Exploring the possibility of integrating traditional music and dance into the design and delivery of lessons on the concepts of echo and waves in the grade 10 Physical Science sound topic

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By

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DECLARATION

I declare that the work contained in this thesis is my original work. It has not been previously submitted in any form for assessment or degree in any other higher education institution. All ideas, quotations and other materials used in this study that were derived from the work of other people have been indicated in the list of references.

Signature: Date: 05/04/2017

DEDICATION

I dedicate this work to the Almighty God, the creator of heaven and earth, my late father, Liveve Hamutenya Chilunda (1939- 1980) and my twin brother Anton Muntomba Liveve (1977-1980). Dad and my brother, I know you would have been proud to read this thesis and would have enjoyed the seed you had planted.

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ABSTRACT

Before Namibian independence in 1990, teaching was mostly characterized by teacher-centred pedagogies in which teachers were perceived as the main sources of knowledge. This resulted in learners being passive recipients of such unquestioned knowledge. After independence and to address this, a new educational system was introduced which promoted learner-centred education (LCE) pedagogy.

Despite these grand ideals, educational changes in sub-Saharan Africa form a complex issue involving tensions between policy formulation and implementation. This presents Namibian teachers with some challenges in enacting LCE pedagogies. One of these challenges is to find ways to motivate learners and to assist their learning by finding relevant and interesting connections between subject topics and their own experiences and everyday culture outside the classroom. An inability to enact the new curriculum results in learners performing poorly in subjects such as Physical Science. Against this backdrop, this study sought to explore whether or not the integration of traditional music and dance into the design and delivery of lessons on the concepts of echo and waves could influence grade 10 Physical Science learners' sense making and dispositions towards science.

This study was underpinned by an interpretive paradigm. It was informed and guided by the socio-cultural theory as my theoretical framework. The study was carried out with a grade 10 Physical Science class consisting of 30 learners at Lyambombla Combined School (pseudonym) in the Kavango West Region in the northern part of Namibia. Data were generated through diagnostic and summative tests, interviews and lesson observations incorporating traditional music and dance.

The findings of the study showed that learners' sense making and dispositions toward science were positively influenced through traditional music and dance. The study thus recommends the incorporation of indigenous ways of knowing in order to enhance meaning making in science classrooms.

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LIST OF ABBREVIATIONS AND/OR ACRONYMS

C2010 - National Curriculum for Basic Education

CRO- Cathode Ray Oscilloscope

IK- Indigenous Knowledge

LCE- Learner Centered Education

LCP- Learner Centered Pedagogy

LoLT- Language of Learning and Teaching

MCQ- Multiple Choice Questions

M Ed- Master of Education

PEEOE – Predict, Explain, Explore, Observe, Explain

PK- Prior Knowledge

PEK- Prior Everyday Knowledge

SCLT- Socio Cultural Learning Theory

SQ- Structured Question

TLSP- Traditional Life Skills Project

USA- United States of America

ZPD- Zone of Proximal Development

CHAPTER 1: SITUATING THE STUDY

1.1 Introduction

This chapter introduces my study which was an exploration of the possibility of integrating traditional music and dance into the design and delivery of lessons of grade 10 Physical Science. More specifically, the study referred to lessons on the concepts of echo and waves under the topic of *sound*. Furthermore, the study was meant to bring a fresh perspective on how traditional music and dance might influence learners' sense making and dispositions towards science.

This chapter presents the background of the study followed by the statement of the problem, the significance of the study, the theoretical framework underpinning the study with the research goal and questions, data gathering techniques used, as well as the definition of key concepts used in the thesis in addition to the thesis outline. Finally, I present a concise summary of the chapter.

1.2 Background of Study

Before its independence in 1990, teaching in Namibia was characterized by teacher-centered approaches in which teachers were perceived as the only sources of knowledge, resulting in learners being passive recipients of that knowledge (Van Graan & Leu, 2006). For example, learners had to commit to memorizing scientific facts in preparation for examinations. According to Nyambe (2008), learners were expected to give word-for-word answers from the textbook. The deficiency of this system was compounded by the irrelevancy of what teachers taught in most science classrooms to the learners' everyday lives. As an attempt to address this challenge, a new curriculum was introduced after independence.

The new educational system, as described by "*Towards Education for All*", builds on learner-centered education (LCE). LCE is aimed at harnessing curiosity and excitement, and promoting democracy and responsibility in learning science concepts. Pomuti, LeCzel, Liman, Swarts and Van Graan (2003) contend that the concept of learner-centeredness further relates to attaining the educational goals of *access*, *equity*, *quality* and *democracy*. It could also be argued that LCE tries to employ a holistic view of learning, valuing life experiences and assisting learners to integrate school life with life outside school. In Namibia and the neighboring South Africa it has been relatively easy in the context of learner-centred education to identify what needs to be changed and to mandate those changes from top down. LCE was considered fundamental for the knowledge-based societies and its attendant economic benefits (Chisholm & Leyendecker, 2008). However, the scope of change in the Namibian education system is frequently underestimated (ibid).

In my experience of teaching Physical Science, I have witnessed nervousness and lack of confidence that some learners experience when faced with the prospect of having science as one of their subjects. Conversations with Science teachers have suggested that this apprehension is linked to the experience that learners do not get any satisfaction from doing Physical Science and also do not see how it relates to their lives (Hodson & Hodson, 1998). Indeed, the content of Physical Science is unconnected with students' everyday experiences, and as a result it appears irrelevant.

To address this problem, engaging learners in all learning and teaching of echo and waves on the topic of *sound* through traditional music and dance may stimulate and encourage a learner-centred pedagogy through a constructivist perspective whereby learners are required to take responsibility for their learning. Nyambe (2008) argues that the constructivist perspective views knowledge as being constructed in the mind of the learner rather than being innately or passively absorbed. Science is also viewed as a human activity (Lemke, 2001); hence science teachers are encouraged to make science relevant to learners' everyday lives, where possible.

In 2010, the Ministry of Education (MoE) in Namibia introduced the National Curriculum for Basic Education known as Curriculum 2010 (C2010). One of the main goals of this curriculum is to develop a knowledge-based society. The concept of knowledge thus embraces everyday life and/or prior knowledge. In this new curriculum, learners are required to explore their social and physical environment and learn through communication with others, for instance, through playing, experimenting with things, and reflecting on them. However, the ability to create new knowledge and acquire new skills does not happen in isolation (C2010). It seemed to me that traditional music and dance, which was the focus of this study, is an integral tool that might enable learners to do border crossing (Aikenhead & Jegede, 1999) from their everyday experiences to scientific ideas and concepts of wave and echo in the topic of *sound*.

According to Millar (2009), it is important to make these connections in science classrooms in order to enhance learning. Most education practitioners would agree that activities can engage learners and help them to develop important skills; they help learners to understand the process of scientific investigation and develop their understanding of concepts.

In this study, it was hoped that an activity whereby learners were taken to the community hall to do their traditional music and dance would help them understand scientific concepts on waves and echo. Furthermore, a number of researchers argue that educators should develop an understanding of the role of learners' prior knowledge in teaching and learning science (Roschelle & Teasley 1995; Gao & Lehman, 2003). For Otero and Nathan (2008), contextualizing the teaching of science involves the use of learners' everyday experiences as a mechanism for conceptual attainment. They further argue that eliciting and building on learners' everyday knowledge plays an essential role in enhancing meaningful learning.

My purpose with this study was, therefore, to help bring the cultural practice of traditional music and dance into the classroom. The study also involved socio-cultural theory, which provided my theoretical framework, with its key proposal that we learn emotionally and conceptually by interacting with the spatial environment (Vygotsky, 1978). This theory was relevant to the study because dance involves socialization and is capable of generating insight into how the interaction between person and environment takes place.

1.3 Statement of the Problem

The National Curriculum for Basic Education 2010 encourages teachers to make use of everyday knowledge, which could be in the form of scientific knowledge or indigenous knowledge. Yet, science teachers are still grappling to incorporate indigenous knowledge into their science classrooms. Examiners' reports for 2012 and 2014 revealed that learners' explanation about the uses of echo, which is an everyday experience, were not clear. For instance, learners failed to explain in the examination that the bat's prey is what reflects back the *sound*, not the bat.

So, the challenge is to find effective ways to teach the characteristics of *sound*. It is against this backdrop that this study sought to explore whether or not the integration of traditional music and dance into the design and delivery of lessons on the concepts of echo and waves influence grade 10 Physical Science learners' sense making and dispositions towards science.

1.4 Significance of the Study

The significance of this study lies in the use of traditional music and dance in enhancing development of scientific concepts, namely, echo and waves on the topic of *sound*. This was intended to enable learners to understand that scientific knowledge is part of their everyday lives. A study by Mansilla (2007) in Kampala on interdisciplinary teaching of Sound of Music, enabled learners to learn about *sound* waves in Physics and about musical instruments and composition in Music. However, the study did not facilitate learners to identify the characteristics of *sound* or to define the phenomenon itself.

Therefore, the role of my study was to surface the essential issue of whether it is possible to integrate traditional music and dance into learning echo and waves and so influence the learners' sense making and dispositions towards science.

