influence motion. G2 explained the forces at play when playing the game stating, "*Frictional force (Frictional between their body and the surface slows down the player down). Gravity's effect is mostly parallel to the surface, it still contributes to their acceleration down the slide*". By engaging in hands-on practical activities (Asheela et al., 2021), learners can visualise and internalise the principles of acceleration and force, which could result in more engaged learners throughout the lesson (Zayyad, 2020). This style of teaching seems to

help learners stay interested in their work for longer periods. Vygotsky (1978) argued that such mediated activities, guided by teachers or peers, help learners form connections between theoretical concepts and real-world applications.

In line with the sociocultural theory, the role of the teacher is important in structuring activities to ensure effective mediation. For example, teachers can scaffold learning by breaking down Newton's second law into manageable units, such as identifying the forces acting on a sliding object and guiding learners to calculate net force and acceleration. This scaffolding mirrors Vygotsky's concept of the ZPD, as learners require support to bridge the gap between what they can do independently and what they can achieve with guidance (Vygotsky, 1978).

5.4.1.2 Traditional practices illustrating Newton's second law

In response to the question: Are there any traditional practices or activities in your community that illustrate the principles of Newton's second law, G1 stated that "*in some cultures, dances like the Maori Haka*". This part of the response given by G1 seems to be supplemented with an answer from the internet. The *Moari Haka* is a dance from New Zealand instead of *Umxhentso*, which is a Xhosa traditional dance. G2 answered, "*Yes, carrying a coffin, rowing a boat and throwing spears*". Regardless of the different traditional dances, G1 and G2's responses reveal the cultural relevance of Newton's second law, particularly through activities like traditional dancing, rowing boats and carrying coffins. These examples highlight how scientific principles are embedded in cultural practices. These are important in shaping the development of the learners (Daneshfar & Moharami, 2018). The interaction between learners and the cultural aspects of their environment is important to the learners' development and potential performance (Pathan et al., 2018). Culture and language are tools that shape learning experiences. In this regard, Vygotsky (1978) emphasised that language serves as a mediating tool, enabling learners to articulate and refine their understanding.

G1 added that another example of a traditional practice is the "*Highland fling [that] involves rapid movements and spinning. The force applied by the dancers (F) accelerates their bodies (m) in various directions, illustrating Newton's second law*". It could be surmised that G1's description of the traditional dance demonstrates how dancers apply force to accelerate their bodies,

illustrating Newton's law in a culturally meaningful context. Similarly, rowing boats, an activity that the community does to cross the river in the village, shows how the force applied to oars propels the boat, linking the principles of force, mass and acceleration to traditional practice. Such examples underscore the importance of integrating IK into teaching, as Mavuru and Ramnarain (2020) advocate, to make learning more accessible and relatable.

The responses also illustrate the challenges learners face when crossing cultural and linguistic borders. For instance, learners in rural South Africa often encounter a disconnect between isiXhosa (their home language) and English (the language of instruction), which can hinder their understanding of scientific concepts (Aikenhead & Jegede, 1999). G2 explained how to play the game by stating, "*Uya entabeni uphethu iphelu (itanki elisikiweyo, iphahla lemoto, fisherboard etc). Uchopha kulo uaplye iforce by pushing the object le uhleli kuyo*" (You go to the mountain carry a board (a piece of a tank, the roof of a car, fisherboard etc). You then sit on it then apply a force by pushing the object you are seated on). When the learner who was representing G2 was done explaining, the learners from both groups started clapping for him. This shows that teachers should adopt culturally responsive strategies, such as integrating learners' home languages and cultural references, to bridge this gap and create inclusive learning environments. The way the learners learn seems to be largely influenced by the cultural and historical contexts in which they live (Scott & Palincsar, 2013).

5.4.1.3 Understanding the game of Umtyibilizi

G1 explained how the game worked:

Gravity (Fg) - The force of gravity [gravitational force] pulls you down the hill, accelerating you downward. The force is evident throughout the slide. Normal Force (FN) - The hill's surface exerts a normal force on you, perpendicular to the surface. This force opposes your weight and keeps you on the hill. Frictional Force (Ff) - As you slide friction between your cardboard\trash bag and the hill slows down. The force of friction opposes motion.

For example, G2's explanation of *umtyibilizi* involves a collaborative effort to identify and describe the forces at play, such as gravitational force, friction and air resistance. This aligns with the concept of peer-assisted learning strategies, where structured peer interactions support mutual

learning (Zayyad, 2020). The group discussions and shared experiences reflect the social interaction principle, as learners collectively explore and explain Newton's second law. Social interaction is a cornerstone of Vygotsky's theory, as learning occurs through collaboration with peers and MKOs (Vygotsky, 1987).

The game of *umtyibilizi* also demonstrates how learners benefit from observing and communicating with one another. G2 added:

When playing the sliding game Newton's 2nd law comes into action. Here is a breakdown of forces involved: Initial force (Pushing off by feet or hands. This force accelerates their body down). Frictional force (Frictional between their body and the surface slows down the player down. The F_f opposes player's motion converting it to heat). Gravity's effect is mostly parallel to the surface, it still contributes to their acceleration down the slide. Air resistance opposes the player's motion, slowing them down as they slide.

As G2 described, players apply an initial force to propel themselves downhill, experiencing the interplay of various forces. By integrating learners' prior knowledge and life experiences, teachers can help learners better understand their schoolwork (Gwekwerere, 2016; Turuk, 2008). Learners refine their understanding of these concepts through discussions, building on each other's insights. According to Vygotsky (1978), such social interactions enable learners to internalise new knowledge, transforming it into personal understanding.

Teachers play a crucial role in facilitating these interactions by organising group activities and encouraging active participation. Techniques like role play, group work and simulations can further enhance learners' engagement, allowing them to apply theoretical knowledge in collaborative settings (Zhou, 2020).

Both groups described *umtyibilizi* as a thrilling sliding game. G1 emphasised the excitement and accomplishment players feel as they navigate obstacles and race downhill. They described the game as exhilarating, with the wind rushing past and laughter filling the air. G2 noted the physical sensations of weightlessness and gravity while sliding.

G1 suggested measuring the distance travelled and the time taken to calculate acceleration. By comparing players of different masses, such as children and adults, they could observe how mass affects the force required to accelerate. G2 highlighted the interaction of forces, showing that the net force acting on a player determines their acceleration, while mass remains constant.

5.4.1.4 Learning through demonstration of Newton's second law

As stated by G2 above (see Section 5.4.1.3), G2's explanation of the forces involved in *umtyibilizi*, including initial force, friction and gravity, shows how collaborative efforts can help learners analyse and apply scientific principles. The ZPD represents the distance between what learners can achieve independently and what they can accomplish with assistance (Vygotsky, 1978; Zaretsky, 2021). In the context of Newton's second law, learners often require guidance from MKOs, such as teachers or peers, to fully grasp complex concepts.

When asked how *umtyibilizi* can be used to demonstrate the understanding of acceleration, mass, and forces as described by Newton's second law, G1 responded, "*Acceleration - measure the distance travelled and time taken to reach the finish line. Mass - have players of different masses (e.g. adults and children) participate*". The teacher's role in scaffolding learning is particularly evident in activities like measuring acceleration during *umtyibilizi*. By providing tools such as timers and worksheets, teachers can guide learners to calculate distance, time, and velocity, gradually reducing support as learners gain confidence. This process aligns with Bruner's (1960) concept of scaffolding, which involves breaking tasks into smaller units and providing targeted assistance.

Moreover, the MKO is not always the teacher. Other learners can act as MKOs by allowing them to benefit from the other learners' experiences and skills (Zhou, 2020). As G1 noted, learners of different ages and experiences can serve as MKOs, helping one another understand concepts like force and acceleration. For example, older learners might demonstrate how to calculate net force during a game of *umtyibilizi*, fostering a collaborative and inclusive learning environment. The learners who end up helping to explain when they start understanding their work end up becoming the MKOs (Stott, 2016).

Umtyibilizi has the potential to offer a unique way to teach acceleration, mass, and force as described by Newton’s second law. By observing players’ movements and experimenting with variables like mass and surface type, learners can better understand the relationship between force, mass and acceleration. The cultural relevance of *umtyibilizi* makes it a powerful tool for teaching science, connecting theoretical concepts to practical, enjoyable activities. Both G1 and G2 emphasised how the game helps visualise forces like gravity, friction and air resistance, providing a deeper understanding of Newton’s second law in action.

Table 5.7: How Indigenous knowledge can be linked to scientific concepts

Theme	Indigenous Knowledge	Scientific Concept
Newton’s second law in daily activities	<i>“We see and experience Newton’s second law when pushing a wheelbarrow – The force you apply the handle of the wheelbarrow (F) propels it forward. The mass of the wheelbarrow and its contents (m) determines how much force is required to achieve a certain acceleration (a)”</i>	Newton’s second law explains how force, mass and acceleration are related. To move an object, such as a wheelbarrow, you must apply a force that depends on its mass and the desired acceleration. The larger the mass or acceleration, the greater the force required.
Traditional practices illustrating Newton’s second law	<i>“Uya entabeni uphethu iphelu (itanki elisikiweyo, iphahla lemoto, fisherboard etc). Uchopha kulo uaplye iforce by pushing the object le uhleli kuyo”</i> (You go to the mountain carry a board (a piece of a tank, the roof of a car, fisherboard etc). You then sit on it then apply a force by pushing the object you are seated on)	Gravitational force pulls the object down the slope, driving its motion and acceleration. The slope exerts a normal force perpendicular to the surface, counteracting the object’s weight. Frictional force and air resistance oppose the motion, slowing the object as it slides.
Description of <i>umtyibilizi</i>	<i>“Gravity (Fg) - The force of gravity [gravitational force] pulls you down the hill, accelerating you downward. The force is evident throughout the slide. Normal Force (FN) - The hill’s</i>	The initial push provides the force needed to overcome inertia and start the motion. As the object moves, the gravitational force works to accelerate it while friction and air resistance slow it

	<p><i>surface exerts a normal force on you, perpendicular to the surface. This force opposes your weight and keeps you on the hill.</i></p> <p><i>Frictional Force (F_f) - As you slide friction between your cardboard\trash bag and the hill slows down. The force of friction opposes motion”</i></p>	<p>down. These forces combine to determine the object’s speed and acceleration down the slope.</p>
<p>Learning through demonstration of Newton’s second law</p>	<p><i>“When playing the sliding game Newton’s 2nd law comes into action. Here is a breakdown of forces involved: Initial force (Pushing off by feet or hands. This force accelerates their body down). Frictional force (Frictional between their body and the surface slows down the player down. The F_f opposes player’s motion converting it to heat). Gravity’s effect is mostly parallel to the surface, it still contributes to their acceleration down the slide. Air resistance opposes the player’s motion, slowing them down as they slide”</i></p>	<p>As the object slides, potential energy from its height is converted into kinetic energy. This illustrates the conservation of energy in motion.</p>

5.4.2 Summary

The responses from G1 and G2 demonstrate how Newton’s second law manifests in daily life, traditional practices and community games like *umtyibilizi*. During the group activities, the learners mentioned how the forces experienced when playing *umtyibilizi* apply to those in Newton’s second law. By linking scientific principles to relatable activities, learners can better grasp abstract concepts. This approach not only enhances understanding but also fosters an appreciation for the cultural and scientific value of everyday experiences (Gwekwerere, 2016; Turuk, 2008).

Newton's second law is not just a classroom theory; it is a principle woven into the fabric of our daily lives, traditions and games. Through activities like *umtyibilizi*, we see how force, mass and acceleration interact to shape motion and create memorable, educational experiences. The group's responses provide a rich source of evidence for analysing the teaching and learning of Newton's second law through Vygotsky's framework. Examples like pushing a wheelbarrow, lifting a coffin and playing *umtyibilizi* demonstrate how learners use real-life experiences to understand scientific concepts. These activities highlight the importance of mediation, cultural relevance and social interaction in fostering meaningful learning.

Teachers can build on these insights by designing lessons that integrate learners' cultural practices and prior knowledge. For instance, a lesson on Newton's second law could include a discussion of traditional activities like rowing boats or sliding downhill, followed by hands-on experiments to calculate force, mass and acceleration. Such an approach aligns with Vygotsky's emphasis on creating meaningful and contextually relevant learning experiences (Vygotsky, 1978).

5.5 Chapter Summary

This chapter explored the integration of IK into the teaching of Newton's second law through the Indigenous game *umtyibilizi*. The lesson leveraged learners' cultural experiences, using their childhood memories of sliding on grassy or sandy slopes to contextualise scientific concepts such as friction, applied force and acceleration. While some learners initially struggled to connect the game to physics, guided discussions and collaborative activities helped bridge the gap between their everyday knowledge and scientific principles.

Vygotsky's (1978) sociocultural theory provided a framework for understanding how language, social interactions and scaffolding supported learners within their ZPDs. Bilingual instruction and peer discussions allowed learners to articulate intuitive understandings in their home languages, facilitating their transition from informal reasoning to formal scientific concepts. Group activities also reinforced key ideas, demonstrating how forces in traditional practices and community games reflect Newton's second law in real life. Despite these benefits, challenges remain in learners' ability to apply concepts independently, particularly in tasks involving force components. To address this, the teacher should enhance mediation through hands-on experiments, visual aids, and

step-by-step guidance, ensuring learners can confidently engage with and apply Newton's second law in various contexts.

Overall, this chapter highlights the value of culturally relevant teaching strategies in making science more accessible and meaningful. By linking Physical Sciences to everyday experiences, learners not only deepen their conceptual understanding but also develop a greater appreciation for the scientific principles embedded in their cultural practices.

In the next chapter, the data analysis generated from the presentation by the IKCs, lesson observations and learners' reflective journals are discussed.

CHAPTER SIX: PRESENTATIONS BY THE INDIGENOUS KNOWLEDGE CUSTODIANS, LESSON OBSERVATIONS AND LEARNERS' REFLECTIVE JOURNALS

6.1 Introduction

In the previous chapter, I analysed and discussed qualitative data from Grade 11 learners' lesson observations, group activities, discussions and sharing circles.

This chapter presents the findings and analysis of data generated through learners' reflective journals, the practical demonstrations conducted by the two IKCs, and the lesson observations. The lesson observations included an exemplar lesson that integrated IK into Newton's second law. These findings are used to provide answers to the following research questions:

- How do Grade 11 Physical Sciences learners talk, interact and participate during the presentation by the Indigenous Knowledge Custodians on the traditional way forces are used during *umtyibilizi*?
- How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of using an exemplar lesson that integrates learners' local knowledge (*umtyibilizi*) when learning about Newton's second law?

To foster interaction and create a relaxed environment, the presentation began with a tug-of-war game as an icebreaker. The absence of a rope did not deter the learners; instead, they improvised by forming human chains, with one team holding onto each other's waists and the front participants gripping their opponents' hands. This act of creativity aligns with Vygotsky's (1978) idea that learning is embedded in social and cultural contexts. The game allowed learners to solve a practical problem together, showcasing the importance of socially mediated learning. The presence of primary school learners, who joined during their break time, further enriched the interaction. This

inclusivity broke down barriers of age and status, allowing knowledge sharing to occur in a non-intimidating, playful atmosphere.



Figure 6.1: Tug-of-war (ice breaker) between Grade 11 females and males; Grade 11s with primary school learners

6.2 Presentation by the Two Indigenous Knowledge Custodians

The interaction between the Grade 11 Physical Sciences learners, the IKCs, and the primary school learners during the presentation is an excellent demonstration of Vygotsky's sociocultural theory. This theory emphasises the role of social interaction, culture and collaboration in cognitive development, particularly through the ZPD, the use of cultural tools, and socially mediated learning (Vygotsky, 1978).

The day began with the high school learners, a critical friend and I taking a walk to the nearby primary school, which served as the research site for the practical demonstration or presentation. This movement from one space to another symbolises the bridging of different learning contexts, formal education and cultural practices. Aikenhead and Jegede (1999) state that this form of learning makes education more meaningful and relatable. Vygotsky argued that learning occurs when individuals are exposed to tasks just beyond their current level of understanding, but within their ZPD, where guidance or collaboration can help them succeed. In this scenario, the IKCs, who were fraternal twins from the primary school (illustrating that IKCs do not need to be adults only), assumed the role of experts within the ZPD. The IKCs were addressed using their clan names, Bhayi for the male and MaBhayi for the female. As active practitioners of the Indigenous game

umtyibilizi, they facilitated learning for the Grade 11 learners by sharing their knowledge of this cultural practice.