1.5 Theoretical Framework

This study was guided by the socio-cultural theory which is based on the work of Vygotsky (1978), emphasizing the important role of culture and context in constructing knowledge and enhancing meaningful learning. According to this theory, individuals construct cognitive schemes through interactions and communication with each other. That is, meaningful learning occurs by engaging in social activities (Lemke, 2001). Potentially, traditional music and dance may be a platform for enhancing meaningful learning since participants from diverse cultural backgrounds can work collaboratively in many activities such as: sharing knowledge when working in small groups, while performing traditional music and dance.

From the perspective of socio-cultural theory, interactive classrooms, argumentations and conversations may help teachers and learners clear their doubts, improve current knowledge, acquire new attitudes and reasoning skills, gain new insights, make informed decisions and even change their perceptions (Stears, Malcolm & Kowlas, 2003). That is, when learners are provided with an appropriate learning environment and the classroom becomes a social unit, then a teacher and/or experienced peer is able to provide the learner with constant support in order for the learner to develop complex skills and attitudes. Instructions may be part of the lessons with no hindrances (Oon & Subramanian, 2010).

1.6 Research Goal and Questions

The main goal of this study was to explore the possibility of integrating traditional music and dance into the design and delivery of lessons on the concepts of echo and waves in the topic of *sound* in grade 10 Physical Science; and how this integration influences (or not) learners' sense making and dispositions towards science. Two objectives of this study were:

- To design and deliver lessons that integrate traditional music and dance on the concepts of echo and waves, on the topic of *sound*; and
- To create an opportunity for learners to investigate and explore ways of making the learning relevant on the topic of *sound*, and to improve learners' ability to align their everyday knowledge with that of the concepts of echo and waves on the topic of sound.

To achieve this goal and objectives, the following main question and sub-questions were asked.

1.6.1 Main Research Question

How does the integration of traditional music and dance into the design and delivery of lessons on the concepts of echo and waves, on the topic of *sound* influence grade 10 Physical Science learners' sense making and dispositions towards science?

1.6.2 Sub-questions

1. What factors enable or constrain grade 10 Physical Science learners' understanding of the concept of waves and echo on the topic of *sound*?
2. What factors influence grade 10 Physical Science learners' sense making and dispositions towards science when taught the topic of echo and waves in a traditional way?
3. What are grade 10 Physical Science learners' dispositions towards the integration of traditional music and dance in the design and delivery of lessons on echo and waves?

4. In what ways are grade 10 Physical Science learners' sense making and dispositions towards science influenced when traditional music and dance are integrated in the teaching of concepts on echo and waves?

1.7 Data Gathering Techniques

The followings data gathering techniques were used:

- Diagnostic test;
- Observations;
- Interviews [semi- structured and stimulated recall interviews]; and
- Summative test.

1.8 Definition of Concepts

The followings are the concise definitions of some concepts used in this thesis:

- **Amplitude** is the distance from the point where displacement is zero (equilibrium point) to any point where the particle has reached (Kadis, 2015).
- **Dispositions** are the participation repertoires from which a learner recognizes, selects, edits, responds to, resists, searches for and constructs learning opportunities (Atallah, Bryant & Dada, 2010).
- **Echo** is a reflected sound that is heard again by its initial observer (Kadis, 2015).
- **Frequency** is the total number of waves produced per second (Kadis, 2015).
- **Indigenous knowledge** is a legacy of knowledge and skills unique to an exacting indigenous culture and involving wisdom that has been developed and passed on over generations (Semali & Kincheloe, 1999; Mapara, 2009).

- **Prior everyday knowledge** is the kind of knowledge which the learners possess and explore through their social and material environment and learn through communication with others (Vygotsky, 1978).

- **Sense-making** is the ability of learners to bond scientific language and concepts to their already existing knowledge under real life conditions (Uushona, 2013).

- **Sound** is the phenomenon we experience when our ears are disturbed by vibrations in the air or solid objects that surround us (Kadis, 2015).

- **Toppaya** is the flat gongs played with the hands while sitting (Balocnit, 2016).

- **Traditional dance** is a dance in an ethnic group which is considered by most members of the group to be their cultural heritage (Cocks, Alexander & Dold, 2012); and which has not been created or introduced by most of the current participants of this study (Mbusi, 2011).

- **Waves** are a type of energy transmission that results from a periodic disturbance (vibration); and they are composed of a series of repeating patterns (Kadis, 2015).

1.9 Sound Waves

Sound is the phenomenon we experience when our ears are disturbed by vibrations in the air or solid objects that surround us. As an object vibrates, it sets the surrounding air in motion, sending alternating waves of compression and rarefaction radiating outward from the object that vibrates. Sound information is transmitted through the medium in which the vibrator is located. The amplitude, period and frequency of the vibrations are characteristics of a sound wave. The amplitude is experienced as loudness, and frequency as pitch (Kadis, 2015). Sound waves are longitudinal waves of compression and rarefaction in which the air molecules move back and forth parallel to the direction of wave travel centred on an average position and resulting in no net movement of the molecules. Waves are transmitters of energy that result from a periodic disturbance (vibration). They are composed of a series of repeating patterns as illustrated in the diagram below.

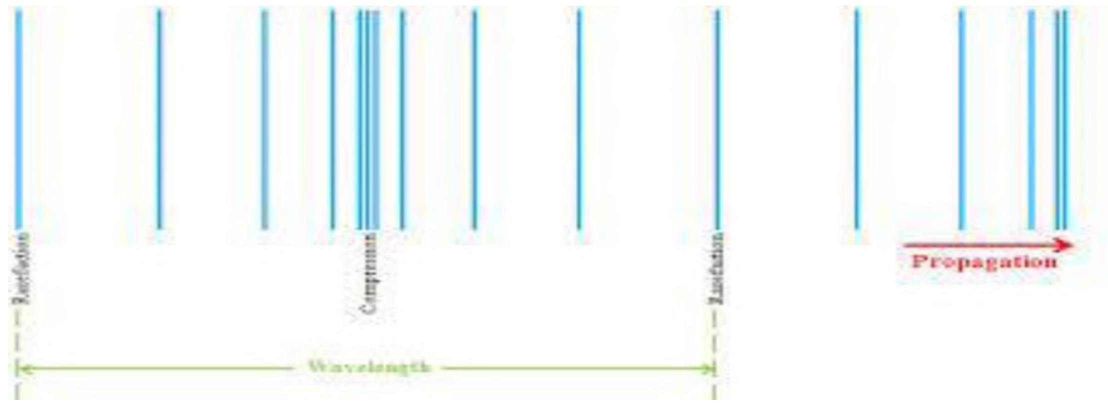

Figure 1: Longitudinal wave (source: https://scienceaid.net/physics/waves/properties.html)

The wave shown above is longitudinal. The vibrations travel through the air, liquid and solid, and not the molecules themselves. Sound requires a medium for transmission – which may be solid, liquid or gas.

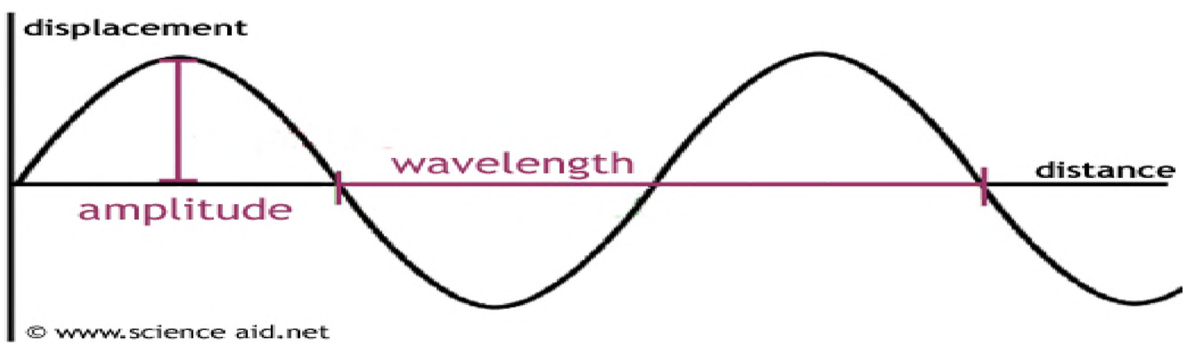

Figure 2: Wave pattern (source: https://scienceaid.net/physics/waves/properties.html)

In support of the above diagram, Mansilla (2007) noted that to understand how instruments make sound and how to use sound to create aesthetic experiences, learners are expected to master a few key concepts in Physics, namely: propagation medium, amplitude and length; rarefaction and compression; vibration and resonance. In my study, traditional music and dance enabled learners to make sense of these concepts from a Physics perspective and to closely examine the intrinsic elements of sound by observing the wave patterns formed on an oscilloscope (CRO) during a traditional concert.

1.10 Thesis Outline

This thesis consists of six chapters.

Chapter one outlined the background and the significance of the study, the research goal and questions as well as detailing the chapters of the thesis.

Chapter two presents a review of the literature based on the conceptual framework. The theoretical framework of socio-cultural theory informing this study is described.

Chapter three presents the methodology used. Furthermore, it outlines research issues relating to ethics, validity and trustworthiness of the study.

Chapter four presents the results, analysis and discussion of phase one of the study.

Chapter five presents an analysis of the results discussed in narrative form.

Chapter six contains the conclusion drawn from the study, its limitations, as well as some recommendations arising from the findings that need to be addressed by future research.