Table 6.1: Indigenous knowledge custodians’ profile

Pseudonym	Age	Gender	Education	Home
Bhayi	10 years	Female	Grade 3	Mqanduli
MaBhayi	10 years	Male	Grade 4	Mqanduli



Figure 6.2: The two IKCs with the Grade 11 Physical Sciences learners

The primary school grounds, with its natural slope ideal for *umtyibilizi*, provided a contextual and physical space for this cultural learning to occur. According to Vygotsky (1978), cultural tools, both material and symbolic, are critical mediators of learning. The slope and the Indigenous game itself functioned as cultural tools that linked the learners to Indigenous Knowledge. These tools

allowed the learners to engage directly with the environment, enhancing their understanding of the game's mechanics and cultural significance.



Figure 6.3: The slope at the nearby primary school



Figure 6.4: The primary learners that joined with one showing us how the five-litre bottle is used during the game and a learner walking up the slope carrying the bottle

Moreover, the entire event exemplified Vygotsky's (1978) emphasis on the social nature of learning. He argued that higher cognitive functions originate in social interactions that are later internalised by the learners. The tug-of-war game, followed by the demonstration of *umtyibilizi*, created opportunities for peer learning and cultural exchange. The Grade 11 learners, who might not have been familiar with the Indigenous game or had not played it in years, learned through observation, participation and guided interactions with the IKCs and their younger peers. This collaboration brought about a deeper appreciation for Indigenous Knowledge and its relevance within the broader educational context.

The interplay of social interaction, cultural tools and the ZPD in this activity highlights how IK can be effectively integrated into formal education. Vygotsky’s (1978) theory underscores that learning is not confined to traditional classrooms but is enriched by engaging with cultural practices and the community. By positioning the primary school learners as IKCs, the presentation not only celebrated their expertise but also demonstrated the potential of intergenerational learning in preserving cultural heritage – IK is intergenerational because it is passed from one generation to the next through their practices, shared beliefs and stories (Kibirige & Van Rooyen, 2006; Vasudevan & Novoa, 2022).

6.2.1 Development of themes

The responses from the IKCs’ presentations were colour-coded to form sub-themes. From those sub-themes, themes emerged which in turn allowed for the literature and theory to surface.

Table 6.2: Themes that emerged from the IKCs’ presentations

Sub-themes	Themes	Literature
Scaffolding through demonstration; role of the teacher in mediation	Contextualising mediation in <i>umtyibilizi</i>	Vygotsky (1978); Fadiran et al. (2018); Kuhlane (2011); Shinana et al. (2021); Bruner (1960); Zaretsky (2021); Stott (2016)
Language as a medium of learning; connecting classroom learning with cultural practices	Integrating cultural practices with academic learning	Vygotsky (1978); Vygotsky (1987); Aikenhead & Jegede (1999); Hatcher et al. (2009); Michie et al. (2023); Pathan et al. (2018); Kibirige & Van Rooyen (2006); Seehawer (2023); Mayana (2020); Rivet & Krajcik (2008); Vasudevan & Novoa (2022)
Learning as a group; building teamwork and communication skills	Learning through peer collaboration	Vygotsky (1978); Zayyad (2020); Rapanta (2023); Erbil (2020)

Role of the teacher in supporting ZPD; Peer-to-peer learning in the ZPD	Facilitating development through guided participation	Vygotsky (1978); Schneuwly & Leopoldoff (2022); Stott (2016)
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The presentation by the IKCs reflects the core tenets of Vygotsky’s (1978) sociocultural theory by emphasising collaboration, the use of cultural tools, and socially mediated learning. The blending of formal education with Indigenous practices underscores the importance of contextualised learning environments where learners actively engage with their cultural heritage. Through this process, knowledge is not merely transmitted but co-constructed, fostering a deeper understanding and respect for cultural diversity. The research question aimed to understand what the Grade 11 Physical Sciences learners talked about, interacted and participated in during the presentation by the IKCs on the traditional way forces are used during *umtyibilizi*. Also, if the Grade 11 Physical Sciences learners’ talk and sense making shifted (or not) as a result of the practical demonstration of *umtyibilizi* by the IKCs. By analysing the presentation by the IKCs and the interactions of the Grade 11 learners, we explored the research objectives for these presentations.

6.2.1.1 Contextualising mediation in *umtyibilizi*

In the context of *umtyibilizi*, IKCs (who are the MKO in this context) mediated the game by demonstrating and explaining its rules and techniques for playing the game. For instance, Bhayi stated, “*Udlalwa kanje (ebonisa abanye abantwana) funeke uwumise endaweni ehlayo*” (It is played this way, Bhayi showing the other learners how the game is played, you must be on a slope). MaBhayi further added the tools that can be used to play the game saying, “*Nantsi nantsi (ekhomba kwiFascia-board)*” (There it is, there it is (pointing at the fascia board)). This explanation of the need for a downhill slope and tools like flattened two-litre bottles and fascia board (to use as a sledge) demonstrates the role of physical tools in facilitating understanding. Mediation of learning involves the teacher or an MKO guiding learners through structured activities (Stott, 2016) to try and bridge the gap between prior knowledge (Kuhlana, 2011) and new concepts (Vygotsky, 1978).

These tools are used to lower the frictional force that would have been between the clothes and the surface. When asked why the tools are needed instead of just sitting on the ground with the clothes

MaBhayi (and murmurs from Grade 11 learners) responded that “*Zokrazuka*” (they will get torn). Meaning that due to that higher friction, the clothes would get torn, hence the use of the tools. This shows learners’ active engagement, such as questioning why certain materials were used (e.g. “*Why not slide on clothing?*”), reflects the process of connecting theoretical concepts (force and motion) with real-life experiences. Vygotsky (1978) emphasised that such interactions promote the internalisation of learning through external tools and social guidance.

Vygotsky (1978) asserted that learning is mediated by tools and symbols that reflect the sociocultural context. In the case of *umtyibilizi*, tools such as flattened bottles and fascia board served as cultural artefacts, enabling learners to interact with and manipulate their environment. These objects facilitated the understanding of abstract concepts such as friction, balance and momentum, often without explicit instruction. This is how Fadiran et al. (2018) and Shinana et al. (2021) explained visualisation, representing difficult concepts by artefacts to help improve the learners’ understanding.

For example, the learners experimenting with the sliding material’s texture and incline unconsciously explored the principles of Newton’s second law. L5 asked, “*Umqengqelezi kakhulu?*” meaning (Does it slide down a lot?) which refers to the angle of the slope. I also acted as an MKO, mediating this learning by posing questions like, “*So ndingakwazi urhubuluza apha?*” (So can I slide here, on a flat surface?) or “*So kutheni usebenzisa ibhotile ungarhubuluzi ngempahla?*” (So why do you use the bottle and not just use slide with your clothes?). These interactions highlight the mediated nature of learning, where tools and social discourse work in tandem to advance cognitive development.

- **Scaffolding through demonstration**

The IKCs and older learners scaffolded knowledge by breaking down the game into manageable steps. For example, they highlighted the importance of choosing the right materials to ensure safety and maximise sliding efficiency. MaBhayi (and murmurs from Grade 11 learners) responded that “*Zokrazuka*” when asked why they used a sledge when sliding. My role in asking probing questions further enhanced this mediation, encouraging learners to reflect on the principles of

Newton's second law embedded in the activity. This aligns with Bruner's (1960) concept of scaffolding, where learners are supported until they can perform tasks independently.

Scaffolding, another key aspect of Vygotsky's theory, involves providing learners with temporary support to accomplish tasks beyond their independent capabilities. In *umtyibilizi*, scaffolding occurs as experienced players (IKCs) demonstrate optimal sliding techniques. The Grade 11 learners who had not played the game in a very long time observed, imitated and gradually refined their skills, moving from reliance on others to independent mastery.

For instance, a learner who initially struggled with balancing on the sliding surface was guided by an IKC or some of the primary school learners who requested to join us because it was break time. The IKCs and primary school learners demonstrated how to position their bodies, adjust their weight and push off effectively. Over time, the Grade 11 learners internalised these techniques, exemplifying Vygotsky's concept of the ZPD, where learning is most effective when supported by others (Zaretsky, 2021).

- **Role of the teacher in mediation**

Integrating *umtyibilizi* into formal education necessitates active mediation by the teachers. Teachers can design activities that build on the game's inherent educational value, using it to teach the principles of physics, teamwork and cultural heritage. For example, they might guide the learners in measuring the sliding distance on different surfaces, prompting them to hypothesise and test variables like weight and slope.

Through strategic questioning and structured tasks, the teachers can connect the activity to curriculum objectives, fostering a deeper understanding of scientific concepts while preserving the cultural significance of *umtyibilizi*. This dual approach aligns with Vygotsky's emphasis on bridging everyday and scientific knowledge.

6.2.1.2 Integrating cultural practices with academic learning

The game of *umtyibilizi* is deeply rooted in the learners' cultural context, providing a familiar and engaging way to explore scientific principles; for instance, L6 said, "*Ewe banikeni*

amakhalboardi” (Yes give them the cardboards). Learners used locally available materials such as bottles, cardboards and fascia-boards, highlighting the importance of integrating culturally relevant resources in education. Vygotsky (1987) asserted that learning is mediated through cultural tools, and in this case, the game serves as a tool to bridge the gap between IK and WS.

Cultural practices like *umtyibilizi*, which has been played by different generations (Kibirige & Van Rooyen, 2006; Vasudevan & Novoa, 2022), offer a rich context for learning, rooted in the community’s history and values. L8 stated, “*Ye ta phinda kaloku sibone*” (Please try again for us to see). One of the Grade 11 learners (L9) quickly went down the slope so L8 was asking them to repeat it. This shows that the Grade 11s also played *umtyibilizi* when they were younger. By integrating such practices into the curriculum, teachers can create a more inclusive learning environment that respects and validates diverse cultural identities (Rivet & Krajcik, 2008).

For example, *umtyibilizi* can serve as a starting point for lessons on friction, acceleration and surface texture. Learners can relate these abstract concepts to their lived experiences, making learning more meaningful and engaging, hence the ‘Two-Ways-Thinking’ (Michie et al., 2023) and ‘Two-Eyed-Seeing’ (Hatcher et al., 2009) approach. Moreover, this activity fosters collaborative problem solving as learners worked together to optimise their sliding techniques, reflecting the communal ethos of many Indigenous cultures. L7 stated, “*Cela ubhekele taAndi...ohh uyaphusha*” (May you please move taAndi ... ohh you are pushing me), this symbolises working together and assisting one another. This is a depiction of Ubuntu, togetherness in the way the learners acted (Sehawer, 2023).

The use of isiXhosa during the activity underscores the role of language in mediating learning. Vygotsky (1978) posited that language is both a cultural artefact and a psychological tool that facilitates higher cognitive functions. The learners’ discussions, such as debating the safety of different sliding materials, demonstrate how language fosters critical thinking and collaborative problem solving. Pathan et al. (2018) emphasised that language plays a crucial role in activities influenced by social interactions. L3 stated, “*Ha-a izoyomlimaza, izonilimaza lento*” (No it will hurt him, this will hurt you guys) when some learners wanted to try using a broken desk. It was crucial that these learners understood that they would be hurt if they continued with the desk and they listened and put it aside.

Integrating Indigenous games into lessons also mitigates the challenges of “border crossing” (Aikenhead & Jegede, 1999), where learners navigate between home and school cultures. By using a culturally familiar game and their home language, the activity reduced alienation and made learning more accessible.

Language plays an important role in Vygotsky’s theory, serving as the primary medium through which knowledge is transmitted. In *umtyibilizi*, the use of an Indigenous language (isiXhosa) enhanced communication and strengthened cultural ties between the Grade 11 and the primary school learners. The learners did not only learn the mechanics of the game but also the associated terminology and expressions, enriching their language skills.

I further leveraged this linguistic dimension by encouraging the learners to document their observations and reflections in the language that they are most comfortable with (Mayana, 2020). This process reinforces bilingual proficiency and highlights the value of Indigenous languages in the academic discourse.

6.2.1.3 Learning through peer collaboration

During *umtyibilizi*, some of the Grade 11 learners and IKCs acted as MKOs, modelling correct techniques and providing feedback. For instance, when a Grade 11 learner was guided by a primary learner, they exemplified peer-assisted learning, a process that enhances both cognitive and social development (Zayyad, 2020). This is evident when Bhayi stated, “*Udlalwa kanje (ebonisa abanye abantwana) funeke uwumise endaweni ehlayo*” (It is played this way (Bhayi showing the other learners how the game is played) you must be on a slope). Vygotsky (1978) emphasised the importance of social interactions in learning, particularly the role of MKOs in guiding less experienced individuals.

The collaborative nature of the game fostered teamwork and communication. For instance, L9 stated, “*Boy (Bhayi) sithembe wena*” (Boy we trust in you) while L10 added, “*Bayenza kamnandi*” (They are doing it nicely). This shows that the learners encouraged each other, offered constructive criticism and celebrated successes. As Rapanta (2023) noted, such interactions cultivate

argumentation and negotiation skills, which are essential for both academic and real-world success.

The cheering and laughter observed during the activity indicate the importance of creating a positive social environment for learning. L3 stated, “*Ewe iya-enjoy-eka, iright*” (Yes this is enjoyable, it is alright). This aligns with Erbil’s (2020) assertion that interactive activities promote engagement and motivation, leading to deeper understanding.

6.2.1.4 Facilitating development through guided participation

The concept of the ZPD, which represents the gap between what learners can achieve independently and what they can achieve with guidance (Vygotsky, 1978), was evident in the practical activity of *umtyibilizi*. The Grade 11 learners initially required assistance to slide effectively, but through repeated practice and guidance, they developed the confidence and skills to participate independently.

- **Role of the Teacher in Supporting ZPD**

Teachers play a critical role in structuring activities within the ZPD. I commented, “*Nibe careful ke*” (please be careful) and “*Ja ... ja MaNdulibeyinto eflat guys, yabona itafile ... ha-a*” (Yes ... yes it should be something flat guys) when some learner wanted to use a broken table to slide down. In this case, the IKCs and I acted as facilitators, ensuring that learners understood the mechanics of the game, linking it to Newton’s second law, while also keeping safe. I went on to ask, “*Yima another thing endicurious ngayo neh andiniboni ekqaleni because engqondweni yam befanba ndizonibona xa nipha ekuqaleni kwaba sebenzile ... so umntu uvele ayeke azehele?*” (Wait, another thing that I am curious about... I do not see you in the beginning because in my mind I thought I would see the ones that have already played ... so does a person not do anything and just slides down?) L4 responded, “*Ha-a*” (No) and L7 added, “*Uqale uyireve*” (You first push off). This process of breaking down tasks and gradually reducing support is essential for cognitive development (Schneuwly & Leopoldoff, 2022).

- **Peer-to-peer learning in the ZPD**

Learners also assumed the role of MKOs, guiding their peers through the game. For instance, when younger learners (who were at the age that still played the game) helped older ones (who had since stopped playing the game because they felt older) positioned themselves correctly, they reinforced their own understanding while enabling their peers to progress within their ZPD. L2 called out using nicknames, “*YeNomongxoza noNtombi khanize nizotyibiliza*” (Nomongxoza, primary school learner and Ntombi, MaBhayi, please come slide). L2 asked them because these two were very good at the game. The other learners started cheering and clapping, and then L1 stated, “*Abayenzi kakuhle guys*” (They are doing it well guys). This reciprocal teaching dynamic underscores the importance of collaborative learning in sociocultural theory (Stott, 2016). At one point, I was looking at the IKCs as the MKO. This is evident when I commented, “*So niyatyibiliza ngezihlangu*” (so you can use a shoe to slide), as one of the primary learners sat on their school shoes and started sliding down the slope.

Table 6.3: How Indigenous knowledge can be linked to scientific concepts

Theme	Indigenous Knowledge	Scientific Concept
Contextualising mediation in <i>umtyibilizi</i>	When asked why the tools are needed instead of just sitting on the ground with the clothes MaBhayi (and murmurs from Grade 11 learners) responded that “ <i>Zokrazuka</i> ” (they will get torn)	The comment implies awareness of frictional force between the clothes and the ground. This highlights how surface properties (rough or smooth) affect motion and the potential wear and tear on materials.
Integrating cultural practices with academic learning	“ <i>Cela ubhekele taAndi...ohh uyaphusha</i> ” (May you please move taAndi...ohh you are pushing me)	Shows that an external force is required to initiate motion. The activity involves sliding, which illustrates how forces (e.g., gravitational force and the applied force) influence movement on a slope. Without sufficient force, motion cannot occur.