1.10 Concluding Remarks

This chapter introduced the study, presenting its background, context, significance, research goal, questions and the outline of the whole thesis. The next chapter presents a literature review of the conceptual and theoretical perspectives of this study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The aim of this study was to explore the possibility for integrating traditional music and dance into the design and delivery of lessons on the concepts of echo and waves in the topic of *sound* in grade 10 Physical Science, and how this integration influences (or not) learners' sense making and dispositions towards science. This chapter discusses the literature that informed the study.

Firstly, I explore the background of traditional music and dance so as to paint a picture about melody and hearing in relation to *sound* production. Then the literature on ideas about learning science within real life contexts is reviewed. Thereafter, existing concepts, ideas and subject matter relating to traditional music and dance are discussed. The role of wave and echo in the topic of *sound* is outlined. The nature of indigenous knowledge systems' integration across the curriculum and learning science through everyday knowledge are explained. Finally, the theory informing the design of the learning curriculum used in the study is discussed.

2.2 Conceptual Framework

According to Imenda (2014), a conceptual framework entails bringing together a number of concepts to give a broader understanding of a phenomenon or research problem. The following main concepts are discussed below, as each relates to this study: 1) prior knowledge; 2) indigenous knowledge; 3) traditional music and dance; 4) sound waves and echo; 5) dispositions; 6) sense-making. Each concept within a conceptual framework plays an ontological and epistemological role. The ontological assumptions relate to the knowledge of the "way things are", "the nature of reality", "real" existence, and "real" action (Guba & Lincoln, 1994). On the other hand, the epistemological assumptions relate to "how things really are" and "how things really work" in an assumed reality (p. 108).

2.2.1 Prior knowledge

Roschelle (1997) stated that learning begins primarily from prior knowledge and it only becomes secondary learning when new learning materials are introduced. Concurring, Stears, Malcolm and Kowlas (2003) reported that learners learn and appreciate formal sciences better when their everyday experiences are included in the teaching of science. In their study conducted in South Africa, for instance, Stears, et al. (2003) found that learners' participation increased when teachers made use of everyday knowledge in the classroom.

Similarly, Vygotsky (1978) explained that learners are constantly exploring their social and material environment and learn through communication with others. Bringing prior knowledge to school is a requirement for learners to be able to construct concepts correctly. Meyer (2004) explained that teachers classify prior knowledge into three categories, namely, prior teaching, informal learning experiences such as TV shows or museums, and general life experiences of learners. Some general life experiences of learners are components of indigenous knowledge (IK). According to Roschelle, Pea, Hoadley, Gordin and Means (2000), for teachers to be able to assist learners to make use of new experience and skills, they should comprehend how prior knowledge (PK) affects learning.

That is, learners should be given opportunities to explore and deduce the facts and to clear their misconceptions. If a learner does not yet understand heat and temperature, for instance, no quick explanation can possibly resolve the contradiction between the hot desert and the warm wool. It takes weeks for this understanding to emerge (Lewis, 1992). Roschelle et al. (2000) further expressed that recognition of prior knowledge constitutes a theoretical shift towards viewing learning as conceptual change. So, previously, learning was considered as a process of accumulating experience towards the already-existing knowledge. Ultimately, prior knowledge is then the bane of the transmission and absorption model of learning. On the other hand, it is impossible to learn without prior knowledge. For example, the bare notion of 'sound' without prior knowledge, won't explain why a bat is able to avoid an obstacle when flying at night.

There is a widespread agreement that prior knowledge influences learning and that learners construct concepts from prior knowledge (Resnick, 1983). Kasanda, Lubben, Goaseb, Marenga, Kapenda and Campell (2005) argued that the Namibian curriculum based on learner-centred teaching has been successful in broadening learners' acquisition of skills and knowledge for understanding. When considering the learning effect of using daily contexts in science teaching, the different methods of skills and knowledge building used in everyday and scientific domains need to be recognized (Shifafure, 2014). Stears, et al. (2003) affirmed that in order to gain skills and knowledge, learners should be involved in the lesson presentation of background and science information.

Rehder and Murphy (2003) identified one possible role that prior knowledge plays on learning. They considered the relationship between eliciting explanation and the effects of prior knowledge. Engaging in explanation during teaching through traditional music and dance has been proven to promote learning for a better understanding of the science concepts involved in the topic of *sound*. Williams, Lombrozo, Hsu, Hubber and Kim (2016) explained how prior knowledge might interact with guided learning. They argued for the theory of explanation in philosophy which proposes that explanations show how what is being explained is an instance subsumed by a general pattern. In support of this, they found that explanations could determine which prior knowledge is deployed. To enable sense-making of science concepts, learners should invoke those beliefs that demonstrate how what is being explained can be included in the general guide.

Svinicki (1993) argued that prior knowledge affects how a learner perceives new information. In support of this, he emphasized that one of the keys to learning and memory is the richness of the connections a bit of information makes. The more connections, the easier it is to remember. When new information gets hooked up with a particularly rich and well organized portion of memory, it takes up all the connections that already exist. Centrally, this is why it is much easier to learn information in one's existing field of expertise than to learn information from a brand new field and/or concepts. When the learner has nothing to hook new information to, he or she is thrown onto the characteristics of rote memorization (ibid).

However, there should be a balance between school and everyday knowledge. It was observed by Taylor and Fedoroff (1999) that the format and the content of curriculum should be specific enough to ensure that all teachers cover the same conceptual ground. However, the curriculum should not merely consist of list of content if that restrains teachers from pursuing activities which embody the knowledge and even skills and attitudes to be learnt in interesting and creative ways.

According to cognitive learning theory, learners build new knowledge on their prior knowledge. Prior knowledge provides an anchor to accommodate and then assimilate new knowledge into the cognitive structure. Cognitive structure can be defined as "the facts, concepts, propositions, theories, and raw perceptual data that the learner has available to her or him at any point in time and the manner in which it is arranged" (Lee, 2007, p. 2).

In science, the degree of confidence placed in the sequence of the content is so great that the role of prior knowledge is considered as a starting point for ensuing learning. In this sense, prior knowledge can be considered as the pre-instructional knowledge that learners have acquired from previous lessons. In essence, prior knowledge is the foundation for subsequent learning that needs to be mastered before new information is to be taught. This suggests two ways for teachers to make use of the prior knowledge: 'readiness' and 'diagnostic' types of tests (Lee, 2007) to help learners to master certain prerequisite knowledge and skills; and this prerequisite sequencing provides linkages between each lesson as the learner spirals upwards in the course of study.

Eliciting learners' prior everyday knowledge (PEK) in the teaching of science concepts becomes relevant provided that science is connected to the science already known by learners; and provided it gives learners the science they can use in their everyday lives and build on their experiences. Research on learners' PEK in the teaching of science began in 1970s through watchful records of common errors made by learners in solving physics problems (Roschelle, 1997).

The National Curriculum for Basic Education (2010) affirms that the lessons of science should be based on what learners already know; and for the significant teaching to happen, teachers should make use of learners' prior everyday knowledge. In addition, Oloruntegbe and Ikpe (2010), in their study conducted in Nigeria, confirmed that this is essential noting that learners come to school with prior knowledge obtained from their surroundings that should be recognized in the classroom. This instructional approach should also help learners retrieve what they already know about a topic, in the case of this study of '*sound*'. This is sometimes referred to as activating prior knowledge (Christen & Murphy, 1991). A teacher can activate the prior knowledge of her/his learners in an informal, but efficient way, by asking learners to think about what they already know about the concepts.

Cues and questions, as well as advance organizers, are methods that teachers can use to activate learners' prior knowledge. Advance organizers are organizational frameworks that a teacher presents in advance of learning. Cues and questions are very similar, cues being hints about what learners are about to experience. For example, a teacher is giving learners a cue when she explains that the movie they are about to watch on the functioning of the cell will provide some information they already know about the cell, but it will also provide some new information. In telling learners what the topic of the movie is, the teacher helps them to activate their prior knowledge. Also in telling learners to expect some new information, the teacher establishes expectations in the learners. For example, prior to watching a movie on the functioning of the cell, the teacher might ask learners questions that elicit what they already know about the topic. Another way that teachers can help learners use their background knowledge to learn new information is to present them with advance organizers which emphasize the essential ideas that the teacher plans to cover in a lesson or unit (Christen & Murphy, 1991).

2.2.2 Indigenous knowledge (IK)

Semali and Kincheloe (1999) and Mapara (2009) viewed IK as a legacy of knowledge and skills unique to a particular culture and involving wisdom that has been developed and passed on from generation to generation. Indigenous knowledge can be understood through different dimensions such as agriculture, medicine, security, craft skills (technology), cultural practice, and families and linguistics.

According to Kibirige and van Rooyen (2006), indigenous knowledge is local knowledge, derived from interactions between people and their environment. They considered IK as a form of 'traditional wisdom' which is the product of practical engagement with the environment in everyday life. IK is not straightforwardly shared with members of other communities because of the particular elements which circulate it within particular cultural communities. This presents challenges to teachers in multicultural classroom in Namibian schools. Also IK might lack scientific proof.

In the context of this study, integrating traditional music and dance was intended to enable learners to make meaning of the concepts of waves and echo on the topic of *sound*, with the assistance of links to their prior knowledge. Sound waves and their patterns can be demonstrated using these indigenous practices, especially when learners are required to draw longitudinal waves to represent sound. Singing and dancing using drums and handclaps near a wall or building facilitate the experience of an echo that demonstrates reflection of sound.