<p>Learning through peer collaboration</p>	<p>“Udlalwa kanje (ebonisa abanye abantwana) funeke uwumise endaweni ehlayo” (It is played this way, Bhayi showing the other learners how the game is played, you must be on a slope)</p>	<p>Acknowledges the role of a slope in facilitating motion. This connects to gravitational potential energy being converted into kinetic energy as they slide down.</p>
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6.2.2 Summary

The findings illustrate how Indigenous games like *umtyibilizi* can serve as powerful educational tools. By integrating cultural practices into the curriculum, teachers can create meaningful and relatable learning experiences that resonate with learners’ identities. The interplay between mediation, culture and language, social interactions and the ZPD demonstrates the holistic nature of learning, where cognitive, social and cultural dimensions intersect. This game also highlights the potential of IK to enrich modern education. Schools can foster a more inclusive and empowering learning environment by valuing learners’ cultural backgrounds and involving community members in teaching.

Vygotsky’s sociocultural theory provides a valuable lens for understanding how learning unfolds within cultural and social contexts. The game of *umtyibilizi* exemplifies the theory’s core principles, from the mediation of learning through scaffolding and tools to the importance of social interactions and the ZPD. This study underscores the need for educators to integrate culturally relevant practices into teaching, creating opportunities for learners to connect academic concepts with their lived experiences.

By embracing the richness of IK, teachers can not only enhance learning outcomes but also contribute to the preservation and celebration of cultural heritage. The integration of IK into westernised science aligns with Vygotsky’s sociocultural theory, emphasising the role of social interaction and cultural tools in learning. Games like *umtyibilizi* offer a valuable opportunity to bridge the gap between IK and modern pedagogy, fostering a holistic approach to education. By mediating learning, leveraging culture and language and reimagining curricula, teachers can create more inclusive and effective learning environments. As the world becomes increasingly

globalised, preserving and valuing IK remains crucial for promoting cultural diversity and sustainable development.

6.3 Data Generated from Lesson Observation (2)

This section presents the themes emanating from lesson observations during the integration of IK in teaching Newton’s second law using the Indigenous game *umtyibilizi*. The practical work done in linking cultural practices to scientific concepts made science relevant by applying experiences that learners encounter daily. In the process, learners were supported within their ZPD through collaborative teamwork and guided scaffolding that bridged the gap between local knowledge and WS. Each subsection demonstrates how these approaches enhanced the learners’ understanding and meaning making of scientific concepts.

6.3.1 Development of themes

Sub-themes emerged from the lesson observations. From these sub-themes, themes emerged which in turn allowed for the literature and theory to surface.

Table 6.4: Themes that emerged from the lesson observations

Sub-themes	Themes	Literature
Lesson after the demonstration by IKCs (LAD)		
Using culturally relevant games or activities; illustrate, using IK, how force and motion are involved	Hands-on activities that link cultural practices to scientific concepts like Newton’s second law	Vygotsky (1978)
Science activities on everyday practices to demonstrate scientific principles; bridging the gap between home life and science	Making science relatable by using learners’ cultural and everyday experiences	Vygotsky (1978); Vygotsky (1987)

Fostering joint problem solving and collective discovery; each learner contributes unique skills or knowledge to uncover scientific solutions together	Promoting teamwork and shared discovery	Vygotsky (1978)
Providing support, such as guided questions or hands-on activities; real-world examples to introduce basic principles, then guide learners to think more abstractly	Helping learners progress step-by-step from familiar ideas to scientific understanding	Vygotsky (1978)

6.3.1.1 Lesson after the demonstration by IKCs

The lesson that followed after the demonstration by the IKCs began by connecting the Indigenous game, *umtyibilizi*, with scientific concepts. This lesson aimed to integrate IK with WS, to see how this game helped to enhance Grade 11 learners’ talk and sense making of Newton’s second law within a culturally relevant context.

6.3.1.2 Hands-on activity that links cultural practices to Newton’s second law

The second lesson introduced Newton’s second law using a practical activity that integrated *umtyibilizi*. It began with the learners being asked to use two textbooks to create a slope and slide various objects, such as calculators and staples, down them. Asheela et al. (2021) explain this as creating a link between what is done and what is being taught. This hands-on activity mediated their understanding of how mass, acceleration and gravity interact in motion.

Using the game as a framework for the lesson allowed them to bridge the gap between their local knowledge and the scientific concept of Newton’s second law (Whyte et al., 2008). For example, the learners were guided in observing how heavier objects (greater mass) accelerated differently from lighter ones. L5 noted, “*icalculator iyacota kune-sharpener*” (The calculator is slower than the sharpener). Mapfumo (2024) describes the way L5 switched between English and isiXhosa as

code switching, a skill learners use to mediate learning. This is explained by the frictional force on the two objects. This mediation helped them connect their everyday experiences to the abstract concept of force, making it more tangible and understandable (Vygotsky, 1978).

6.3.1.3 Making science relatable by using learners' cultural and everyday experiences

The integration of *umtyibilizi* in this lesson highlighted the relevance of cultural practices in the classroom. The learners used their own language to describe the motion of objects, often drawing parallels to their experiences with *umtyibilizi*.

For instance, L7 described how a heavy sledge “*moves faster on a steeper slope*” while L3 observed how a lighter sledge was “*easier to control*”. These descriptions, though informal, indicated their growing understanding of Newton’s second law. This use of cultural and linguistic connections (Vygotsky 1978) not only enriched the lesson but also validated the learners’ backgrounds and experiences. When the teacher integrated the familiar game, it allowed the learners to see how IK can be linked to and used as a resource for teaching and understanding modern scientific concepts (Haimene, 2023; Mhakure & Otulaja, 2017).

6.3.1.4 Promoting teamwork and shared discovery

The practical activity encouraged collaboration as learners worked in pairs and groups to test different objects on their slopes. As stated above, L7 described how a heavy sledge “*moves faster on a steeper slope*” while L3 observed how a lighter sledge was “*easier to control*”. They discussed their observations, debated their interpretations and shared their conclusions with the class. Affolter (2020) stated that learners deepen their understanding of science through collaborative dialogue. For example, one group noticed that heavier objects slid more smoothly, while another focused on the role of slope angle in determining speed. These interactions allowed learners to refine their understanding through dialogue and shared experiences.

According to Vygotsky (1987), social interaction is critical for learning, as it enables learners to co-construct knowledge. The collaborative nature of this activity ensured that each learner had the opportunity to contribute, ask questions and learn from their peers.

6.3.1.5 Helping learners progress step-by-step from familiar ideas to scientific understanding

At the start of the activity, most learners struggled to relate the sliding motion to Newton’s second law. However, with the guidance of the teacher and the support of their peers, they began to understand the relationships between force, mass and acceleration. It could be hypothesised then that the learners’ progression during this lesson was a clear example of learning within their ZPD (Vygotsky, 1978).

Learning was ensured by asking targeted questions, such as “*How does the weight of the object affect its motion?*” and “*What role does gravity play in the sliding process?*” These questions prompted the learners to think critically and apply their observations to the scientific concepts that were being studied. These interactions keep learners engaged throughout the lesson (Zayyad, 2020). As a result, by the end of the lesson, many learners experienced “*aha*” moments, indicating that they had successfully moved from their current level of understanding to a higher level within their ZPD.

Table 6.5: How Indigenous knowledge can be linked to scientific concepts

Theme	Indigenous Knowledge	Scientific Concept
Hands-on activities that link cultural practices to scientific concepts like Newton’s second law	<i>“icalculator iyacota kunesharpener”</i> (The calculator is slower than the sharpener)	Comparison in speed.
Promoting teamwork and shared discovery	Described how a heavy sledge “ <i>...moves faster on a steeper slope...</i> ” while it was also observed how a lighter sledge was “ <i>...easier to control</i> ”	Describes how gravity affects motion on an incline. A steeper slope increases the component of gravitational force acting along the surface, resulting in faster acceleration due to less friction relative to the gravitational pull. A lighter sledge has less inertia, making it easier to control. This

		highlights how mass affects motion and control; a larger mass has more resistance to changes in motion while a smaller mass has less resistance, hence easier control.
Helping learners progress step-by-step from familiar ideas to scientific understanding	Questions, such as “ <i>How does the weight of the object affect its motion?</i> ” and “ <i>What role does gravity play in the sliding process?</i> ”	Gravitational force pulls the object downhill, providing the force needed for accelerating down the slope (sliding). The steeper the slope, the greater the component of gravitational force acting parallel to the surface.

6.3.2 Summary

These lessons demonstrate the power of integrating IK and Vygotsky’s sociocultural theory in teaching Physical Sciences. By using *umtyibilizi* as an artefact (cultural tool), the learners’ lived experiences were connected to the abstract concepts that they learned in the classroom, fostering engagement and deeper understanding. Mediation of learning, culture and language, social interaction and the ZPD were all central to the success of these lessons.

Integrating culturally relevant examples is something that should be continued to make learning more accessible and meaningful for learners. By valuing their heritage and encouraging collaboration, seemingly, a learning environment that supports their cognitive and emotional development was created. These lessons portray that when learners see the relevance of their culture in the classroom, they are more likely to engage with and understand the subject matter.

6.4 Data Generated from Learner Reflective Journals

The purpose of using learners’ reflective journals was to track learning, analyse the learners’ experiences and gain insights into how the learners learn. In this study, these helped to find out how learners experienced the presentations by IKCs and the exemplar lesson that integrated IK into the topic of Newton’s second law.

All 10 Grade 11 learners submitted their reflective journals. These journals seemed to help the three learners who were too shy to speak as they were more comfortable expressing their thoughts in writing. It was also noted that the female learners seemed to write more than males as they mentioned that they enjoyed reflecting on lessons after they were taught. Some of the learners suggested that other teachers should also adopt this method, as it helped them improve their language skills and would allow their teacher to identify areas where learners struggled with the lesson. For example, L3 stated, “*I feel like other teachers can use the same method to see if we understand*”. L2 added, “*I like doing reflections after the lesson because this improved my writing and speaking*”.

The learners seemed to think that the integration of IK into lessons was beneficial. They explained that the integration of IK made science more relatable and easier to understand. They also appreciated how an Indigenous game like *umtyibilizi* was connected to scientific principles taught in class. This connection made science feel more relevant to their everyday lives. According to Mavuru and Ramnarain (2020), this integration of IK helped learners see the relationship between IK and the science they learn at school. Similarly, Aikenhead and Jegede (1999) argued that local resources like the cultural tools used such as a sledge and the game can serve as valuable tools for teaching science. The learners’ reflections showed that they enjoyed lessons where IK was integrated.

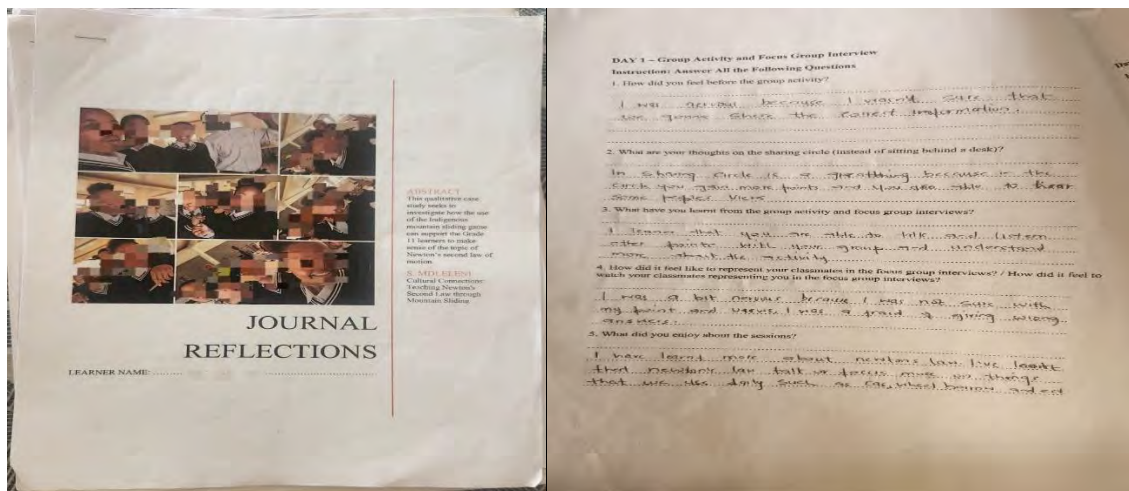


Figure 6.5: Examples of learners’ journals

6.4.1 Development of themes

Sub-themes emerged from the learners’ reflective journals. From these sub-themes, themes emerged, which in turn allowed for the literature and theory to surface.

Table 6.6: Themes that emerged from the learner reflective journals

Sub-themes	Themes	Literature/Theory
Apply theoretical concepts in real-world scenarios; foster critical thinking and a deeper understanding of concepts	Cultural tools and activities for integrating theory and practice	Vygotsky (1978); Affolter (2020); Fadiran et al. (2018); Shinana et al. (2021)
Ensuring that learning feels meaningful and inclusive; making lessons more relatable and engaging while fostering cultural pride	Cultural relevance in learning	Vygotsky (1978); Stott (2016); Zaretsky (2021)
The development of shared knowledge; collective understanding of the topic by listening to and learning from each other	Collaboration and shared understanding	Vygotsky (1978); Seehawer (2023); Zaretsky (2021)
Help learners build confidence and gradually master complex concepts; help learners overcome challenges and achieve academic growth	Growth through support	Vygotsky (1978); Bruner (1960)

The social and cultural dimensions of learning highlighted in this study focused on mediation, culture and language, social interaction, and the ZPD. The Grade 11 Physical Sciences learner

reflective journals offered rich insights into how these elements influence cognitive development and learning experiences.

6.4.1.1 Cultural tools and activities for integrating theory and practice

The process where the learners were guided was evident throughout the journals, as they described how tools such as sharing circles, games and discussions helped them process new concepts. For instance, L3 stated, *“In the sharing circle... you gain more points and are able to hear some people’s views”* This illustrates how structured activities mediated the understanding of complex concepts, providing learners with opportunities to refine their thoughts (Affolter, 2020). Similarly, L7 reflected on understanding *“different forces and the impact of mass and acceleration”* demonstrating how activities bridged theoretical knowledge with practical applications. Mediation in these reflections underscores the importance of using tools and structured experiences to connect abstract concepts to real-world examples (Fadiran et al., 2018; Shinana et al., 2021), such as wheelbarrows and cars, which the learners encounter daily.

6.4.1.2 Cultural relevance in learning

The journals reflected how integrating cultural practices into lessons made learning more relatable and engaging. For example, L6 reflected, *“I learnt that Indigenous mountains got to be an activity thing and they are attracting to play the game called umtybilizi”*. This connection between local traditions and formal learning aligns with Vygotsky’s (1978) assertion that cultural tools, such as language and practices, shape thought processes (Stott, 2016). Similarly, L1’s consideration of cutting grass on the mountain before playing the game demonstrates how personal and cultural experiences influence problem-solving approaches. By embedding cultural relevance into lessons, the teacher fosters an environment (Zaretsky, 2021) where learners can connect new knowledge to familiar contexts, deepening their engagement with the material. Culture and language play an important role in shaping learners’ cognitive development (Vygotsky, 1978).

6.4.1.3 Collaboration and shared understanding

The process whereby the learners influenced each other emerged as a crucial factor in the learners’ reflections, highlighting its role in cognitive development. For instance, L3 wrote, *“You are able*

to talk and listen to other points with your group and understand more about the activity”. This demonstrates how collaborative discussions enabled learners to share perspectives and co-construct knowledge. Likewise, L4 reflected on the nervousness of communicating group views but appreciated the opportunity to share thoughts in a safe space (Seehawer, 2023). These reflections align with Vygotsky’s idea that social interaction is central to learning, as peers challenge and support each other’s understanding (Zaretsky, 2021). Engaging in group activities not only helped learners overcome uncertainties but also enhanced their problem solving and communication skills, fostering a deeper understanding of Newton’s laws.