Cocks, Alexander and Dold (2012) pointed out that indigenous knowledge is not limited to science education only but it also creates opportunities for community elders to contribute in school science by bringing the knowledge they possess. Cocks et al. (2012) also believed that involving cultural knowledge helps to bring back self-image and confidence in both the community and the learners. In after-school programs of the Traditional Life Skills Project (TLSP), parents and grandparents teach children some of the traditional life skills and knowledge of the Nama people, such as various kinds of handicrafts, agricultural techniques, traditional medicine and cosmetics (Klein, 2011). Klein considered IK as a large body of knowledge and skills that has been developed outside the formal education system, and which enables communities to survive. As IK is closely associated with survival and subsistence, it is especially significant in relation to food-security, health, education and natural resource management. Dei (2000) conceptualized IK as a body of knowledge associated with long-term occupancy of a certain place. It is said to refer both to traditional norms and values, and to the living experience and knowledge of a group.

A number of researchers have argued that teachers should develop understanding of the role of learners' prior knowledge in teaching and learning science (Barab & Luehmann, 2003; Rivet & Krajcik, 2008). Concurring, Otero and Nathan (2008) contextualized science teaching as involving the use of learners' prior-everyday experiences as a mechanism for conceptual attainment. They argued that eliciting and building on learners' IK in the form of prior everyday knowledge can play an essential role in enhancing meaningful learning.

Research has shown that when learners' prior knowledge is not recognized, they may find it difficult to grasp new concepts or information and relate it to their preconceptions about a phenomenon they have experienced outside the classroom (Krause, Kelly, Corkins, Purzer &

Tasooji, 2009). The consideration of learners' prior-everyday experiences can support them to learn and to relate the content that they are learning in the classroom to their own context (Rivet & Krajcik, 2008). Thus, they advocate that science teachers should find ways of engaging learners in what they already know about science concepts, identify the science and possible misconceptions that might hinder conceptual understanding.

According to Shifafure (2014), indigenous knowledge (IK) is an all-encompassing knowledge that covers technologies and practices that have been and are still used by indigenous and local people for existence, endurance and adaptation in a variety of environments. Therefore, teachers are urged to identify classroom activities by bringing in concepts of IK that link the community of science with that of the school as stipulated in C2010. In support of this, Rennie, Feher, Dierking and Falk (2011) expressed the need for closing the gap between the classroom and the community.

Hence, in this study I engaged the community's practice of traditional music and dance, using a variety of musical instruments such as drums and handclapping, to elicit the production of sound waves as these appeared on an oscilloscope. Learners experienced the sound phenomena and recognized that an indigenous practice could be used as a learning mediation. Through IK, the link between home experience and school curriculum can be appreciated. The inclusion of aspects of indigenous education obliges us to acknowledge the existence of multiple forms of knowledge rather than benchmarking one standard system.

For indigenous learners and teachers, the introduction of these methods into schools often enhances educational effectiveness by providing an education that adheres to an indigenous person's own inherent perspectives, experiences, language, and customs, thereby making it easier for children to transition into the dominion of adulthood (Balocnit, 2016).

2.3 Traditional Music and Dance

According to Mbusi (2011, p. 5) the term 'traditional dance' has been defined as "a dance in an ethnic group which is considered by most members of the group to be their cultural heritage and which has not been created or introduced by most of the current participants". Knowledge and information, teaching and skills learning should be combined and the development of an arts education program should attach due value to the importance of traditional African arts while recognizing that culture is dynamic and evolving. Indigenous music and dance serve a specific purpose which may express the communal values and social relationships of the people in a given society.

In Kavango West region, the vernacular Rukwangali word for culture is *Mpo*. *Mpo* is generally used, and most commonly by older people, to refer to something that is old and different from the modern – in other words, synonymously with 'tradition' (Akuupa, 2006). But it is rarely used alone; rather, it is linked to '*zetu*', meaning 'our', in order to give a full phrase of *'Mpo zetu'* which literally means *our culture*. The expression *our tradition* clearly means something that carries the authority of the past, and that is associated with a particular population. It is commonly used to refer to practices that are assumed to have been handed down for generations and that need cautious protection against foreign influence (ibid).

Among the Vakwangali and Vanyemba people who largely populate the Kavango West region where I undertook my study, traditional music (singing) and dance is used mainly during customary functions, including the ritual to ensure the fertility of a girl, called *Etembu,* and the ceremony of circumcision–*yoVamba* in the vernacular *Rukwangali* and *Runyemba* word. Traditional dances are also common during joyful occasions such as weddings, the coronation of the *Hompa* – chief - and also during mourning time. Traditionally, in the absence of clinics and hospitals, elders used traditional dances to heal various diseases and barrenness by singing and beating drums in their dance attire.

Similarly, Mbusi (2011) noted that traditional Xhosa dances have been known as a "construction of 'traditional Xhosa values' constituted in the performance of the dance". She further explained that traditional Xhosa dances often do not appear in isolation, but are part of the broader cultural activities. For example, dances of love are performed on special occasions, such as wedding and anniversaries.

Traditional music and dance among the Vakwangali and other tribes living in the Kavango West region, as is the case in many other African cultures, are usually performed in groups, for instance, of girls versus boys, or old women versus men. For every dance occurring in the community, drums are not excluded so they are the main source of sound waves. The number of drums depends on the type of traditional dance and melody of the song. There may be a minimum of three drums known as: *Nkurugoma* - the main drum, *nkinza* and *Matjakili* when dancing *epera, ukambe, unyanga* for ceremonies, and for healing *etusu, etuvika, Kazambi* and *nyambi*. It could be argued that traditional dance forms a unique lens through which one may enter into a world of embodied representation. A dance performance often creates and perpetuates devastatingly accurate portraits of national prejudices, class strife and ethnic tension (Shay, Holman, Newman, Liu, Stout & Anderson, 1999).

2.3 Teaching *sound* through traditional music and dance

In the context of this study, the use of traditional music and dance in teaching science might help enable learners to master the concepts of waves and echo, on the topic of *sound*. For instance, the traditional music and dance among Vakwangali and many other African traditions such as *Xhosa* dances, use similar movements when they move to the rhythmic pulses of their dance (see photograph, below) through their postures, gestures and steps (Mbusi, 2011).

Figure 3: Postures and steps

Fig 4: Males using their palms to play drums

The concepts of sound obviously relate to many daily phenomena and thus may be considered as useful knowledge for learners in helping them to understand their surroundings (Eshach, Lin & Tsai, 2016). For example, the curriculum in Taiwan includes an introduction to instruments such as guitar and *erhu* (a traditional Chinese stringed instrument), sound-related phenomena, such as echo and the use of the cathode ray oscilloscope (CRO) (Eshach, et al., 2016).

According to a study by Mansilla (2007), conducted in Kampala for interdisciplinary teaching of sound in Music, learners learned about sound waves in Physics and about musical instruments and composition in Music only. However, the study did not facilitate learners to learn sound and identify the phenomena of *sound*. Certainly, this study was planned to use traditional music and dances in a social context in teaching the components of sound, namely, echo and waves were central in the learning process. The unit went beyond using music to motivate learners' learning in Physics. It sought to help learners appreciate and understand sound waves. The study revealed that in the case of both teachers and learners in her example, understanding how instruments work and creating music with their hand-made instruments was a valuable learning outcome. It enabled learners to create a compelling artistic experience out of materials in their natural environment and appreciate instruments they encounter and the people who make them. It also invited them to learn about design and problem-solving.

Considering the potential integration of the traditional aspects of music, it is essential for learners to understand how musical instruments work and what constitutes a sound wave, how sound changes depending on wave's frequency and amplitude, how sound waves travel through different media and how sound resonates with different materials. Involving traditional music and dance in teaching science assisted learners to master the concepts of wave and echo, in the topic of *sound*.

In the study conducted in Cordillera region of Luzon Island by Balocnit (2016), *Physics in the Traditional Musical Instruments of the Kalingas*, it was found that the physical properties of each instrument had noteworthy relations with the science of *sound* in physics. The size, shape, length, and diameter of instruments affect the sound produced. In terms of educational content, providing and receiving education through non-traditional methods of teaching and learning, enables learners to integrate different perspectives, cultures, beliefs, values and languages in mainstream education systems and institutions. Balocnit (2016) emphasized that most – if not all – learners considered Physics as a very difficult subject; it was also regarded as unexciting by learners who were not scientifically- and mathematically-oriented.

Given that attitude towards physics, making the subject interesting and enjoyable is a challenge for all Physics teachers. The *interest* factor could make learners appreciate the lessons and may make to topic easier to understand. The physics behind musical instruments is beautifully simple when understood. The sounds made by musical instruments are possible because of standing waves, which come from the constructive interference between waves travelling in both directions along a string or a tube. Studies on traditional musical instruments and their link to scientific concepts are not only a very interesting topic, but also a valuable instructional reference resource for the next generation (ibid).

Among the Kalingas, a group of people in the Cordillera region of Luzon Island, sound is often made by playing a gong. The players hold the largest gongs directly before them, and then they start striking their own gong. Balocnit (2016) explained that, in the toppaya, a player uses his bare palms to play corresponding combinations of accepted dampened and sliding strokes until there is a rhythm and melody to the sound produced, as shown in the photograph below.