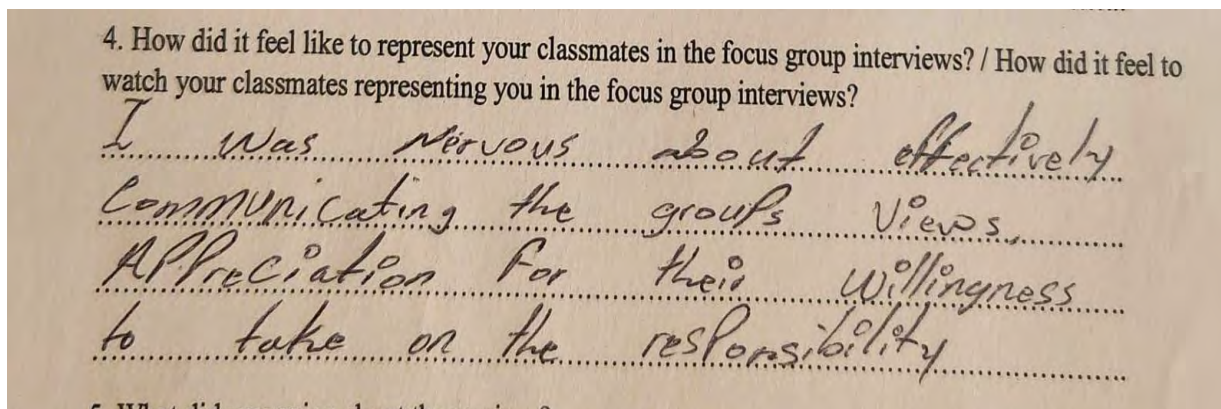


Figure 6.6: An extract from L4’s reflection

6.4.1.4 Growth through support

The journals also provided evidence of learning within the ZPD. For instance, L3 reflected, “*I was nervous because I wasn’t sure if I was going to share the correct information*”. This uncertainty indicated that the learner was operating within their ZPD, relying on group discussions and teacher facilitation to build confidence and refine their understanding. The ZPD represents the gap between what learners can achieve independently and what they can accomplish with guidance (Vygotsky, 1978). Similarly, L7 moved from a basic understanding of forces to grasping the relationship between mass and acceleration, reflecting growth facilitated by structured tasks and peer support. These examples highlight how scaffolding (Bruner, 1960), through collaborative activities and guidance, helped learners transition from initial uncertainty to a more confident and accurate understanding of Physical Sciences concepts.

In conclusion, the reflective journals revealed how Vygotsky's sociocultural theory underpins the learning experiences of Grade 11 Physical Sciences students. Mediation through tools and activities, the integration of cultural and linguistic elements, the emphasis on social interaction, and the activation of the ZPD all contributed to meaningful learning. By creating culturally relevant, interactive, and supportive learning environments, educators can help students engage deeply with scientific concepts, fostering both academic and personal growth.

6.4.2 Summary

The learner reflective journals provided valuable insights into how Grade 11 learners experienced lessons that integrated IK into the topic of Newton's second law. The journals served as a tool to track learning, understand learners' experiences, and identify areas of difficulty. Female learners expressed that journaling improved their writing and speaking skills, with some suggesting that other teachers adopt this method.

These reflections highlighted the benefits of integrating IK into science lessons. Learners found that connecting cultural practices, such as the Indigenous game *umtyibilizi*, to scientific principles made science more relatable and easier to understand. This alignment with everyday life reinforced their engagement and deepened their learning. The use of IK resources, as supported by Mavuru and Ramnarain (2020) and Aikenhead and Jegede (1999), proved effective in helping learners see the relevance of science to their cultural contexts.

Key themes emerged from the journals, including mediation of learning, cultural relevance, social interaction and the ZPD. Learners described how tools like sharing circles and collaborative activities helped them grasp abstract concepts, bridging theory with real-life applications. The integration of culture and language enhanced cognitive development, as learners connected new knowledge to familiar practices. In addition, social interactions played a crucial role in fostering collaboration and shared understanding, allowing learners to co-construct knowledge in a supportive environment.

Finally, the journals revealed evidence of learning within the ZPD, where learners moved from uncertainty to mastery with guidance from teachers and peers. Scaffolding and structured activities helped learners overcome challenges and gain confidence in understanding scientific concepts.

6.5 Chapter Summary

This chapter examined the integration of IK into Grade 11 Physical Sciences, focusing on its impact on learning experiences and cognitive development. The analysis draws on the learners' reflective journals. It provided an account of the integration of Indigenous Knowledge into science education; the teaching of Newton's second law through the game *umtyibilizi*. By underpinning a lesson with learners' cultural experience, learners can engage in a contextual and relevant delivery of scientific ideas such as friction, applied force and acceleration.

Guided discussion, hands-on activities, and collaborative learning helped bridge the gap between everyday knowledge and scientific principles for those who could not initially make connections with physics from the game. In fact, the framing supports Vygotsky's sociocultural theory of mediation through language and social interactions as central to cognitive development. Journal reflections from the learners provided even greater detail about how IK integration influenced their engagement and understanding.

Most of the learners, especially female students, reported an enhancement in their writing and speaking skills and also kept them abreast of the progress they made in learning. The development of journals showed scaffolding, the role of language in learning, and the ZPD. The learners co-constructed knowledge in moving from uncertainty towards a deeper understanding of Newton's second law through group discussions and sharing circles that reinforced the use of culturally responsive teaching. The chapter sums up the importance of infusing culturally relevant practices in the science curriculum as an approach to making learning accessible and meaningful. With IK-mediated learning, structured support and collaborative environments promoted by the teacher, learners will be able to connect abstract ideas in science with their lived experiences. This fosters academic achievement, cultural appreciation and inclusivity in ensuring that the learning of science is relevant and appealing to all learners. In the next chapter, I present the summary of findings, recommendations and conclusion.

CHAPTER SEVEN: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

7.1 Introduction

This study was triggered by my experience as a Physical Sciences teacher in a rural school in the Eastern Cape, South Africa. At this rural school, many learners seem to struggle to understand Physical Sciences, which might be due to the decontextualised teaching methods. Therefore, this interventionist study sought to mobilise the Indigenous gamified approach of *umtyibilizi* to enhance Grade 11 learners' talk and sense making of Newton's second law of motion. To achieve this, the following research questions were addressed.

1. (a) What enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton's second law before the intervention?
(b) What do Grade 11 Physical Sciences learners know from their community about *umtyibilizi* and Newton's second law?
2. How do Grade 11 Physical Sciences learners talk, interact and participate during the presentation by the Indigenous Knowledge Custodians on the traditional way forces are used during *umtyibilizi*?
3. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of the practical demonstration of *umtyibilizi* by the Indigenous Knowledge Custodians?
4. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of using an exemplar lesson that integrates learners' local knowledge (*umtyibilizi*) when learning about Newton's second law?

I now present the research findings, addressing the four research questions, recommendations, areas for future research and limitations of the study as well as my reflections. Finally, I will provide a conclusion.

7.2 Overview of the Study

The study adopted a qualitative research design to generate data from the Grade 11 Physical Sciences and two IKCs. Focus group interviews (sharing circles); group activities; observations (participatory and lesson observations); and learners' reflective journals were used as methods to generate data in this study. In addition, thematic analysis was used to analyse the data, where sub-themes and themes emerged from colour-coded data.

7.3 Summary of Findings

The summary of the findings of the study is presented in relation to my four research questions.

7.3.1 Research question 1

Research question 1 consisted of two research sub-questions and the summary of these is presented below.

7.3.1.1 Research question 1 (a)

What enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton's second law before the intervention?

Several enabling factors from the teaching methods, cultural context, and classroom dynamics led to learners being able to talk and make sense of Newton's second law before the intervention. Of these, my facilitating effect through clear explanation and practical demonstration was the enabling element. I explained the abstract scientific concept by using examples like the forces on rough surfaces to give learners a framework from which they understood some of the basics of Newton's second law. These, therefore, allowed learners to conceptualise and identify the principles of force, mass and acceleration. The second facilitation process that cropped up was collaborative learning through discussions in peer groups. These social interactions provided a space for learners to articulate their understanding, share ideas and learn from each other to build a sense of shared inquiry that got them thinking critically. Bilingual instruction, where I alternated between isiXhosa and English, also supported learners in making connections between their everyday experiences and formal scientific conceptions. This integration of languages allowed for clarity of concepts,

especially in cases where learners fared better when ideas were first explained in their home language before being translated into scientific terminology.

Yet, several factors also hindered learners from engaging in meaningful discussions and developing an understanding of Newton's second law. Two learners were not confident to share their ideas when they were not sure whether they were right. You could see this in how they held back during talks, worried about what their classmates or I might think. Some learners also could not apply what they had learned in class on their own. They could follow what the teacher showed and explained but found it hard to use this knowledge in problem solving or real-life situations. This shows a gap in the learners' ability to get and use scientific ideas outside the classroom. These problems were made worse by the fact that Newton's second law is abstract. Theoretical learning of the law was very far from their real lives and thus difficult to understand for learners who were more used to practical learning.

Also, the setting of the classroom and the method of teaching made an impact on how the learners participated. The examples that I set and the use of two languages were helpful, but at times, the reliance on teacher-led discussions reduced opportunities for the learners to contribute. Many learners might have viewed me as the only disseminator of knowledge, which hampered their potential to explore and make sense of things for themselves. This problem could have been further enhanced in some cases by the lack of examples that related to their culture, whereby the learners could not see how Newton's second law applied to their own lives. Without a clear link between the law's abstract ideas and their daily life, learners found it hard to stay interested in the topic. These limits put forward the necessity of teaching methods that explain while at the same time getting the learners involved in learning to make them feel like owners and controllers of their learning processes.

In short, what helped or hindered the learners to discuss and make attempts at making sense of Newton's second law before the intervention is illustrative of the complex interaction of teaching styles and classroom processes and the cultural and linguistic backgrounds brought by the learners into the classroom. Having a teacher as a guide helped as did the use of the two languages during the sessions. But some problems obstructed good learning. These included some learners talking more than others, learners not feeling sure of themselves, and trouble using what they learned on

their own. To resolve these issues, we need to concentrate more on the learners. That is, examples used should make sense to them, and everyone should be encouraged to join in and helped to think and solve problems.

7.3.1.2 Research question one (b)

What do Grade 11 Physical Sciences learners know from their community about umtyibilizi and Newton's second law?

The first step in addressing this research question was to establish the level of prior everyday knowledge that learners had about *umtyibilizi* as a culturally significant activity within their community. Traditionally, *umtyibilizi* involves sliding objects or persons on surfaces, which naturally integrates concepts of force, friction and motion. Learners may not initially frame this understanding in scientific terms, but they often possess intuitive knowledge based on observation and participation in these activities. For instance, they may have observed that heavier objects require greater force in movement or that smoother surfaces are easier to slide on. Such everyday knowledge acquired from the community is a platform upon which scientific ideas can be built.

In contrast, learners' knowledge of Newton's second law is typically from the portrayal of an abstract concept in textbooks or classroom instruction as most of them have difficulty relating this concept to their everyday experiences. This is because westernised pedagogies often ignore the situated and cultural aspects of learning. This discontinuity between their everyday, experiential knowledge and the principles of formal science provides an opportunity for authentic educational intervention. By bridging this gap, teachers would allow learners to envision where Physical Sciences broadly influences their lived experiences. It is also essential to consider how learners' cultural knowledge informs their interpretation of scientific ideas.

7.3.2 Research question two

How do Grade 11 Physical Sciences learners talk, interact, and participate during the presentation by the Indigenous Knowledge Custodians on the traditional way forces are used during umtyibilizi?

During the presentation by the IKCs, learners seemed to be influenced by their sense of cultural identity and their curiosity about how traditional practices integrate with modern science. Indeed,

this was a unique opportunity for the learners to see the practical use of forces in a context relevant to culture. Observations often indicate how much learners who are attached to their cultural heritage participate by asking questions or sometimes telling anecdotes related to their experiences with *umtyibilizi*. This level of engagement underlines the importance of culturally relevant pedagogy in promoting active learning.

Furthermore, the presence of IKCs provided an opportunity for a collaborative learning environment in which learners witnessed their cultural practices validated within an academic setting. It seemed to encourage them to participate more freely and make connections to how the IKCs explained a certain thing to what was taught in Physical Sciences. For example, a learner explained the use of a plastic bottle as a sledge, hence relating the traditional practice to Newton's second law. These interactions also signal how cultural context informs and shapes learners' understanding and engagement.

Some participation may be determined by confidence, prior knowledge and language barriers; hence, not all learners participated in the discussion and explanation equally. Some of them were reluctant to contribute because they may have not wanted to be proved wrong, and others may have had difficulties in formulating their ideas using a scientific perspective. It was my role and the IKCs to ensure that the environment was made non-threatening and that all learners were at ease to contribute. These challenges were minimised through techniques such as group discussions, guided questioning and peer support to make the experience worthwhile for all the learners.

The learners making connections between the two knowledge systems also came out in the way learners interacted during such presentations, as an evolving understanding of WS. As they engaged with the IKCs, the learners started to make links between traditional practices and scientific principles. It was in this instance that curiosity was stirred and a drive to learn more about such concepts, thus illustrating the potential transformation in integrating Indigenous Knowledge into the curriculum.

7.3.3 Research question three

How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of the practical demonstration of umtyibilizi by the Indigenous Knowledge Custodians?

The practical demonstration of *umtyibilizi* had a profound impact on learners' sense making, as it allowed them to witness the real-world application of abstract scientific concepts. Before the demonstration, learners might have relied on a fragmented or theoretical understanding of forces and motion. However, seeing *umtyibilizi* in action provided a tangible context that bridged the gap between theory and practice. The learners also observed, for example, a change in the surface texture or weight of an object to determine the force necessary to create movement, a culturally relevant demonstration of Newton's second law.

As learners processed the demonstration by the IKCs, the learners' language and explanations seemed to evolve. They would describe what they observed, saying something like "*it's harder to push*" or "*it goes faster on smooth surfaces,*" using everyday language. With my help as the teacher, such observations were reframed into scientifically sounding explanations, such as "*the heavier something is, the more force is required to overcome friction*" or "*friction is less on smoother surfaces, so it accelerates more.*" Such a shift in language also reflected a conceptual shift whereby learners increasingly integrated scientific language into their sense making.

In addition, the demonstration encouraged the learners to learn collaboratively: They shared their observations and interpretations with their peers. These discussions seemed to bring different levels of understanding to light and thus enabled peer teaching and collective problem solving. For example, one learner explained how the angle of the sliding surface affected acceleration, which seemed to encourage others to test this idea during the lesson that integrated IK. Working together while playing *umtyibilizi* helped the learners to develop a collaborative dynamic that not only improved learning but also reinforced the social and cultural dimensions of education.

However, not all learners experienced this level of transformation – for some, intuitive understanding of *umtyibilizi* was not so easily matched by the formal scientific concepts being presented. Therefore, further support from me in the form of step-by-step explanations or the opportunity to explore these ideas through hands-on activities at their own pace was required. In

addressing such challenges, the practical demonstration served as a powerful tool to foster meaningful learning and appreciation for culture.

7.3.4 Research question four

How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of using an exemplar lesson that integrates learners' local knowledge (umtyibilizi) when learning about Newton's second law?

Integration of *umtyibilizi*, a culturally significant game, within the exemplar lesson enabled shifts in Grade 11 learners' talk and sense making via meaningful connections between everyday experiences and Newton's second law. This shift was evident in the reflective journals, classroom discussions, and practical activities on how learners gradually moved from reliance on cultural knowledge towards articulating scientific concepts in informal and formal language.

The reflective journals revealed that *umtyibilizi* inspired learners to express their conceptual understanding of science in culturally relevant and informal ways, such as code switching between isiXhosa and English. For example, L5 explained, "*icalculator iyacota kune-sharpener*" (The calculator is slower than the sharpener), showing an initial intuitive understanding of friction and acceleration. As the lesson unfolded, learners were more willing to share their thoughts supported by collaborative group work and teacher facilitation. For L3, "*you gain more points and are able to hear some people's views*", which shows that structured group discussions allowed learners to refine their thinking through peer interaction.

The integration of the local knowledge of the learners, in this case, specifically through the Indigenous game *umtyibilizi*, made the Grade 11 Physical Sciences learners talk and make sense of Newton's second law differently. Of the changes in discourse on Newton's second law, probably one of the biggest changes was seeing learners relating to the concepts taught. Using *umtyibilizi*, a game with which learners were very familiar and the exemplar lesson bridged the gap between abstract scientific principles and learners' lived experiences. This approach allowed learners to visualise Newton's second law in action within a context they understood, making the concepts more tangible and meaningful. For example, learners reflected on how the game involved forces and motion, which aligned with the principles of acceleration and mass described by the law.

Linking cultural practices with scientific concepts showed that they developed a better understanding and pride in the relevance of learning as the learners witnessed their local knowledge becoming valued in classrooms.

In general, learners participated more effectively and had improved discussions within that lesson; they were more articulate than expected, especially those who were shy and mostly silent during sessions of such a nature. The use of a sharing stick saw the avoidance of the previous one-sided view when it came to learners discussing or deliberating a subject. Every single learner became willing to discuss a given situation. The bilingual nature of the lesson also continued to feature as an important resource drawn upon to support learners in their sense making. I also code-switched between isiXhosa and English, for example, to create a discursive space wherein learners discussed the scientific concepts in a language with which they felt comfortable before turning to the formal scientific registers expected in assessment conditions. Such code switching allowed the learners to engage deeper with the material as they could construct meaning by drawing from their cultural and linguistic resources.