Figure 5: Toppaya of the Kalingas Community (Balocnit, 2016)

When teaching the concepts of echo and waves on the topic of *sound* through traditional music and dance, learners (customarily, males) use their palms to play drums in order to create rhythm and melody of the sound. This has demonstrated that sound travels in a straight line. At the same time, female learners and other males enjoy the handclaps to strike the rhythmic pattern of the sound perceived. They form a straight line to come up with a good rhythm and melody of the sound.

The traditional drum performs a similar function to the guitar. In Physics, teachers often use the guitar or use folk music to demonstrate factors that affect sound waves. Therefore, to have a practical application, the traditional drum can be used to help learners understand the concepts by relating the theory to their experience in the home. There is value in using indigenous knowledge and education in the public school system. Learners of all backgrounds can benefit from being exposed to indigenous education as it can contribute to clearer understanding and admiration of the subject matter. Learners also find practical applications of the physics concepts in their own activities. The insertion of indigenous knowledge into the curricula, instructional materials, and textbooks has the effect of preparing learners for the wider world as in other educational systems, such as the Western model.

2.4 Sense-Making

Sharma (2010) defined sense-making as the act of making sense of the world around us, often in the service of some task or goal. Uushona (2013) referred to sense-making as the process whereby learners are able to make sense of the new concepts emerging from the topic being taught. It deals with the issue of whether learners are able to relate a particular situation to what they know or have experienced. This study aimed to explore the possibility of *using traditional music and dance* as a teaching mechanism to enable learners to make meaning between what they can see and experience and the scientific ideas and concepts of waves and echo. Learning through interaction and iterative practice such as observation, imitation and repeated feedback on the task done by learners through a social grouping might enable sense-making (Bandura, 1977).

In sense-making situations, people may have a gap in understanding and not be sure how to act. Weick (1996) explained that sense-making often involves gathering information, gaining an understanding of the information and then using the understanding to finish a task. Audet, Hickman and Dobrynina (1996) suggested the use of learning journals as a way of enhancing scientific sense-making.

Campbell, Schwarz and Windschitl (2016), saw sense-making as a conversation that can support reasoning and learning. By sense-making, they simply meant working with both learners' ideas (including their experiences, language, and ways of knowing) and with dependable ideas in texts and other materials—in ways that help generate meaningful connections. This requires asking learners to talk about their thinking, to compare ideas, to test these ideas, and to see if they can be used to explain natural events and processes. These types of reasoning experiences occur often during learners' engagement with science practices such as argumentation from evidence, constructing explanations, or revising models. It is believed that such engagements can influence learners' dispositions.

2.5 Dispositions

Dispositions are relatively enduring habits of mind and action (Katz & Chard, 2005) that encourage learners to respond to experiences in particular ways. Atallah, (2003) defined disposition as participation repertoires from which a learner recognizes, selects, edits, responds to, resists, searches for and constructs a learning opportunity. According to Atallah, Bryant and Dada (2010), dispositions as beliefs or tendencies exhibit a frequent, conscious and voluntary behaviour directed towards learning a subject.

The study was hoped to encourage a disposition of inner strength to cope with challenges, stress and the ability to bounce back from difficulties. The key ingredients for resilience leading to success in learners are: happiness, self-confidence and self-reliance (Atallah, 2003). This study thus hoped to provide opportunities to participate in traditional music and dance performance to enable learners to realize the science embedded in music and dance, hence enabling sense-making in learning science concepts.

Traditional music and dance concentrate involve deep engagement in learning and provide an approach to pedagogy that allows learners to be at the centre of learning as advocated by the socio-cultural theory (Vygotsky, 1978). It was hoped that learners might begin to navigate their own pathways to realize the usefulness of traditional music and dance and the curriculum rather than depending only on the teacher's direction.

Clegg, Bonsignore, Ahn, Yip, Pauw, Gubbels and Rhodes (2014) noted, in a study in the metro area of Washington DC, that it is becoming increasingly important to help young learners develop scientific dispositions. The development of a scientific disposition unlocks opportunities for learners to explore potential roles for them in science, whether they choose to pursue scientific careers or just use science practically in their everyday lives (Basu & Barton, 2007). Clegg and Kolodner (2014) focused on scientific inquiry as a disposition that might help learners explore their worlds. To support learners' efforts to develop scientific dispositions, scholars must work out ways to help learners move beyond abstract facts and phenomena, to extend their classroom experiences beyond the limits of school. Brady (1995) proposed that teachers should enable learners to *scientize* their daily activities, and that involves helping learners perceive the world through scientific lens, and to incorporate this vision in practical applications across the contexts of their everyday lives. Following Aikenhead and Jegede (1999), this study hoped that integrating traditional music and dance would enable learners to cross borders from their everyday lived-experiences (context) to scientific knowledge (content) as it happened in Kuhlane's (2011) study in South Africa.

2.6 Theoretical Framework

Theoretical frameworks influence every aspect of the research including the research problem, methodology, data analysis and interpretation (Merriam, 2009). A theoretical framework is mainly derived from concepts, theories and literature of the particular discipline (ibid). Essentially, the theoretical framework in my study was provided by Vygotsky's (1978) socio-cultural theory.

Socio-cultural Learning Theories (SCLT)

This research used the term socio-cultural to refer to the general social and cultural circumstances in which individuals conduct their methods of acquiring knowledge, skills and attitudes. The socio-cultural theories adopted for this study was based on the work of Vygotsky (1978), emphasizing the important role of *culture* and *context* in constructing knowledge and enhancing meaningful learning. According to this theory, individuals construct cognitive schemes through interactions and communication with each other. In other words, meaningful learning occurs by engaging in social activities (Lemke, 2001). Accepting that learning progresses slowly over time, via many small steps (Vygotsky, 1978), the centre of learning is one whose genesis is demonstrated in minute, or micro, moment-to-moment occurrences. According to Vygotsky, mental development arises as a consequence of the interaction of two distinct processes, one with biological roots and the other with socio-cultural origins. These two developmental lines merge during the ontogenesis of the child.

Potentially, traditional music and dance may be a platform for enhancing meaningful learning, since participants from diverse cultural backgrounds can work collaboratively on many activities, such as sharing knowledge when working in small groups and when performing traditional music and dance.

From this perspective, interactive classrooms, argumentations and conversations might help teachers and learners to clear any doubts they may have, help improve current knowledge, help acquire new attitudes and reasoning skills, gain new insights, make informed decisions and even help change perceptions (Stears, Malcolm & Kowlas, 2003). In essence, when learners are provided with an appropriate learning environment and instruction, they are more able to participate in the lessons (Oon & Subramanian, 2010). This means that a classroom becomes a social unit whereby a teacher and/or experienced peer are able to provide the learner with constant support in order to aid the learners' evolving understanding, knowledge and development of complex skills and attitudes.

Investigation by Lantolf and Thorne (2006) of the socio-cultural approach found that the methodology is not intended merely as an alternative to other research methodologies, but is a necessary consequence of Vygotsky's new way of theorizing humans and human psychological functions as mediated by social practices and cultural artefacts. In other words, the methodology, generally referred to as the 'genetic method' (Romand, 2009), emerges from the stance that Vygotsky adopted for overcoming the mind-body dualism that had – in his view – affected psychology and other social sciences for years.

In adopting the socio-cultural theory, this study focused on the concepts of mediation of learning, the zone of proximal development, internalization and Africa and Africanization of knowledge and pedagogy which are discussed below.

2.6.1 Mediation of learning

Mediation of learning is a technique or skill incorporated to explain how knowledge is acquired in the learning process; it is a learner-centred skill which supports the social constructivist perspective. It is sometimes referred to as a theory which assists learners to make sense of abstract scientific concepts when cognitive development is acquired (Ramasike, 2016). This study viewed mediation of learning as a skill to draw learning through social interaction.

Learners' cognitive development is the primary focus when new scientific concepts are constructed. In that way, mediation of learning is believed to promote such a development (ibid). Therefore, learners' development is supported to the full potential through this skill. According to Lantolf (1994), language, signs and symbols help learners to internalise ideas as they develop their inner potential as stated in Vygotsky's perception that development of inner potential promotes improvement of individual self-regulation (Vygotsky, 1978; Ramasike, 2016). Such an improvement informs construction of mental structures.

Gibbons (2003) argued that mediation of learning is the connection between the existing states of mental development through the zone of proximal development (ZPD) (Vygotsky, 1978; Stott, 2016) to the intended scaffold status. Some learners' cognitive reasoning level may be higher than that of their peers. Such learners should be given an opportunity to share ideas with peers in order to promote joint construction of ideas which is a basic element of social construction also Bourdieusian concepts of acquiring cultural, social and symbolic capitals (Gibbons, 2003). Learning, therefore, takes place at social and cultural levels. Mediation of learning involves construction, deconstruction and reconstruction as learners try to make sense of new concepts with the assistance of a teacher; and social and cultural mediations of learning develop from an individual to a group (collectives) of learners (Shepard, 2000).

2.6.2 Learning in the zone of proximal development (ZPD)

Vygotsky (1978) defined the ZPD in terms of actual and potential development. The characteristic of actual development is independence (i.e. what the learner is able to do independently). Potential development is what is beyond the independent understanding or problem-solving abilities of the learner. The most frequently referenced definition of the ZPD is "the distance between the actual developmental levels as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86).

The ZPD has fascinated teachers for a number of reasons. One of them is the notion of assisted performance, which, although not equivalent to the ZPD, has been the driving force behind much of the interest in Vygotsky's research. Another persuasive feature of the ZPD is that in contrast to traditional tests and measures that only indicate the level of development already attained, the ZPD is forward-looking through its assertion that what one can do today with assistance is indicative of what one will be able to do independently in the future. In this sense, ZPD-oriented assessment provides willpower of both developments achieved and developmental achievable

In this sense, the ZPD is not only a model of the developmental process, but also a conceptual tool that teachers can use to understand aspects of learners' emerging capacities that are in early stages of maturation. When teachers use the ZPD proactively as a diagnostic tool, it has the potential of creating conditions for learning that may give rise to specific forms of development in the future. Within the scope of one's potential development, the ZPD refers to a special zone characterized by what the learner can do with assistance, *en route* to independence. It is important to note that the ZPD is not statically defined by an outside task or piece of knowledge, but as part of a larger process that defines learning in terms of the ever-shifting needs of a learner.

2.6.3 Internalization process in the social form

Internalization is the process by which what is external to the learner, existing on the interpersonal plane, moves inward to the intrapersonal plane. In essence, internalization is the process that assists the learner through the ZPD. Several processes were identified by Vygotsky (1978) and others (Lantolf & Thorne, 2006; Tharp & Gallimore, 1991) that advance internalization, including imitation, scaffolding, and play/role playing (Bandura, 1977). For the purpose of this study *scaffolding is* referred to as assisted performance (Tharp & Gallimore, 1991; scaffolding is the novice-expert interaction through which a more capable other provides assistance to the learner or novice. Participation in schooling involves, at least in part, learning through participation in socio-culturally and institutionally organized practices. One of Vygotsky's most important findings was that learning collaboratively with others (Dewey, 1959), particularly in instructional settings, precedes and shapes development. The relationship between learning and development is not directly causal, but intentionally designed learning environments can stimulate qualitative developmental changes.

Tharp and Gallimore (1991) further outlined the obligations for successful scaffolding, stating that the expert must (i) know what the learner is trying to learn, and (ii) understand what the learner needs in order to learn. The terms novice and expert are not defined by age, nor are they static. In other words, a younger, less experienced person may find himself in the role of expert within a given context; a role can then shift as the context for learning shifts. This is especially important when considering scaffolding within group work among peers. The term peers, in this case, does not imply static equality, but is broad enough to include shifting levels of proficiency.

In order for there to be successful scaffolding, the novice and expert need to understand each other through interaction, as implied by Tharp and Gallimore's (1991), second obligation given above. The expert needs to understand what the learner knows and needs to know—in short, where the learner is. On the other hand, the novice needs to understand what the expert is trying to tell and to move beyond the current level of expert's understanding. This mutual understanding is created during interaction, and is referred to as intersubjectivity. Therefore, the socio-cultural approach can help account for the teacher's understandings of the task of teaching.

2.7 Concluding Remarks

This chapter engaged with literature relevant to this study. The process helped to generate new ideas that are useful to the goals of this study. For instance, the study on the connection of Physics with the traditional musical instruments of the Kalingas community helped in planning similar interventions in the study area. Also, studies involving the integration of everyday life activities into the learning of science demonstrated how this could be done practically. Studies on dances offered ideas on what to look for when integrating dance into Physics.

The next chapter discusses the methods used to gather data in this study.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methodological frameworks that guided the research process used to explore the integration and delivery of traditional music and dance into the design and delivery of lessons on the topic of sound in Grade 10 Physical Science. According to McMillan and Schumacher (2010, p. 490), “a research design is the plan that describes the conditions and procedures for collecting and analysing data”. Additionally, a design specifies a plan for gathering empirical evidence that will be used to answer the research question(s).

This chapter also discusses the mixed methods research design which enabled me to obtain credible answers to questions (McMillan & Schumacher, 2010). The reasons for deciding on a mixed methods approach and qualitative case study are described and discussed.

The data gathering tools used in the study are discussed including the sampling of participants. How the data were analysed is explained followed by a discussion of ethics, validity and trustworthiness and the limitations of the study. The chapter ends with some concluding remarks.

3.2 Research Design

The research design was informed by the adopted theoretical frameworks, specifically, a socio-cultural theories. Cohen, Manion and Morrison’s (2011) review of research designs mostly defined concepts and areas of study that are open to changes of methodology. The design of the research implies an overview of purpose, types of data required, data gathering strategies and data analysis techniques used. The research design assisted to get close into the research subject using the interpretive paradigm.

3.2.1 Interpretive paradigm

This study was underpinned by an interpretive paradigm or approach. Cohen, et al. (2011, p. 21) interpreted the interpretive paradigm as the way of understanding the “subjective world of human experience and the efforts made to get inside the person and understand from within”.

They explained that interpretive approaches focus on action as behaviour with meaning and intention of participants to share their everyday interactions-experiences.

Bertram and Christiansen (2015, p. 26) explained that an interpretive paradigm is a "perspective that has the possibility to lead the researcher to make interpretations with the purpose to understand the method that they choose". They emphasised that in terms of the interpretive paradigm, meaning can only be understood in the relationship between researcher and respondents. This relationship between the researcher and the respondents is thought to be biased. In view of this, the standard for the quality of this type of research does not expect objectivity between the researcher and the respondents.

Lending support, Victor, Treschuk, Peoples and Lewis (2016), pointed out that an interpretive paradigm focuses on subjectivity by exploring the views, experiences, perceptions and meanings of participants in relation to the reality of the faith-based recovery process, which relies on context. Working within an interpretive paradigm underscores that the world is changeable and that it is people who define the meaning of a particular situation (Bertram & Christiansen, 2015).

A mixed method research design was used in this study. Hence, quantitative and qualitative data were collected with more focus on qualitative data than on quantitative data (Cohen et al., 2011). This method involves integrating quantitative and qualitative approaches in collecting data in a single study with a view that the problem needs to be studied through multiple phases of research that include multiple types of methods in order to achieve triangulation, concurrent procedure and clarity of the result (Creswell, 2013).

Qualitative research design emphasizes gathering data on naturally occurring events. In general, a researcher must explore with a variety of methods until a deep understanding is achieved (McMillan & Schumacher, 2010). Babbie and Mouton (2001) further clarify that the distinctive feature of qualitative research is that it focuses on the process rather than on the outcomes and tends to provide description and insights in the understanding of actions. Creswell (2013) explained that qualitative research provides a platform for the researcher to interact with the participants.

In this study, the qualitative approach helped the researcher to interact with the participants. As Maxwell (1992) explained, a qualitative approach surfaces the participants' understanding of the meanings of the events, situations and actions they are involved in and of the accounts that they give of their lives and experiences. Therefore, this study was informed by an interactive design, whereby personal experiences and interests were the focus of inquiry. Within the interpretive paradigm, the study employed a case study.

3.2.2 Case study

A case study is a form of problem-based learning, whereby a researcher presents a situation that needs a resolution. The case study readers are given details about the situation, often in a historical context. A case study was considered the most appropriate method for this study because it allowed in-depth investigation of how learners attempted to learn science concepts. According to Shifafure (2014), a qualitative case study is an approach to research that facilitates exploration within its context using a variety of data gathering tools. This method examines a single entity in depth, employing multiple sources of data found in the setting (McMillan & Schumacher, 2010).

Gerring (2006) outlined a case study as an intensive study of a single unit with an aim to generalize across a larger set of units. This provides a general understanding of the case study method as well as specific tools for its successful implementation. This study was characterised by collecting evidence through interviews (typically open-ended) and direct observations (formal or casual) of physical artefacts. This involved using multiple sources of evidence – triangulation – which evince the character of a case study.

The objectives and challenges outlined below are followed by specific examples and data, which were used to analyse the possibility of integrating traditional music, determine what happened, and made recommendations. The framework illustrated in Figure 6 below was used to realize the meaning-making of learners studying waves and echo in grade 10 Physical Science.

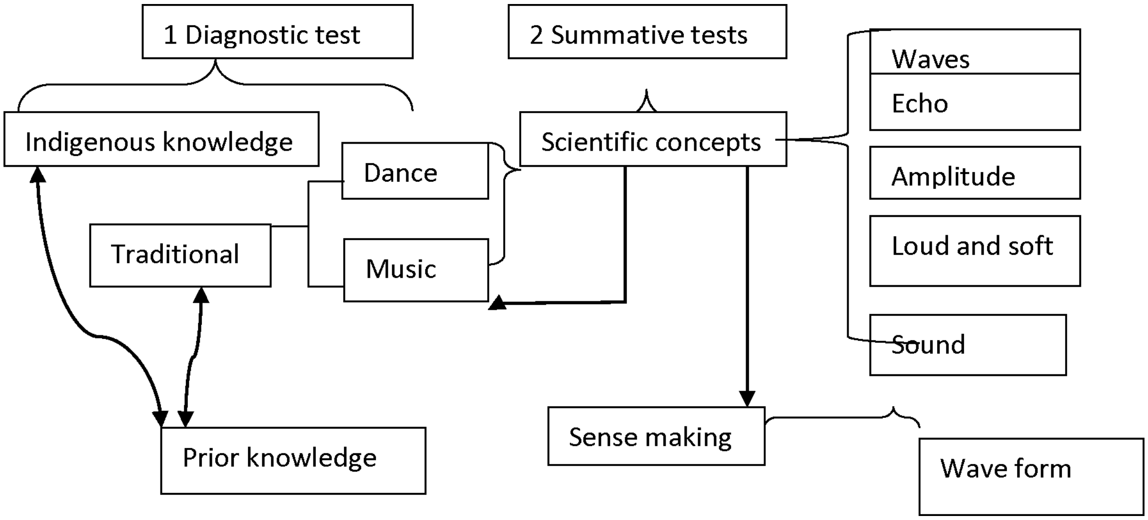

Figure 6: **Summary of wave concepts to analyse sense making of learners towards science (Adapted from*: www.intechopen.com*)**

The summary of wave concepts helped in the evaluation of the level of learners' prior knowledge and the end product of learners' engagement with the intervention of the lessons on waves and echo was evaluated through a summative test. A case study approach enabled me to focus on the topic under study hoping to understand the contemporary teaching and learning strategies used for learners to make sense of the concepts of echo and waves.