Another significant change occurred regarding learners' cognitive engagement with Newton's second law on how *umtybilizi* supported the learners to reflect on the relationship of force, mass and acceleration in a real context. These were further supported by cognitive development through activities such as group problem solving and reflective journaling, enabling learners to apply knowledge and reflect upon the learning process. For instance, some learners started to progress beyond mere recall to connecting the underlying principles. Such a shift in behaviour reflected an increased internalisation and generalisation of scientific knowledge, a prime sign of meaningful learning. Moreover, the cultural relevance of the lesson raised a sense of curiosity and eagerness to learn among the learners because they were more interested in what they were being taught when it dealt with their lives.

Nevertheless, not all these changes were positive, and some challenges remained. The exemplar lesson enhanced the ability of the learners to talk about Newton's second law in familiar contexts; however, problems that involved force components at angles or other more complex scenarios revealed missing problem-solving resources for the learners, indicating the need for further scaffolding and practice. Moreover, even with the sharing stick and structured activities, several

of the learners were very reluctant to participate in discussions. That means that learners need to be made aware that all voices are welcome and valued in the classroom. Finally, whereas the bilingual approach and cultural integration favoured the understanding of the learners, for some, the passage to the formal scientific language and terminology was problematic, a situation that evidences the necessity of continued scaffolding in scientific literacy.

In sum, the use of culturally based knowledge with bilingual instruction through the lessons drove far more meaningful learning that affirmed their backgrounds and resulted in critical thinking. However, independent application, confidence and scientific language use were all areas that needed further support and development. These findings highlight the importance of culturally responsive teaching in making connections between learners' everyday experiences and the abstract principles of science that will eventually help to bridge the gap, allowing for more inclusive and effective educational practices.

7.4 Recommendations

The results of the study led to the following recommendations to improve the teaching and learning of Newton's second law in Grade 11 Physical Sciences:

1. Integration of IK

Learners' IK should be integrated into science lessons in the form of game-playing like *umtybilizi*, among others. When the learners see that such abstract concepts are relevant to their culture, they will be able to engage with them.

2. Bilingual instruction

Schools should actively support the use of learners' home languages and English in science education. This bilingual approach will facilitate a better link between learners' informal, everyday knowledge and formal scientific terminology, enabling them to comprehend the learning material more easily.

3. Facilitating equity in participation

Teachers should use strategies such as planned group discussions, the 'sharing stick' strategy, and questioning differentiated in form and level to ensure that all learners can participate in active learning during class, regardless of confidence levels.

4. Continuing professional development

Teachers should be empowered with culturally responsive teaching methods and inclusive discussion facilitation. Workshops and collaborative forums may help teachers share practices that encourage effective engagement with local knowledge in science curricula.

5. Improved problem-solving practice

Learners need to be afforded opportunities to solve a range of problems from simple to complex to build their competence in applying Newton's second law in different contexts. Teachers should scaffold these tasks to gradually increase the difficulty while providing support.

6. Classroom environment

Schools have a responsibility to ensure that safe, supportive classroom environments are established in which learners feel confident to share ideas, make mistakes and learn cooperatively without fear of judgement or ridicule.

7.5 Areas of Further Research

The study affords these opportunities for further research:

1. The effect of culturally responsive teaching on other subjects

For example, a future study might explore how an integrated local knowledge approach would enable or constrain learners' understanding of other physics concepts like the laws of conservation of energy, thermodynamics, electromagnetism and so on.

2. Longitudinal studies of bilingual instruction

For instance, bilingual science instruction and its long-term effects on learners' achievement results and career intentions in STEAM subjects could be pursued.

3. Learners' perceptions of science

Further research might be done to explore the impact of including Indigenous Knowledge on learners' dispositions toward science, including interest, motivation and sense of belonging.

4. Preparedness of teachers

Studies can be made on the preparedness and perceptions of teachers concerning integrating Indigenous Knowledge in science education, studying obstacles and required support.

5. Wider use of IK

The studies might explore how Indigenous Knowledge Systems in agriculture, medicine and other practices inform teaching strategies across disciplines.

6. Complementarity of Theories

A future study could complement Vygotsky's sociocultural theory with an additional theoretical perspective focused on sense-making. This would provide a more comprehensive understanding of how learners construct knowledge, particularly complex scientific concepts that require both social and cognitive scaffolding.

7.6 Limitations

The limitations of this study are as follows:

1. Sample size and context

The research setting was situated in one Grade 11 class in a specific region; thus, findings cannot be generalised to other contexts with different cultural, linguistic or educational settings. However, it is acknowledged that case studies are not intended to generalise but are instead to provide some insights into the problem identified.

2. Short intervention period

The intervention period for this study was short, which could limit the extent of the changes that were observed in the learners' understanding and engagement.

3. Subjectivity in observations

The data generation relied on qualitative approaches, such as lesson observation and group discussions, which, despite the best efforts of the critical friend and me to remain objective, may be biased.

4. Narrow scope of knowledge integration

The use of *umtyibilizi* as a single cultural context for integrating Newton's second law may not reveal the depth of other cultural practices in enhancing learning.

If I were to do this study again, I would encourage my learners to do mind maps and concept maps to reinforce their conceptual understanding.

7.7 My Reflections

It was towards the end of my first year of Honours in Education at Rhodes University that I met Mthembu, a supervisor whose mentorship would play a huge role in shaping my academic journey. That meeting, which at the time perhaps seemed ordinary, was the beginning of a collaborative and dynamic partnership. As 2023 approached, I felt excited and motivated to dive into the second year of my Honours. I was eager now to go deeper into my knowledge, challenging myself academically and exploring new research opportunities.

The second year of Honours proved to be a life-changing experience. I took particular interest in the process behind research and how these espoused academic works came into being. The critical thinking, data analysis, and academic writing skills I acquired indeed formed a proper grounding for whatever I was to do later in life. By the end of 2023, I felt quite accomplished and had an increasing need to further my studies. It is from this point that my interest in seeking to pursue a master's degree took shape.

Finally, in 2024, I signed up for a master's degree, supervised by Prof Ngcoza, commonly known as Mthembu as highlighted earlier and co-supervised by Prof Jojo (mathematics education). The first indication was that the momentum that had characterised my work during Honours would flow into my master's work. As it were, the strides of our efforts were only intensified. The supervision and encouragement by my supervisor and co-supervisor created an enabling environment for me, and I grasped every opportunity to push beyond my limits.

The moment that defined 2024 was presenting my Honours work at the SAARMSTE conference in Namibia. This was one of the pivotal experiences of my life, in that it allowed me to share my findings with a broader audience and to engage with other researchers in my field. It was an absolute honour to have won the slide competition at the conference, as all my work went into it, and I truly believe that reflects how good the work was. Such recognition always gives me confidence in what I do.

Shortly after the conference, another important milestone was the acceptance of my master's proposal in record time. This achievement was very meaningful because it spoke to the clarity and rigour of my research plan and the excellent collaboration between my supervisors and me. With my proposal approved, I had enough time to really dive into the core of my research.

The year 2024, also afforded me the opportunity to co-author a journal article with Prof Ngcoza. This was quite a challenging yet enriching experience since it required great attention to detail and a deep understanding of the publication process. When the article got accepted for publication, it felt like the culmination of months of dedication and teamwork. It was immensely gratifying to know that my work would contribute to the academic discourse in my field.

Of course, these accomplishments too were not without their own fair share of challenges. To be sure, keeping many irons in the fire demands real focus and discipline. There were times when I felt like doubting my ability to pull it all off, especially during the festive season, when I found myself working on my thesis. But I knew that to achieve what I had in mind, I had to make certain sacrifices.

2024 is a year that, in retrospect, I am grateful for and proud of. It was a year of hard work, growth and milestones beyond my expectations. The journey was not easy; instead, each challenge I went through taught me a great deal about resilience, persistence and sticking to my aspirations.

I am very excited about what 2025 holds. This year started with me attending the SAARMSTE conference in Potchefstroom, where I presented part of my master's study and received very constructive feedback to improve the quality of my thesis. The most important highlight was having both my supervisor and co-supervisor supporting me on the day of my presentation. Hearing that my co-supervisor, Prof Jojo, drove from Pretoria to Potchefstroom specifically to support me, was and is still heart-warming and I am grateful. It showed that she indeed cares and I appreciate her for that and am thankful for her insights throughout this process.

In addition, registration for PhD studies should further what has so far been gained. I aim to conduct more research in the field in which I am engaged and explore newer academic horizons. The coming way may be quite thorny and troublesome; however, from what has occurred in 2024

and gained, I would say that successes have equipped me with will and optimism towards their resolution.

I move forward with the knowledge that hard work pays off and that strong mentors can make all the difference. My journey so far has been a testament to the power of dedication, collaboration and a clear vision. I am ready to embrace the next chapter with an open mind and steadfast commitment to the realisation of my goals.

7.8 Conclusion

This study investigated how Grade 11 Physical Sciences learners' discursive and interpretive practices about Newton's second law of motion changed as a result of the integration of the IK game *umtybilizi*. Before the intervention, learners were constrained by low confidence, unequal participation and an inability to connect abstract ideas to their lived experiences. These were further exacerbated in part by a lack of opportunities for interactive use. However, the intervention has shown how culturally responsive teaching, combined with bilingual instructional support and inclusive strategies in the classroom, enhances the learner's understanding and engagement.

By situating abstract scientific principles in learners' cultural context, the intervention validated their identities and made learning more relatable and meaningful. Learners showed improved participation, critical thinking, and sense-making, although challenges in problem-solving and transitioning to formal scientific language persisted.

The study further points out that the integration of IK into science education has the potential to allow for more inclusive, engaging, and effective learning environments; it also flags the sustained support and professional development for teachers, and further research is required because of the identified limitations.

Ultimately, it contributes to an emerging body of evidence that argues for culturally responsive pedagogies that bridge the gap between learners' everyday experiences and the abstract nature of scientific knowledge. It is through this kind of approach that teachers can afford learners opportunities to see themselves as capable contributors to scientific discourses and foster a deeper appreciation of both their cultural heritage and the principles of science.

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APPENDICES

APPENDIX A1: ETHICAL CLEARANCE



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

7 September 2024

Ms Sinethemba MDLELENI

Education Department

g22m7469@campus.ru.ac.za

Dear Ms Sinethemba Mdleleni

Re: Cultural Connections: Teaching Newton's Second Law through Mountain Sliding

APPLICATION NUMBER: 2024-7937-8888

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,

Prof Mags Blackie

Chair: Education Faculty Research Ethics Committee

APPENDIX A2: RESEARCH APPROVAL FROM DEPARTMENT OF EDUCATION



Province of the
EASTERN CAPE
EDUCATION



OFFICE OF THE DIRECTOR: CORPORATE PLANNING, MONITORING, POLICY & RES. CO.
Steve Vukile Tshwete Complex, Zone 8 Zwelitsha, 5608, Private Bag X0032, Bhisho, 5605 REPUBLIC OF SOUTH AFRICA
Enquiries: **Ms F. Pakade** . Tel: 040 602 7071. Fax 086 602 2024. Email: lundiswa.pakade@ecdoe.gov.za
Website: www.eceducation.gov.za Date: 12 August 2024

Ms. Sinethemba Mdleleni
10 EZ Myeko Street
Phase 2
Ncambedlana
Mthatha
5099


Dear Ms. Mdleleni

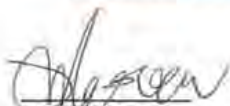
**PERMISSION TO UNDERTAKE A MASTERS RESEARCH: CULTURAL CONNECTIONS:
TEACHING NEWTON'S SECOND LAW THROUGH MOUNTAIN SLIDING**

1. Your application to conduct the above-mentioned research involving ten (10) Grade 11 Physical Sciences learners, Physical Sciences teacher and two Indigenous Knowledge Custodians at Intaba Secondary schools at the rural town of Mqanduli in OR. Tambo Inland district under the jurisdiction of the Eastern Cape Department of Education (ECDoE) is hereby approved based on the following conditions:
 - a. All financial implications will be borne by you. The Department will not be liable for any financial implications occurred during this research.
 - b. Institutions and respondents must not be identifiable in any way from the results of the investigation.
 - c. You are responsible to seek parent's consent for minors.
 - d. No interruptions with educator time and task during school timeframes are allowed.
 - e. Research may not be conducted during official contact time.
 - f. Prior approval from the principal and the affected teacher/s must be obtained in writing if research at a school within a classroom are part and partial of the research.
 - g. You must present a copy of the written approval letter of the Eastern Cape Department of Education (ECDoE) to the Cluster and District Directors before any research is undertaken at any institutions within that particular district.

Research Approval letter

Page1

- 
- h. It is your responsibility to make all the arrangements concerning your research.
 - i. Should you wish to extend the period of research after approval has been granted, an application to do this must be directed to Chief Director: Corporate Strategy Management prior to expiry date.
 - j. You are responsible for presenting the Department with a copy of your final paper/report/dissertation/thesis free of charge in hard copy and electronic format. This must be accompanied by a separate synopsis (maximum 2 – 3 typed pages) of the most important findings and recommendations if it does not already contain a synopsis;
 - k. You will be responsible for presenting the findings to the Departmental Research Committee and/or Senior Management of the Department when and/or where necessary.
 - l. You are requested to inform in writing your presentation on your finding to the Chief Director: Corporate Strategy Management upon completion of your research.
 - m. You must comply with all the requirements as completed in the Terms and Conditions to conduct Research in the ECDoE document duly completed by you.
 - n. You must submit a signed copy of your commitment form and comply with your ethical undertaking.
 - o. You are required to submit on a six-monthly (bi-annual) basis, from the date of permission of the research, concise reports to the Chief Director: Corporate Strategy Management.
2. The Department reserves a right to withdraw the application for research should there be non-compliance to the approval letter and contract signed as indicated in the Terms and Conditions to conduct Research in the ECDoE and/or legal requirements to do so.
 3. The Department will publish the completed Research on its website.
 4. The Department wishes you well in your undertaking. You can contact the Mrs. Fundiswa Pakade on the numbers indicated in the letterhead or email fundiswa.pakade@ecdoe.gov.za should you need any assistance.



T. MASOEU
CHIEF DIRECTOR: CORPORATE STRATEGY MANAGEMENT
FOR ACTING HEAD OF DEPARTMENT: EDUCATION

Research Approval Letter

APPENDIX A3: GATE KEEPERS LETTERS

LETTER TO THE SCHOOL PRINCIPAL

QINGQOLO SENIOR SECONDARY SCHOOL

Rhodes University

Drostdy Road

Makhanda

6139

30 May 2024

Dear Sir

My name is Mdleleni Sinethemba (student number: 22M7469), registered as a MEd student in the field of Science Education in the Education Department at Rhodes University. As part of the master's course, we are required to conduct a research project. I hereby humbly request your permission to conduct a research study with ten Physical Sciences learners from Qingqolo Senior Secondary School. I am seeking to generate data for the study by engaging with Grade 11 Physical Sciences learners during the months of August 2024 to November 2025. This qualitative case study seeks to investigate how the use of the Indigenous mountain sliding game can support the Grade 11 learners to make sense of the topic of Newton's second law of motion.

PROJECT TITLE: CULTURAL CONNECTIONS: TEACHING NEWTON'S SECOND LAW THROUGH MOUNTAIN SLIDING

Duration: August 2024 - November 2025

Research goal

The main goal in this study, if my request is accepted is to mobilise the Indigenous gamified approach of *umtyibilizi* (mountain sliding game) to enhance Grade 11 learners' talk and sense making of Newton's second law of motion. To achieve this goal, the following research questions will be addressed:

Research Questions:

1. (a) What enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton's second law before the intervention?

(b) What do Grade 11 Physical Sciences learners know from their community about *umtyibilizi* and Newton's second law?
2. How do Grade 11 Physical Sciences learners talk, interact and participate during the presentation by the Indigenous Knowledge Custodians on the traditional way forces are used during *umtyibilizi*?
3. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of the practical demonstration of *umtyibilizi* by the Indigenous Knowledge Custodians?
4. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of using an exemplar lesson that integrates learners' local knowledge (*umtyibilizi*) when learning about Newton's second law?

Data collection methods will involve focus group interviews (sharing circles), group activities, observations (participatory and lesson observations) and learners' reflective journals. The focus group interviews will be face-to-face. The interview questions will be translated into isiXhosa

since it is a language that is predominantly spoken in the area. Practical demonstrations by learners from the primary school. Therefore, consistent with ethics, the Physical Sciences' learners will be given an option to respond to questions in a language they are comfortable with. Additionally, exemplar lesson plans that integrate IK with Physical Sciences (Newton's second law) will be used.

I therefore request your permission to allow the Grade 11 Physical Sciences learners from your school to take part in this study. I am seeking to generate data for the study by engaging with Grade 11 Physical Sciences learners during the months of August 2024 to November 2025. Data gathering would be every Friday at 14:00 to 15:30 in August or September 2024. The learners will be free to withdraw at any time if they so wish without any prejudice.

Should you need further information regarding this study, please feel free to contact me at my email mdlelenisinethemba@gmail.com or cell number 0732249064, my supervisor Professor Kenneth Mlungisi Ngcoza at k.ngcoza@ru.ac.za and co-supervisor Professor Zingiswa Jojo zingiswa.jojo@ru.ac.za.

Your favourable consideration will be very much appreciated.

Yours faithfully

Student name: Mdleleni Sinethemba

Email address: mdlelenisinethemba@gmail.com

Cell number: 073 224 9064

Rhodes University, Research Office, Ethics

Dr Janet Hayward, Ethics Coordinator: ethics-committee@ru.ac.za

T: +27 (0) 46 603 8111 F: +27 (0) 82 739 4378

Room 220, Main Admin Building, Drostdy Road, Makhanda, 6139

LETTER TO THE SCHOOL PRINCIPAL

QINGQOLO PRIMARY SCHOOL

Rhodes University

Drostdy Road

Makhanda

6139

30 May 2024

Dear Madam

My name is Mdleleni Sinethemba (student number 22M7469) registered as a MEd student in the field of Science Education in the Education Department at Rhodes University. As part of the master's course, we are required to conduct a research project. My supervisor is Professor Kenneth Mlungisi Ngcoza. With your assistance, I am hoping to conduct research with Grade 11 Physical Sciences' learners on the integration of indigenous knowledge in Physical Sciences' teaching and learning. The purpose of this research is to mobilise the Indigenous mountain sliding game to support Grade 11 learners to make sense of Newton's second law in South Africa. I require assistance from two learners who play the mountain sliding game to be the Indigenous Knowledge Custodians in the study.

PROJECT TITLE: CULTURAL CONNECTIONS: TEACHING NEWTON'S SECOND LAW THROUGH MOUNTAIN SLIDING

Duration: August 2024 - November 2025

Research goal

The main goal of this study is to mobilise the Indigenous gamified approach of *umtyibilizi* (mountain sliding game) to enhance Grade 11 learners' engagement and sense making of Newton's second law of motion. To achieve this goal, the following research questions will be addressed:

Research Questions:

1. (a) What enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton's second law before the intervention?

(b) What do Grade 11 Physical Sciences learners know from their community about *umtyibilizi* and Newton's second law?
2. How do Grade 11 Physical Sciences learners talk, interact and participate during the presentation by the Indigenous Knowledge Custodians on the traditional way forces are used during *umtyibilizi*?
3. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of the practical demonstration of *umtyibilizi* by the Indigenous Knowledge Custodians?
4. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of using an exemplar lesson that integrates learners' local knowledge (*umtyibilizi*) when learning about Newton's second law?

The two learners from the primary school will assist in showing the Grade 11 learners how the mountain sliding game is played.

I am seeking permission to generate data for the study by engaging with the Indigenous Knowledge Custodians during the months of August 2024 to November 2025. The practical demonstration would be done on one Friday at 14:00 to 15:30 in August or September 2024. I therefore request your permission to allow the learners from your school to take part in this study. The learners will be free to withdraw at any time if they so wish without any prejudice.

Should you need further information regarding this study, please feel free to contact me at my email mdlelenisinethemba@gmail.com or cell number 0732249064, my supervisor Professor Kenneth Mlungisi Ngcoza at k.ngcoza@ru.ac.za and co-supervisor Professor Zingiswa Jojo zingiswa.jojo@ru.ac.za.

Your favourably consideration will be very much appreciated.

Yours faithfully

Student name: Mdleleni Sinethemba

Email address: mdlelenisinethemba@gmail.com

Cell number: 073 224 9064

Rhodes University, Research Office, Ethics

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Room 220, Main Admin Building, Drostdy Road, Makhanda, 6139

LETTER TO A CRITICAL FRIEND

Rhodes University

Drostdy Road

Makhanda

6139

30 May 2024

Dear Madam

My name is Mdleleni Sinthemba (student number: 22M7469), registered as a MEd student in the field of Science Education in the Education Department at Rhodes University. As part of the master's course, we are required to conduct a research project. May you please assist me to conduct research on Grade 11 learners by becoming my critical friend during the period of the study?

As a critical friend, you will serve as a supportive yet challenging partner who provides constructive feedback, ask probing questions and offer alternative perspectives. Your role will be to enhance the rigour and validity of the research by encouraging reflection, identifying potential biases and suggesting improvement to the methodology and interpretation of finding. The details of the research are listed below.

PROJECT TITLE: CULTURAL CONNECTIONS: TEACHING NEWTON'S SECOND LAW THROUGH MOUNTAIN SLIDING

Duration: August 2024 - November 2025

Research goal

The main goal of this study is to mobilise the Indigenous gamified approach of *umtyibilizi* (mountain sliding game) to enhance Grade 11 learners' talk and sense making of Newton's second law of motion. To achieve this goal, the following research questions will be addressed:

Research Questions:

1. (a) What enables and/or constrains Grade 11 Physical Sciences learners to talk and make sense of Newton's second law before the intervention?

(b) What do Grade 11 Physical Sciences learners know from their community about *umtyibilizi* and Newton's second law?
2. How do Grade 11 Physical Sciences learners talk, interact and participate during the presentation by the Indigenous Knowledge Custodians on the traditional way forces are used during *umtyibilizi*?
3. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of the practical demonstration of *umtyibilizi* by the Indigenous Knowledge Custodians?
4. How do Grade 11 Physical Sciences learners' talk and sense making shift (or not) as a result of using an exemplar lesson that integrates learners' local knowledge (*umtyibilizi*) when learning about Newton's second law?

I request that you help me generate data with the Grade 11 Physical Sciences learners in order to mobilise the Indigenous gamified approach of *umtyibilizi* (mountain sliding game) to enhance Grade 11 learners' engagement and sense making of Newton's second law of motion. Data collection methods will involve focus group interviews (sharing circles), group activities,

observations (participatory and lesson observations) and learners' reflective journals. The focus group interviews will be face-to-face or online platforms. The interview questions will be translated into isiXhosa since it is a language that is predominantly spoken in the area. Therefore, consistent with ethics, the Physical Sciences' learners will be given an option to respond to questions in a language they are comfortable with. Additionally, exemplar lesson plans that integrate IK with Physical Sciences (Newton's second law) will be used.

I am seeking to generate data for the study by engaging with Grade 11 Physical Sciences learners, with your assistance, during the months of August 2024 to November 2025. Data gathering would be every Friday at 14:00 to 15:30 in August or September 2024. You will be free to withdraw at any time if they so wish without any prejudice.

Should you need further information regarding this study, please feel free to contact me at my email mdlelenisinethemba@gmail.com or cell number 0732249064, my supervisor Professor Kenneth Mlungisi Ngcoza at k.ngcoza@ru.ac.za and co-supervisor Professor Zingiswa Jojo zingiswa.jojo@ru.ac.za.

Your favourably consideration will be very much appreciated.

Yours faithfully

Student name: Mdleleni Sinethemba

Email address: mdlelenisinethemba@gmail.com

Cell number: 073 224 9064

Rhodes University, Research Office, Ethics

Dr Janet Hayward, Ethics Coordinator: ethics-committee@ru.ac.za

T: +27 (0) 46 603 8111 F: +27 (0) 82 739 4378

Room 220, Main Admin Building, Drostdy Road, Makhanda, 6139

Education Department

Rhodes University

P.O. Box 94

Grahamstown

6140

Dear parent/guardian

My name is Sinethemba Mdleleni, and I am studying for a MEd in Science Education at Rhodes University, Education Department. I would like to carry out a study where the data gathering will commence in August 2024 to November 2025.

I request your permission for your child to be involved in this study. Your child will be involved in a one-month implementation phase where Indigenous game is integrated to the Newton's second law curriculum. The data gathering would be every Friday at 14:00 to 15:30 in August or September 2024. Your child's name will not be revealed without your consent. I wish to promise that you have a right to access the information that will be gathered during this research study at any time when you want it.

Should you need further information regarding this study, please feel free to contact me at my email mdlelenisinethemba@gmail.com or cell number 0732249064, my supervisor Professor Kenneth Mlungisi Ngcoza at k.ngcoza@ru.ac.za and co-supervisor Professor Zingiswa Jojo zingiswa.jojo@ru.ac.za.

Yours sincerely

Sinethemba Mdleleni

(Student number: 22M7469)

APPROVAL

I, _____

Parent/Guadian of _____

I permit Sinethemba Mdleleni to work with my child in piloting the use of umtyibilizi to each Newton's second law in the Grade 11 Physical Sciences' curriculum. 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 _____

Rhodes University, Research Office, Ethics

Dr Janet Hayward, Ethics Coordinator: ethics-committee@ru.ac.za

T: +27 (0) 46 603 8111 F: +27 (0) 82 739 4378

Room 220, Main Admin Building, Drostdy Road, Makhanda, 6139

Education Department

Rhodes University

P.O. Box 94

Grahamstown

6140

Mzali/umgcini othandekayo

Igama lam ndingu Sinethemba Mdleleni, ndifundela iMED kwiScience Education kwiDyunivesithi iRhodes, kwiSebe leMfundo. Bendinqwena ukuphanda ngokwezeMfundo apho uphononongo luya kuqalisa kwi nyanga ka-Agasti 2024 ukuya kuNovemba 2025.

Ndicela imvume yakho ukuba umntwana wakho athathe inxaxheba kolu phononongo. Umntwana wakho uya kubandakanyeka kwisigaba senyanga enye sokuphunyezwa, apho imidlalo yemveli idityaniswa kumthetho wesibini kaNewton kwi Kharithyulamu. Sizodibana ngolweziHlanu ngo 14:00 kudekuba ngu 15:30 kwi nyanga ka-Agasti okanye uSeptemba 2024. Igama lomntwana wakho aliyi kuchazwa ngaphandle kwemvume yakho. Ndinqwenela ukuthembisa ukuba unelungelo lokufikelela kulwazi oluya kuhlanganiswa ngexesha lolu phando nangaliphi na ixesha xa ulufuna.

Ukuba ufuna ulwazi oluthe vetshe malunga nolu phononongo, nceda uqhakamshelane nam kule dilesi ye-imeyile: mdlelenisinethemba@gmail.com okanye kwinombolo yeselula ethi 0732249064 okanye umphathi wam uNjingalwazi Kenneth Mlungisi Ngcoza [ku-k.ngcoza@ru.ac.za](mailto:k.ngcoza@ru.ac.za) okanye usekela mpathi uNjingalwazi Zingiswa Jojo ku- zingiswa.jojo@ru.ac.za.

Ozithobileyo

Sinethemba Mdleleni

(Inombolo yokuba ngumfundi: 22M7469)

ISIQINISEKISO

Mna _____

Umzali/uMgcini

ka _____

Ndivumela uSinethemba Mdleleni ukuba asebenze nomntwana wam ekuvavanyeni ukusetyenziswa komtyibilizi kuMthetho weSibini kaNewton ngamnye kwiKharityhulam yeZifunfundo Zobunzululwazi zeBanga le-11. Kuyandivuyisa ukuqinisekiswa ukuba igama lomntwana wam aliyi kutyhilwa ngaphandle kwemvume yam. Kwakhona, ingxelo yophando malunga noku iya kwenziwa ifumaneke nanini na xa ndiyifuna.

Umsayino/utyikityo _____

Umhla _____

Rhodes University, Research Office, Ethics

Dr Janet Hayward, Ethics Coordinator: ethics-committee@ru.ac.za

T: +27 (0) 46 603 8111 F: +27 (0) 82 739 4378

Room 220, Main Admin Building, Drostdy Road, Makhanda, 6139

Education Department

Rhodes University

P.O. Box 94

Grahamstown

6140

LETTER TO THE PARENT OF THE INDIGENOUS KNOWLEDGE CUSTODIAN 1

Enquiries: Ms Sinethemba Mdleleni

Cell number: 0732249064

Dear Parent/ Guardian

RE: PERMISSION LETTER: PRESENTATION OF PRACTICAL DEMONSTRATION ON PLAYING UMTYIBILIZI (MOUNTAIN SLIDING GAME)

I am Sinethemba Mdleleni (Student number: 22M7469), a part-time student at Rhodes University, South Africa studying for a MEd in Science Education. I am a Physical Science teacher at Qingqolo Senior Secondary School. I would like to carry out a study were the data gathering will commence in August 2024 to November 2025.

I sincerely ask that you allow your child perform a live demonstration of the process of playing *umtyibilizi* (mountain sliding game) for a group of ten Grade 11 Physical Sciences learners who are participating in my project. The data gathering would be one Friday at 14:00 to 15:30 in August or September 2024. I would like to request permission to record their presentation. Your child's name will not be revealed without your consent. I wish to promise that you have a right to access the information that will be gathered during this research study at any time when you want it.

Signature:.....

Your cooperation will be highly appreciated.

Yours Sincerely

Ms Sinethemba Mdleleni

Should you need further information regarding this study, please feel free to contact me at my email mdlelenisinethemba@gmail.com or cell number 0732249064, my supervisor Professor Kenneth Mlungisi Ngcoza at k.ngcoza@ru.ac.za and co-supervisor Professor Zingiswa Jojo zingiswa.jojo@ru.ac.za.

Please fill in the following.

I Mr/Mrs/Ms.....(your name).

AGREE

OR DISAGREE

(Choose by placing an X on the box)

with Sinethemba Mdleleni working with my child in piloting the use of *umtyibilizi* to each Newton's second law in the Grade 11 Physical Sciences' curriculum. 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.

Sign.....

Phone number.....

Translation/ Inguqulelo

ILETA EYA KUMGCINI WOLWAZI LWEMVELI '1'

Imibuzo: Nkosazana Sinethemba Mdleleni

Inombolo: 0732249064

Mzali/ umgcini othandekayo

IMPENDULO: INCWADI YEMVUME: UKUNIKEZELO LWENTO EBONAKALAYO
EKUDLALWENI KOMTYIBILIZI (Mountain Sliding)

NdinguSinethemba Mdleleni (Inombolo yomfundi: 22M7469), umfundi ongesosigxina kwiDyunivesithi yaseRhodes, eMzantsi Afrika ndifundela i-MEd kwiMfundo yeNzululwazi. Ndingutitshala wezifundo zeNzululwazi kwisikolo iQingqolo Senior Secondary School. Bendingwena ukuphanda ngokwezeMfundo apho uphononongo luya kuqalisa kwi nyanga ka-Agasti 2024 ukuya kuNovemba 2025.

Ndicela ngokunyanisekileyo ukuba umntana wakho enze umboniso ophilayo wenkqubo yokudlala umtyibilizi (Mountain Sliding) kwiqela labafundi abalishumi beBanga le-11 bezifundo zeNzululwazi abathatha inxaxheba kwiprojekthi yam. Ndingathanda ukucela imvume yokushicilela intetho yakho. Sizodibana ngolwesiHlanu ngo 14:00 kudekuba ngu 15:30 kwi nyanga ka-Agasti okanye uSeptemba 2024. Igama lomntwana wakho aliyi kuchazwa ngaphandle kwemvume yakho. Ndingwenela ukuthembisa ukuba unelungelo lokufikelela kulwazi oluya kuhlanganiswa ngexesha lolu phando nangaliphi na ixesha xa ulufuna.

Utyikityo:.....

Intsebenziswano yenu iya kuthakazelelwa kakhulu.

Ozithobileyo

Nkosazana Sinethemba Mdleleni

Ukuba ufuna ulwazi oluthe vetshe malunga nolu phononongo, nceda uqhakamshelane nam kule dilesi ye-imeyile: mdlelenisinethemba@gmail.com okanye kwinombolo yeselula ethi 0732249064 okanye umphathi wam uNjingalwazi Kenneth Mlungisi Ngcoza [ku-k.ngcoza@ru.ac.za](mailto:k-ngcoza@ru.ac.za) okanye usekela mpathi uNjingalwazi Zingiswa Jojo ku- zingiswa.jojo@ru.ac.za.

Ndibamba ngazo zozibini

Ndiyakucela kwakhona ukuba uncede uzalise esisiqendu silandelayo.

Mna Nkosikazi/Mnumzana.....(igama lakho).

Ndiyavuma OKANYE Andivumi

(khetha ngokufakela X kwibhokisi)

uSinethemba Mdleleni ukuba asebenze nomntwana wam ekuvavanyeni ukusetyenziswa komtyibilizi kuMthetho weSibini kaNewton ngamnye kwiKharityhulam yeZifunfundo Zobunzululwazi zeBanga le-11. Kuyandivuyisa ukuqinisekiswa ukuba igama lomntwana wam aliyi kutyhilwa ngaphandle kwemvume yam. Kwakhona, ingxelo yophando malunga noku iya kwenziwa ifumaneke nanini na xa ndiyifuna.