In the context of this study, the qualitative case study method was used to work directly with the research participants (grade 10 learners) in order to explore the possibility of the integration of traditional music and dance in the design and delivery of lessons on the topic of *sound*.

3.3 Research Goal and Questions

As outlined earlier, the main goal of this study was to explore the possibility of integrating traditional music and dance into the design and delivery of lessons on the concepts of echo and waves, on the topic of *sound* in grade 10 Physical Science, and how it influences (or not) learners' sense-making and dispositions towards science. The objectives of the study were:

- To design and deliver lessons that integrated traditional music and dance into the concepts of echo and waves on the topic of *sound*; and

- To create an opportunity for learners to investigate and explore ways of making the learning of the topic of *sound* relevant.

To achieve this goal and objectives the following main question and sub-questions were asked:

Main research question

How does the integration of traditional music and dance into the design and delivery of lessons on the concepts of echo and waves on the topic of *sound* influence grade 10 Physical Science learners' sense making and dispositions towards science?

Sub-questions

1. What factors enable or constrain grade 10 Physical Science learners' understanding of the concept of waves and echo in the topic of *sound*?
2. What factors influence grade 10 Physical Science learners' sense making and dispositions towards science when taught the topic of echo and waves in a traditional way?
3. What are grade 10 Physical Science learners' dispositions towards the integration of traditional music and dance in the design and delivery of lessons on echo and waves on the topic *sound*?
4. In what ways are grade 10 Physical Science learners' sense making and dispositions towards science influenced when traditional music and dance is integrated in the teaching of concepts on echo and waves on the topic *sound*?

3.4 Research Context

The study was conducted in the Kavango West region in Namibia (see the Figure 7) which is a map of Kavango West and East of Namibia and map of Namibia, respectively at Lyambombola Combined School (pseudonym) in the Kavango West Region in the northern part of Namibia.

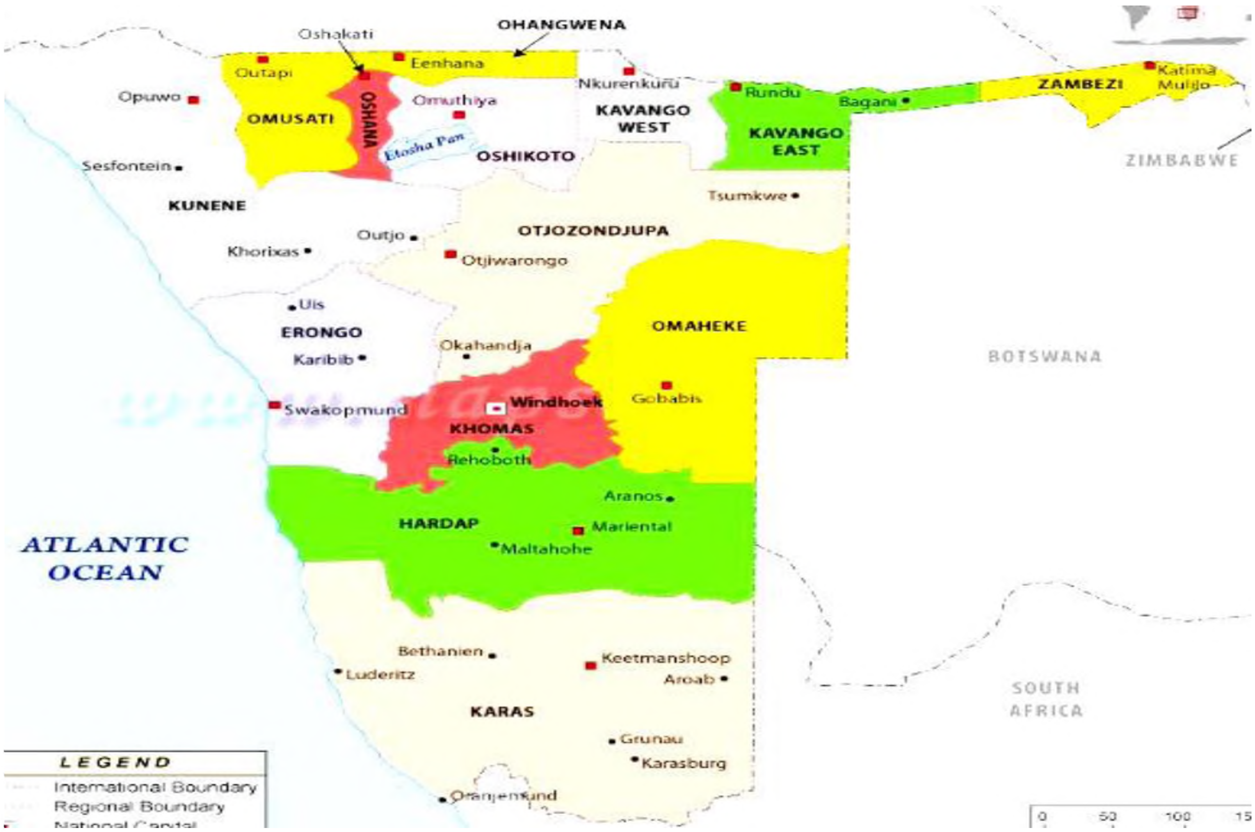

Figure 7: Showing 14 regions of Namibia

This government combined school is situated in the central part of Nkurenkuru town. It offers classes from grades 5 up to 10. At the time of this study in 2016, the school had registered 852 learners of which 414 were female and 438 were males. The staff included 29 teachers, 21 being males and 8 females. The school has adequate, conducive classrooms with a Science laboratory and School library and are led by more knowledgeable people.

3.5 Sampling and Participants

Sampling entails deciding which participants are to be included in the research. There were five Government combined schools in the circuit that offered grade 5-10 and were thus suitable for the purpose of this study.

According to Bertram and Christiansen (2015), convenience sampling entails selecting a sample which is easy for the researcher to reach. Similarly, Cohen, et al. (2011) noted that in convenience sampling, a researcher chooses the sample from those people who provide easy access. Also, purposive sampling was used to choose the grade because the main study of the concepts of *sound* starts in grade 10. Therefore, grade 10 was chosen at this research site, which consisted of 15 males and 15 females of the 30 learners.

The data gathering techniques used in this study are discussed below.

3.6 Data Gathering Approaches

The effective use of a particular tool depends firstly on selecting an appropriate tool. For instance, it would be impossible to design a learning program involving dance and signing without first capturing video images of dances and singing concert and observing them. Thurmond (2001) recommended employing a variety of data gathering techniques in the same study so they can supplement each other and enrich the data (Denzin & Lincoln, 2008). A process where two or more data gathering techniques are used is referred to as triangulation (Thurmond, 2001; Denzin & Lincoln, 2008).

The researcher must collect and store multiple sources of evidence comprehensively and systematically, in formats that can be referenced and sorted, so that the converging lines of inquiry and patterns can be uncovered. Researchers carefully observe the object of the case study and identify causal factors associated with the observed phenomena (Shoaib & Mujtaba, 2016). Renegotiation of arrangements with the objects of the study or addition of questions to interviews may be necessary as the study progresses. Case study research is flexible, but when changes are made, they need to be documented systematically.

The idea of triangulation was initially pioneered by Campbell and Fiske (1959) to embrace multiple methods used to gather data (Foss & Ellefsen, 2002). Foss and Ellefsen (2002) claim that triangulation is a strategy used to strengthen data accuracy and access a precise representation of reality (Cohen et al., 2011). To that end, the project was designed as a qualitative case study where insight into the participants' thoughts, voice and context were at the heart of the study (see Section 3.2.2). On that note, both qualitative and quantitative approaches were used, as highlighted in Section 3.2.2, to explore the case under study. According to Ramasike (2016), methodological triangulation consists of qualitative and quantitative data sourced from research participants for the study.

Data from the 30 learners' diagnostic test were used to determine whether the research participants hared the same sentiments with regard to prior knowledge on sound and echo. Methods for assessing diagnostic status are not described but some information is provided about developing or evaluating a test, or other data gathering techniques A range of data gathering strategies was used at different stages of this qualitative case study, as explained in the following section.

3.6.1 Documents

Documents used as a data source included learners' responses on the diagnostic test, summative test responses, and completed worksheets from an echo and waves activity; these provided insight into how learners make sense of different concepts on the topic of *sound*. Additionally, the examiners' reports were analysed to strengthen the context of the study.

3.6.1.1 Diagnostic test responses

Cohen et al. (2011) defined a diagnostic test as an in-depth check to discover particular strengths, weaknesses and difficulties that a learner experiences, and is designed to expose causes and specific areas of weaknesses or strength. Based on the definition, it is evident that a diagnostic test can be administered at any stage of the topic discussion. In this study, a diagnostic test was used at the beginning of the research process, to elicit learners' prior knowledge in order to inform the intervention lessons.