Tyikitya.....

Inombolo yomnxeba.....

Rhodes University, Research Office, Ethics

Dr Janet Hayward, Ethics Coordinator: ethics-committee@ru.ac.za

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Room 220, Main Admin Building, Drostdy Road, Makhanda, 6139

Education Department

Rhodes University

P.O. Box 94

Grahamstown

6140

LETTER TO THE PARENT OF THE INDIGENOUS KNOWLEDGE CUSTODIAN 2

Enquiries: Ms Sinethemba Mdleleni

Cell number: 0732249064

Dear Parent/ Guardian

RE: PERMISSION LETTER: PRESENTATION OF PRACTICAL DEMONSTRATION ON PLAYING UMTYIBILIZI (MOUNTAIN SLIDING GAME)

I am Sinethemba Mdleleni (Student number: 22M7469), a part-time student at Rhodes University, South Africa studying for a MEd in Science Education. I am a Physical Science teacher at Qingqolo Senior Secondary School. I would like to carry out a study were the data gathering will commence in August 2024 to November 2025.

I sincerely ask that you allow your child perform a live demonstration of the process of playing *umtyibilizi* (mountain sliding game) for a group of ten Grade 11 Physical Sciences learners who are participating in my project. The data gathering would be one Friday at 14:00 to 15:30 in August or September 2024. I would like to request permission to record their presentation. Your child's name will not be revealed without your consent. I wish to promise that you have a right to access the information that will be gathered during this research study at any time when you want it.

Signature:.....

Your cooperation will be highly appreciated.

Yours Sincerely

Ms Sinethemba Mdleleni

Should you need further information regarding this study, please feel free to contact me at my email mdlelenisinethemba@gmail.com or cell number 0732249064, my supervisor Professor Kenneth Mlungisi Ngcoza at k.ngcoza@ru.ac.za and co-supervisor Professor Zingiswa Jojo zingiswa.jojo@ru.ac.za.

Please fill in the following.

I Mr/Mrs/Ms.....(your name).

AGREE OR DISAGREE

(Choose by placing an X on the box)

with Sinethemba Mdleleni working with my child in piloting the use of *umtyibilizi* to each Newton's second law in the Grade 11 Physical Sciences' curriculum. 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.

Sign.....

Phone number.....

Rhodes University, Research Office, Ethics

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Room 220, Main Admin Building, Drostdy Road, Makhanda, 6139

Translation/ Inguqulelo

ILETA EYA KUMGCINI WOLWAZI LWEMVELI '2'

Imibuzo: Nkosazana Sinethemba Mdleleni

Inombolo: 0732249064

Mzali/ umgcini othandekayo

IMPENDULO: INCWADI YEMVUME: UKUNIKEZELO LWENTO EBONAKALAYO EKUDLALWENI KOMTYIBILIZI (Mountain Sliding)

NdinguSinethemba Mdleleni (Inombolo yomfundi: 22M7469), umfundi ongesosigxina kwiDyunivesithi yaseRhodes, eMzantsi Afrika ndifundela i-MEd kwiMfundo yeNzululwazi. Ndingutitshala wezifundo zeNzululwazi kwisikolo iQingqolo Senior Secondary School. Bendingwena ukuphanda ngokwezeMfundo apho uphononongo luya kuqalisa kwi nyanga ka-Agasti 2024 ukuya kuNovemba 2025.

Ndicela ngokunyanisekileyo ukuba umntana wakho enze umboniso ophilayo wenkqubo yokudlala umtyibilizi (Mountain Sliding) kwiqela labafundi abalishumi beBanga le-11 bezifundo zeNzululwazi abathatha inxaxheba kwiprojekthi yam. Ndingathanda ukucela imvume yokushicilela intetho yakho. Sizodibana ngolwesiHlanu ngo 14:00 kudekuba ngu 15:30 kwi nyanga ka-Agasti okanye uSeptemba 2024. Igama lomntwana wakho aliyi kuchazwa ngaphandle kwemvume yakho. Ndingwenela ukuthembisa ukuba unelungelo lokufikelela kulwazi oluya kuhlnganiswa ngexesha lolu phando nangaliphi na ixesha xa ulufuna.

Utyikityo:.....

Intsebenziswano yenu iya kuthakazelelwa kakhulu.

Ozithobileyo

Nkosazana Sinethemba Mdleleni

Ukuba ufuna ulwazi oluthe vetshe malunga nolu phononongo, nceda uqhakamshelane nam kule dilesi ye-imeyile: mdlelenisinethemba@gmail.com okanye kwinombolo yeselula ethi 0732249064 okanye umphathi wam uNjingalwazi Kenneth Mlungisi Ngcoza ku-k.ngcoza@ru.ac.za okanye usekela mpathi uNjingalwazi Zingiswa Jojo ku- zingiswa.jojo@ru.ac.za.

Ndibamba ngazo zozibini

Ndiyakucela kwakhona ukuba uncede uzalise esisiqendu silandelayo.

Mna Nkosikazi/Mnumzana.....(igama lakho).

Ndiyavuma OKANYE Andivumi

(khetha ngokufakela X kwibhokisi)

uSinethemba Mdleleni ukuba asebenze nomntwana wam ekuvavanyeni ukusetyenziswa komtyibilizi kuMthetho weSibini kaNewton ngamnye kwiKharityhulam yeZifunfundo Zobunzululwazi zeBanga le-11. Kuyandivuyisa ukuqinisekiswa ukuba igama lomntwana wam aliyi kutyhilwa ngaphandle kwemvume yam. Kwakhona, ingxelo yophando malunga noku iya kwenziwa ifumaneke nanini na xa ndiyifuna.

Tyikitya.....

Inombolo yomnxeba.....

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APPENDIX A4: ASSENT LETTERS

CHILD PARTICIPANT'S ASSENT FORM

INFORMED ASSENT DECLARATION

(Grade 11 participants)



PROJECT TITLE: CULTURAL CONNECTIONS: TEACHING NEWTON'S SECOND LAW THROUGH MOUNTAIN SLIDING

Duration: August 2024 - November 2025

Purpose of the study: This study seeks to investigate how the use of the Indigenous Mountain sliding game can support the Grade 11 learners to talk and make sense of the topic of Newton's second law of motion.

Your Physical Sciences teacher needs your help. A Physical Sciences project on the topic of Newton's second law has been developed and we would like to pilot it in your school. I invite you to participate in this project on the months of August 2024 to November 2025 and tell us whether it works or not. Data gathering would be every Friday at 14:00 to 15:30 in August or September 2024. Teachers (researcher and the critical friend) will take notes, pictures of the projects as evidence of work without showing learners' images and videos with blurred faces.

If you would like to participate, you will be involved in four-afternoon sessions of about an hour each spread over a month.

Researcher's name: Ms Sinethemba Mdleleni

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 other people?

YES

NO

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

YES

NO

6. Has the researcher answered all your questions?

YES

NO

7. 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

YES

NO

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

YES

NO

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

YES

NO

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

...

N

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

YES

NO

Signature of Grade 11 learner Date

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CHILD PARTICIPANT'S ASSENT FORM

INFORMED ASSENT DECLARATION

(INKXAXHEBA YOMNTWANA WEBANGA LESHUMI ELINANYE)



Isihloko seProjekthi: uQhakamshelwano lweNkcubeko: Ukufundisa uMthetho kaNewton nge-Mountain Sliding (Utyibiliko entabeni)

Ubude bexesha: Agasti 2024 - Novemba 2025

Injongo yolu phando: Olu phononongo lujonge ukuphanda ukuba ukusetyenziswa komdlalo wokutyibilika weNtaba yeMveli kunokuxhasa njani abafundi beBanga le-11 ukuba babe nentsingiselo yesihloko somthetho wesibini kaNewton wokushukuma. (Law of Motion)

Utitshala wakho wezifundo zobunzululwazi (Physical Science) ufuna uncedo lwakho. Iprojekthi yesifundo ngobunzululwazi (Physical Sciences) ngesihloko somthetho wesibini kaNewton iphuhlisiwe kwaye ndingathanda ukuyivavanya esikolweni sakho. Ndiyakumema ukuba uthathe inxaxheba kule projekthi kwinyanga ka-Agasti 2024 ukuya kuNovemba 2025 kwaye usixelele ukuba iyasebenza okanye ayisebenzi. Sizodibana ngolweziHlanu ngo 14:00 kudekuba ngu 15:30 kwi nyanga ka-Agasti okanye uSeptemba 2024. Ootitshala (umphandi kunye nomhlobo ogxekayo) baya kuthatha amanqaku, imifanekiso yeeprojekthi njengobungqina bomsebenzi ngaphandle kokubonisa imifanekiso yabafundi kunye yemiboniso bhanya bhanya ezinobuso obumfiliba.

Ukuba ungathanda ukuthatha inxaxheba, uya kubandakanyeka kwiiseshoni zasemva kwemini ezine malunga neyure nganye kwinyanga enye.

Igama lomphandi : Ms Sinethemba Mdleleni

Igama

lomthathi-

nxaxheba:.....

1. Ingaba umphandi ukucacisele yonke into azokuyenza kwakunye nafuna wena uyenze?

EWE

HAYI

2. Ingaba umphandi ukucacisele na ukuba kutheni efuna wena uthathe inxaxheba?

EWE

HAYI

3. Uyayazi ukuba igama lakho nezinto ozozitsho koluphando azizokuboniswa abanye abantu?

EWE

HAYI

4. Umbuzile umphandi imibuzo nayiphi ngoluphando?

EWE

HAYI

5. Ingaba umphandi uyiphendule yonke imibuzo yakho?

EWE

HAYI

6. Uyaqonda ukuba ungangavumi ukuthabatha inxaxheba koluphando ukuba uyafuna, kwaye akukho nto izakwehlela ukuba akuvumanga, akukho nanto iyakuchaphazela izifundo zakho?

EWE

HAYI

7. Uyaqonda ukuba ungayeka ukuthabatha inxaxheba koluphando nanini na xa uziva ungafuni ukuqhubeka?

EWE

HAYI

8. Uyazazi ukuba ungathetha nabani xa uziva ukhathazekile okanye unemibuzo ngoluphando?

EWE

HAYI

9. Ukhona umntu okunyanzelisa ngokuthabatha inxaxheba koluphando?

EWE

HAYI

10. Ingaba unolwazi lokuba umzali wakho, nenqununu kunye notitshala wakho banolwazi ngoluphando kwaye bavumile ukuba ungayinxalenye yalo?

YAYI

11. Uyavuma ukuthabatha inxaxheba koluphando?

EWE

HAYI

Utyikityo lomfundi

Umhla

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Dr Janet Hayward, Ethics Coordinator: ethics-committee@ru.ac.za

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Room 220, Main Admin Building, Drostdy Road, Makhanda, 6139

CHILD PARTICIPANT'S ASSENT FORM

INFORMED ASSENT DECLARATION

(Indigenous Knowledge Custodians – Primary School Learners)



PROJECT TITLE: CULTURAL CONNECTIONS: TEACHING NEWTON'S SECOND LAW THROUGH MOUNTAIN SLIDING

Duration: August 2024 - November 2025

Purpose of the study: This study seeks to investigate how the use of the Indigenous Mountain sliding game can support the Grade 11 learners to talk and make sense of the topic of Newton's second law of motion.

A Physical Sciences project on the topic of Newton's second law has been developed and we would like to pilot it at the Secondary School. I invite you to participate in this project on the months of August 2024 to November 2025, showing us and also explaining how the mountain sliding game is played. Data gathering would be every Friday at 14:00 to 15:30 in August or September 2024. Teachers (researcher and the critical friend) will take notes, pictures of the projects as evidence of work without showing learners' images and videos with blurred faces.

If you would like to participate, you will be involved in an afternoon session for about an hour.

Researcher's name: Ms Sinethemba Mdleleni

Name of participant: _

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

YES

NO

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

YES

NO

7. Do you know that your name and what you say will be kept a secret from other people?

YES

NO

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

YES

NO

12. Has the researcher answered all your questions?

YES

NO

13. 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

YES NO

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

 YES NO

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

 YES NO

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

 N

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

 YES NO

Signature of the Primary learner Date

Rhodes University, Research Office, Ethics

Dr Janet Hayward, Ethics Coordinator: ethics-committee@ru.ac.za

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Room 220, Main Admin Building, Drostdy Road, Makhanda, 6139

CHILD PARTICIPANT'S ASSENT FORM

INFORMED ASSENT DECLARATION

(ILETA EYA KUMGCINI WOLWAZI LWEMVELI – ABAFUNDI AMABANGA APHANTSI)



Isihloko seProjekthi: uQhakamshelwano lweNkcubeko: Ukufundisa uMthetho kaNewton nge-Mountain Sliding (Utyibiliko entabeni).

Ubude bexesha: Agasti 2024 - Novemba 2025

Injongo yolu phononongo: Olu phononongo lujonge ukuphanda ukuba ukusetyenziswa komdlalo wokutyibilika weNtaba yeMveli unokuxhasa njani abafundi beBanga le-11 ukuba babe nentsingiselo yesihloko somthetho wesibini kaNewton wokushukuma (law of Motion)

Iprojekthi yeSifundo Ngobunzululwazi (Physical Sciences) ngesihloko somthetho wesibini kaNewton iphuhlisiwe kwaye ingathanda ukuyivavanya kwiSikolo samabanga aphakathi. Ndiyakumema ukuba uthathe inxaxheba kule projekthi kwinyanga ka-Agasti 2024 ukuya kuNovemba 2025, usibonisa kwaye ucacisa nokuba udlalwa njani umdlalo wokutyibilika entabeni. Sizodibana ngolweziHlanu ngo 14:00 kudekube ngu 15:30 kwi nyanga ka-Agasti okanye uSeptemba 2024. Ootitshala (umphandi kunye nomhlobo ogxekayo) baya kuthatha amanqaku, imifanekiso yeeprojekthi njengobungqina bomsebenzi ngaphandle kokubonisa imifanekiso yabafundi kunye nemiboniso bhanya bhanya ezinobuso obumfiliba.

Ukuba ungathanda ukuba nenxaxheba, uya kuba nenxaxheba kucwangciso lwasemva kwemini olumalunga neyure.

Ukuba ungathanda ukuba nenxaxheba, uya kuba nenxaxheba kucwangciso lwasemva kwemini olumalunga neyure.

Igama lomphandi: Ms Sinethemba Mdleleni

Igama

lomthathi-nxaxheba:

.....

12. Ingaba umphandi ukucacisele yonke into azokuyenza kwakunye nafuna wena uyenze?

EWE

HAYI

13. Ingaba umphandi ukucacisele na ukuba kutheni efuna wena uthathe inxaxheba?

EWE

HAYI

14. Uyayazi ukuba igama lakho nezinto ozozitsho koluphando azizokuboniswa abanye abantu?

EWE

HAYI

15. Umbuzile umphandi imibuzo nayiphi ngoluphando?

EWE

HAYI

16. Ingaba umphandi uyiphendule yonke imibuzo yakho?

EWE

HAYI

17. Uyaqonda ukuba ungangavumi ukuthabatha inxaxheba koluphando ukuba uyafuna, kwaye akukho nto izakwehlela ukuba akuvumanga, akukho nanto iyakuchaphazela izifundo zakho?

EWE

HAYI

18. Uyaqonda ukuba ungayeka ukuthabatha inxaxheba koluphando nanini na xa uziva ungafuni ukuqhubeka?

EWE

HAYI

19. Uyazazi ukuba ungathetha nabani xa uziva ukhathazekile okanye unemibuzo ngoluphando?

EWE

HAYI

20. Ukhona umntu okunyanzelisa ngokuthabatha inxaxheba koluphando?

EWE

HAYI

21. Ingaba unolwazi lokuba umzali wakho, nenqununu kunye notitshala wakho banolwazi ngoluphando kwaye bavumile ukuba ungayinxalenye yalo?

YAYI

22. Uyavuma ukuthabatha inxaxheba koluphando?

EWE

HAYI

Utyikityo lomfundi

Umhla

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Dr Janet Hayward, Ethics Coordinator: ethics-committee@ru.ac.za

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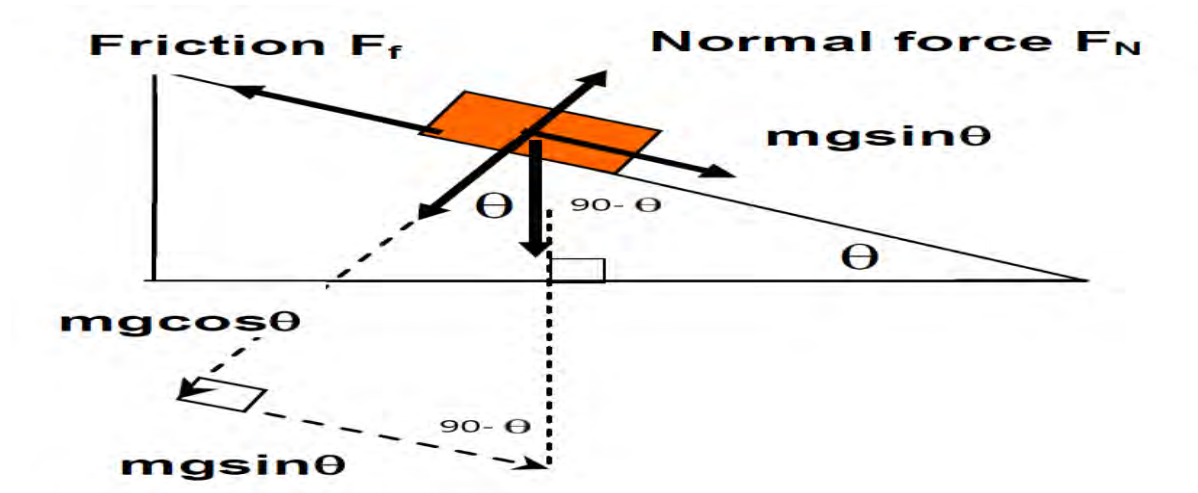
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APPENDIX B: FIGURES USED

Figure 1 – skier sliding down the slope (adapted from google: <https://images.app.goo.gl/wJhjwaCuHKYhEBXk6>), Figure 2 – a learner playing *umtybilizi* (mountain sliding game).



Figure 3 – resolved forces on an inclined plane (adapted from google: <https://images.app.goo.gl/GnQBaNc6RYJKPYuu5>)



APPENDIX C1: DATA-GATHERING METHODS

TABLE: Shows the tools, methods and the purpose for the gathering of information

Stage	Method to be used to gather data	Purpose	Research questions
Stage 1	Focus Group Interview (sharing circles)	To find out learners limitations and restrictions in learning science	1a
Stage 2	Group Activity	To find out learners' knowledge on cultural beliefs and practices about forces and Newton's laws	1b
Stage 3	Participatory and observation	How learners interact, and learn during the presentation by expert community members and using the module	2, 3 & 4
Stage 4	Journal reflection	To find out the influence of two community members on learners' constraints and motivation	1, 3 & 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 Newton's second law?
5. What are the key components of Newton's second law?
6. How do you learn Newton's second law at school?
7. What difficulties do you experience when learning Newton's second law?
8. Are there any specific aspects of Newton's second law 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 ACTIVITY QUESTIONS

Group Activity Questions

1. How do you see and experience Newton's second law in action in your daily activities?
2. Can you give an example of a situation in your community where Newton's second law is evident?
3. Are there any traditional practices or activities in your community that illustrate the principles of Newton's second law?
4. What is your experience of the game called *umtyibilizi*?
5. Have you ever played *umtyibilizi*?
6. Can you explain how *umtyibilizi* is played?
7. How can we explain what happens when we play *umtyibilizi* using Newton's second law (what forces are evident)?
8. How can *umtyibilizi* be used demonstrate the understanding of acceleration, mass and forces as described by Newton's second law?

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	
Learners sense making shifts or (not) as a result of the practical demonstration	
Others things:	

Attitudes	Remarks
Learners' view on IK	
Learners' interest in IK	
Learners' 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	
Others things:	

APPENDIX C5: JOURNAL REFLECTIONS

Journal Reflections

Instruction: Answer All the Following Questions

1. What have you learned from the exemplar lesson that integrates *umtyibilizi*?

.....

.....

.....

.....

.....

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

.....

.....

.....

.....

3. What have you enjoyed in this lessons?

.....

.....

.....

.....

4. What have you not enjoyed in this lesson?

.....

.....

.....

5. How can the lesson be improved?

.....

.....

.....

.....

APPENDIX D – COLOUR-CODED RESPONSES

APPENDIX D1

Group Activity

Key: **Mediation of learning**

Culture and Language

Social Interaction

Zone of Proximal Development

More Knowledgeable Other

1. How do you see and experience Newton's second law in action in your daily activities?

G1: "We see and experience Newton's second law when pushing a wheelbarrow – The force you apply the handle of the wheelbarrow (F) propels it forward.

The mass of the wheelbarrow and its contents (m) determines how much force is required to achieve a certain acceleration (a).

As you push, the force you apply overcomes the resistance from friction and the weight of the load, causing the wheelbarrow to accelerate".

G2: "We always see the application of Newton's 2nd law of motion in daily life when we try to move an object, like stopping a moving ball rolling on the ground, reducing the weight of the racing cars".

2. Can you give an example of a situation in your community where Newton's second law is evident?

G1: "When lifting a coffin, Newton's second law is needed at work – The force applied by the pallbearers lifting the coffin. The mass of the coffin and its contents. The acceleration of the coffin as it's lifted".

G2: "One's body movement to the side when a car makes a sharp turn, when pushing a car".

3. Are there any traditional practices or activities in your community that illustrate the principles of Newton's second law?

G1: "Yes

Traditional dancing – In some cultures, dances like the Maori Haka or the Scottish Highland fling involve rapid movements and spinning.

The force applied by the dancers (F) accelerates their bodies (m) in various directions, illustrating Newton's second law.

Rowing a boat – In many coastal communities, rowing a boat is a traditional activity that demonstrates Newton's second law.

The force applied to the oars (F) propels the boat and its occupants (M) determines the acceleration".

G2: "Yes, carrying a coffin, throwing spears".

4. What is your experience of the game called *umtyibilizi*?

G1: "We had an absolute blast playing *umtyibilizi*, we a rush of excitement and thrill, the wind and sun on our faces. Navigating obstacles and reaching the finish line would give us a sense of accomplishment and pride, making us laugh and scream with joy. It was a wild adventure that would left [leave] us feeling alive, carefree and grinning from ear to ear".

G2: Thrill of weightlessness and gravity as you slide and fall

5. Have you ever played *umtyibilizi*?

G1: "Yes".

G2: "Yes".

6. Can you explain how *umtyibilizi* is played?

G1: "Push off with your feet to gain speed. Start sliding slowly, trying to control your speed. Aim for narrow path between two trees. Try to jump over a nearby rock".

G2: "Uya entabeni uphetha iphelu (itanki elisikiweyo, iphahla lemoto, fisherboard e.t.c.). Uchopha kulo uaplye iforce by pushing the object le uhleli kuyo". ("You go to the mountain carry a board (a piece of a tank, the roof of a car, fisherboard e.t.c). You then seat on it then apply a force by pushing the object you are seated on".

7. How can we explain what happens when we play *umtyibilizi* using Newton's second law (what forces are evident)?

G1: "Gravity (Fg) - The force of gravity pulls you down the hill, accelerating you downward. The force is evident throughout the slide.

Normal Force (FN) - The hill's surface exerts a normal force on you, perpendicular to the surface. This force opposes your weight and keeps you on the hill

Frictional Force (Ff)-As you slide friction between your cardboard\trash bag and the hill slows down. The force of friction opposes motion”.

G2: “When playing the sliding game Newton’s 2nd law comes into action. Here is a breakdown of forces involved: Initial force (Pushing off by feet or hands. This force accelerates their body down).Frictional force (Frictional between their body and the surface slows down the player down. The Ff opposes player’s motion converting it to heat). Gravity’s effect is mostly parallel to the surface, it still contributes to their acceleration down the slide. Air resistance opposes the player’s motion, slowing them down as they slide”.

8. How can *umtybilizi* be used demonstrate the understanding of acceleration, mass and forces as described by Newton’s second law?

G1: “Acceleration-Measure the distance travelled and time taken to reach the finish line
Mass – Have players of different masses (e.g. adults and children) participate”

G2: “When these forces interact, Newton’s 2nd law applies. The net force acting on the player is the sum of initial force, FN, Ff, Fg and resistance. The player’s mass remains constant. The resulting acceleration is the change in their velocity as they slide”.

APPENDIX D2: IKCs' PRESENTATION

IKCs Presentation

Key: Mediation of learning

Culture and Language

Social Interaction

Zone of Proximal Development

More Knowledgeable Other

SCENE1: explaining umtyibilizi

Grade 11: Bhokela yizoma apha phambi kwam, thetha ke ntwana uba umtyibilizi udlalwa kanjani.

IKC1: Udlalwa kakuhle (laughter)

Grade 11: Uthini? :

Researcher: uthi udlalwa kakuhle.

IKC1: Udlalwa kanje (ebonisa abanye abantwana) funeke uwumise endaweni ehlayo

Researcher: Uhm

IKC1: Rhubuluze endaweni ehlayo

Researcher: Funeke ibeyindawo ehlayo ne?

IKC1 and IKC2: Ewe

Researcher: So ndingakwazi urhubuluza apha?

IKC1: Ha-a

Researcher: So kutheni usebenzisa ibhotile ungarhubuluzi ngempahla?

IKC2 and Grade 11 mumurs: Zokrazuka

Researcher: Zokrazuka?

IKC1: Ewe.

Researcher: Ohh... yintoni enye enidlala ngayo umtyibilizi? Like into ekanje?

IKC1: ikhona enyii...2 litre, 1 litre

Researcher: What if ayombombozi like yintoni enye

Grade 11: Lizinki

IKC1: Amazinki

IKC2: Yilanto ilikhalbhodi

Researcher: Yintoni lonto

IKC2: Nantsi nantsi (ekhomba kwiFascia-board)

Grade11: ifascia-board?

Researcher: Ohh...nomkhoba neh? Umkhoba yimbombozi neh?

Grade 11: Ewe.

Researcher: Ohh

Researcher: Aba badlala ngee nto... abayoyiki? Aba badlala nge zinki?

IKC1: Hayi!

Researcher: Hayi fondini izinki lokukukrazula

IKC1: Yhooo hayi

Researcher: Anoyiki

IKC2: Hayi.

SCENE 2 – playing of umtyibilizi

A Grade 11 child went down the slide (umtyibilizi)

(All laugh)

Grade 11: **Ye ta phinda kaloku sibone**

Grade 11 (L5): **Umqengqelezi kakhulu?**

Grade 11: Ewe uyazihlela.

Grade 11: Ndincedwe nguwe

Grade 11 (L7): **Cela ubhekele taAndi...ohh uyaphusha**

(Laughter and cheering)

Grade 11: Yiya maO

Grade 11: Hay hay yhoo (laughing softly)

Grade 11: Cela uDEE mgoku

Grade 11: Makuye uJako imfanele lento

Grade 11: Nedesika iyenza

Researcher: Nolimala kengoku.

Grade 11: Ha-a izovele iyoma iyowa phaya

Grade 11(L3): Ha-a izoyomlimaza, izonilimaza lento

Researcher: Nibe careful ke

Grade 11: Ndihekhe?Uhamba wedwa?

Grade 11: Aybo Asanele

Grade 11: Makukhwele wena,wena uzokwazi ukuyiqhuba

Grade 11: Awudlalwa kanjalo umtyibilizi nazi iimbombozi

Researcher: Ja...ja bayibeyinto eflat guys, yabona itafile...ha-a

Grade 11: Iyatyibilika

Grade 11: Nantso ke

Grade 11: Worse ba ibiplanga yabo if ibiplanga

Grade 11: Bendiya uba ibiyawugqoxinga

Grade 11 girl trying umtyibilizi

Grade 11: Uyakukrazuka utight ngoku ntwana

(Laughter and cheering)

Grade11: Kutheni wajika wajonga ezantsi?

Researcher: So niyatyibiliza ngezihlangu

Grade 11: Mem ucinga ukuya ngoku?

Grade 11: Hayi mem!!!

Research: Yhoo hay!!!

Grade 11: Ohhh (Laughing softly)

Grade 11: Khome ndizame ngezihlangu

Grade 11 learner trying umtyibilizi with shoes

Grade 11: Ha-a sumphusha uzozixhasela

(Laughter)

Grade 11: Makungene abantwana abancinci guys

Grade 11 (L6): Ewe banikeni amakhalboardi

Grade 11: Thatha boy

Grade 11: Onika ungaveli ngapha nje boy

Grade 11: Khohle sani ndizotyibilika mna ndoyika nokoyika

Grade 11: Huh?

Grade 11: Khanibhekele Anu ndimbone

Grade 11: Anu bhekela

(Cheering)

Researcher: Yeah but kubo ingathi its less riskier andiyazi uba yenzwa yintoni mhlambi yilento babene-mass encinci

(Cheering)

Researcher: Yeah kwaba bantwana bancinci iya-enjoy-eka kodwa kuni yey vele ibengathi umntu uzowa pha phantsi

Grade 11(L3): Ewe iya-enjoy-eka, iright

(Laughter)

Researcher: Yeah let's try nina nobabini

Grade 11: Ndiyakutshalenja

IKC1 and Grade 11 go together to slide

Grade 11: Hayi Anu umqhathile

Researcher: Unamagqinga (Laughing)

Researcher: Yima another thing endicurious ngayo neh andiniboni ekqaleni because engqondweni yam befanba ndizonibona xa nipha ekuqaleni kwaba sebenzile... so umntu uvele ayeke azehlele?

Grade 11(L4): Ha-a

Grade 11(L7): Uqale uyireve

Researcher: Laughing

Grade 11(L1): Yiza yiza Ntombi

Grade 11(L10): Mabangene bobayiTwo

Grade 11: Makahambe noBOY

Grade 11: Umshiye mntase

Grade 11(L9): Boy sithembe wena

Grade 11(L10): Bayenza kamnandi...

(Laughter)

Researcher: Ufuna utrya uSomeleze?

Grade 11: Hayi akaboni

Researcher: Ohh ilanga neh

Grade 11: Tshona tshona sufika pha ezantsi ujikeleze

Researcher:Kodwa kutheni yena esenza ngenyawo yambona yena wenza ngenyawo

Grade 11(L2): YeNomongxoza noNtombi khanize nizotyibiliza

(Cheering)

Grade 11(L1): Abayenzi kakuhle guys

APPENDIX D1: LESSON PLAN AND OBSERVATION SCHEDULE

LESSON PLAN AND OBSERVATION SCHEDULE

Lesson Plan: Introduction to Newton's second law using *umtyibilizi*

Objective: Learners will understand the relationship between force, mass and acceleration.

Materials: A slope (made from books), various objects (e.g. bottles, fascia board or cardboard), a timer, a spring scale and a measuring tape.

1. Engage (15 minutes):

Discuss *umtyibilizi* and ask learners about their experiences.

Ask guiding questions:

“What factors influence how fast you slide?”

“Why do heavier individuals sometimes slide faster?”

2. Explore (25 minutes):

Divide learners into groups.

Have them slide objects of different masses down a slope and time their descent.

Record observations on the relationship between mass and acceleration.

3. Explain (20 minutes):

Introduce Newton's second law and connect it to their observations.

Discuss how gravity (force) and mass affect acceleration during sliding.

4. Elaborate (10 minutes):

Challenge learners to explain how friction influences their results.

Discuss strategies to minimise friction in *umtyibilizi*.

5. Evaluate (10 minutes):

Learners reflect on the lesson.

Observation Schedule (Adapted from Nikodemus, 2017)

Name of the school: Intaba Highschool (pseudonym)

Observation Date:

Grade 11

Subject: Physical Sciences

Number of participants: 10

Lesson Topic: Introduction to Newton's second law using *umtyibilizi*

Observer: MaNduli

Social interactions	Remarks
The participation of learners during the lesson	The children where socialising, talking, finding the solutions together and working as a team
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 also 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 other children's views
How learners are motivated in the lesson	
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

<p>The use of English and how it impacts participation</p>	<p>The learner did not quite use English as their strong and more used language and because of that all of the learners participated</p>
<p>The use of mother tongue and how it impacts on participation</p>	<p>I strongly believe that the learners used their mother tongue and that led to all of the learners to participate</p>
<p>How learners' everyday experiences and ways of talking and knowing are expressed during the lesson</p>	<p>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</p>
<p>Other things:</p>	<p>The learners learnt many ways to express their answers and not keep them to themselves</p>
<p>Learner talk</p>	<p>Remarks</p>
<p>The involvement of learners in active learning</p>	<p>All learners were active even those who are known to be quiet had something to say</p>

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 clear scientific explanations
Learners sense making shifts or (not) as a result of the practical demonstration	The way the learners were shifting it demonstrated how umtyibilizi is supposed to be played
Others things:	
Attitudes	Remarks
Learners' view on IK	

Learners' interest in IK	The learners showed very much interest on the IK, they were having fun
Learners' 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 showed interest at all times before and after the IK was illustrated and demonstrated to them how <i>umtyibilizi</i> is supposed to be done
Others things:	The learners were kind and friendly to the IKC and to one another loved and respected their chance of showing their talent