Grade 10 Physical Science learners at the research site were informed about the purpose of the diagnostic test before it was conducted. Learners were also made aware of the subject content area to be covered in preparation for the diagnostic test. This subject area comprised echo and waves under the topic of *sound*. The diagnostic test was informed by the National Curriculum for Basic Education known as Curriculum 2010 (C2010) and considered the grade 10 Physical Science content on *sound* – echo and waves. The diagnostic test (see Appendix F) was administered to 30 grade 10 learners.

The learners' scores from the diagnostic test were used to categorize learners into achievement levels The 15 research participants were selected from all the achievements. The data gathered from the diagnostic test was presented and analysed in chapter 4. Strengths and weaknesses in the learners' prior knowledge of echoes and sound were identified. Such weaknesses might come from misconceptions or alternative conceptions or an inability to make sense of echo and waves concepts and/or an inability to link the required information with prior knowledge. Weaknesses identified from the diagnostic test were considered to be addressed in the planned intervention lessons. The areas where learners showed understanding were also covered in the planned lessons so as to show content progression. After that, the intervention lessons were drawn from the unit of work. The unit of work consisted of a collection of intervention lessons which I taught throughout the research study process.

Centrally, the diagnostic test responses were presented and to answer the research question: What factors enable or constrain grade 10 Physical Science learners' understanding on the concept of wave and echo, on the topic of *sound*? Data obtained from the diagnostic test responses served as a foundation for the presentation of Grade 10 content on *sound*. At the end of the research process particularly the lesson presentations, the focus group members were given a summative test.

3.6.1.2 Summative test responses

According to Biggs (1998), a summative test/assessment can give insight on the understanding of the content presented. This assessment checks the impact of the teaching and learning process as well as evaluating learners' performance (Stiggins, 2005). In Stiggin's (2005) terms, the rating of learners' performance informs the scores which appear on school report cards; however, that was not the focus of this study. The purpose of the summative test was to determine the extent of achievement of the study's goal as well as the challenges that learners experienced when the echo and waves concepts were mediated through traditional music and dance.

The summative test was set and administered to the 15 focus group learners at the end of all the lesson presentations. The learners were chosen purposively based on their diagnostic test achievement levels. The test was aimed at checking on the effect of the intervention on learners' cognitive development, so answering the research question and providing data to be used in selecting interviewees.

The types of questions set in the summative test were mostly designed to probe deeper into the content. It consisted of multiple choice questions (MCQ) and structured questions (SQ). The MCQ that required explanations encouraged more thinking, and structured questions also challenged the critical thinking of the participants. The responses that learners gave were presented, analysed and interpreted to determine the role played by traditional performance together with an interventional activity in learners' sense-making of the concepts of echo and waves, on the topic of *sound*. The data were also used to indicate the effect of learning in an environment where learners were allowed to share their thoughts. The indicated end product to learning was critical to strengths, weaknesses and possible opportunities for incorporating the two central meditational tools under study. The data gathered from the summative test were used in selecting interviewees as discussed below (see Section 3.6.4).

The selection of interviewees was based on the difference in scores between the diagnostic test and summative test. The deviation between the two tests was used to gauge the measure of development the study had on learners' thoughts. The nature of answers pointed to how learners were constructing their ideas at the end of the study, which measured the effect of scaffolding and ZPD (an element of the theoretical framework). Ultimately, summative assessment was used to find out the effectiveness of the study goal.

3.6.2 Classroom Observation

Classroom observation allows the researcher to gather a wide range of information by looking at interaction, verbal expressions, gestures, body orientation, body movement, utterances and facial expressions. During observation the researcher goes to the site of the study and obtains first-hand information (Bertram & Christiansen, 2015). In the context of this study the participants' behaviour was observed during the course of the teaching intervention. The focus of this observation was on signs of confidence and the attitude of learners to grasp the reflection of *sound* formed by a building wall and the wave patterns formed on the oscilloscope during the dance performances.

Observation was thus one of the methods used to gather data. It offered an opportunity to gather 'live' data taking place in a social situation (Cohen, Manion & Morrison, 2011). Through observation one could get the real view and sometimes a sense of what was happening.

Phase one: observations and recording. In order to achieve the main goal of the study, video recordings were used to capture learners' dance performances. Video recordings were also made during the intervention program and this made it possible to capture behaviours and multifarious interactions. Video recordings allowed the investigator to re-examine data again and again (Mbusi, 2011). I was interested in echo and waves, through traditional music and dance, as well as in learners' dispositions toward science and their behaviour when they engaged in dance activities. Learners' behaviour and attitudes can be captured with a greater precision when using video recordings than when using observation notes (ibid).

Using video recordings allows the researcher to observe an activity afterwards, by watching the footage without the disruption of the classroom and/or time constraints (Koshy, 2005). Observation of images captured in this study enabled both the learners and me to enhance the understanding of *sound* waves. Learners were able to understand how instruments work and create music with their handmade instruments, which was a valuable learning outcome.

The video recordings had stimulated learners to understand how musical instruments work and what constitutes a sound wave, how sound changes depending on wave's longitude and amplitude, how a sound wave travels through different media and resonates with different materials. Using traditional music and dance in teaching science thereafter added to the knowledge of learners and helped them to master the concepts of wave and echo through observing waves patterns formed on the oscilloscope during traditional dances.

It was initially planned to visit the school during one afternoon to video-record the dance performances. The key musical instruments to be used during this dance concert were ready and the oscilloscope and sound system were also available. Both school boys and girls were in their traditional attires which is customary whenever traditional dance is performed. At first I recorded the dances impulsively as they were performed. Still, there were cases where learners made mistakes in their positions and I had difficulties in the setting of the oscilloscope and the sound system. These irregularities and their effects are discussed in the next chapter.

Even though video recording is a valuable technique for gathering data, it is not without limitations. Video cameras cannot capture everything. In aiming a video camera, researchers edit and make sampling choices to focus on or avoid particular events (Powell, Francisco & Maher, 2003). For instance, in my own video recording, I tried to focus the camera on those learners who were playing the drums using their bare palms to produce rhythm and melody.

Phase two: observation of video images. Video enables researchers to watch the same sample of events over and over again, each time looking at a different dimension of the recorded verbal and physical behaviour (Mbusi, 2011). Firstly, I watched the video alone to recognize relevant science concepts for grade 10 curriculum. I watched the video repeatedly to get a clear idea of how certain aspects of the dance performances could fit in the program of sound. Later on, I watched the video jointly with the learners, which had elements of a stimulated recall interview (see Section 3.6.5.2). We carefully observed and listened to the handclaps, drum beats and singing to see if they formed a rhythm and melody as well as observing the formation of wave patterns on the oscilloscope and echoes since the dance performance was done close to a building wall.

In terms of validity, it was necessary, after attentive observation, to ask learners to repeat some performances in order to get precision on some rhythm and melody of the *sound* produced. The video images made it possible for both the participants and me to explore many facets of the data. This was, however, strengthened by interviews.

3.6.3 Interviews

Cohen, et al. (2011) defined an interview as a two-person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information. According to Reardon (2016), an interview is a transaction of views between two or more people on a topic of mutual interests aimed at knowledge production.

In qualitative studies, interviews essentially refer to oral questionnaires. The interview technique is flexible and adaptable. The primary advantages of the interview are its potential for accommodating peoples' thoughts even for those who are illiterate or too young to read and write; and those responses can be probed, followed up on, classified, and elaborated to achieve specific accurate responses (McMillan & Schumacher, 2010. Also, nonverbal and verbal behaviours can be noted in a face-to-face interviews and the interviewer has an opportunity to motivate the respondent.

As Maree (2010) explained, an interview is a two-way conversation in which the interviewer asks the participants questions in order to collect data and learn about the ideas, beliefs, opinions and behaviours of the participant. Kvale (2006) placed several kinds of interviews along a series of continua, arguing that interviews differ in the oneness of their purpose. He stated that interviews allow the researcher to investigate and prompt on things that may otherwise go unobserved. For the purpose of this study, I used two types of interviews, namely, focus group interviews and stimulated recall interviews.

3.6.3.1 Focus group interviews

A random selection of learners was made allocating them into three groups each of four learners. An equal number of two boys and two girls were chosen in a group. These groups were consistently used in both sessions as discussed below.

Essentially, a focus group interview is a form of group interview which relies on the interactions within the group who discusses a topic supplied by the researcher (Uushona, 2013). Focus group interview strategy is based on the assumption that group interactions will be productive in widening the range of responses, activating forgotten details of experience and releasing embarrassment that may otherwise deter participants from disclosing information (Maree, 2010). During this data gathering technique, applied in my study, participants were able to build on each other's ideas and comments to provide in-depth views not attainable from individual interviews. Unexpected comments and new perspectives were explored easily within the focus group and that added value to the study.

I acted as moderator to direct discussion among four people with the purpose of collecting in-depth qualitative data about a group's views, attitudes and experience on a defined topic of the study. The focus group interview provided valuable information on how participants talk about a topic and how they respond in a situation where they are exposed to the views and experiences of others about the topic under the study. This was done firstly to promote interactions and open discussions of the participants' views and experiences. Secondly, it helped in the analysis of the data through an understanding of what was happening in the group as well as why it happened.

Thirdly, the focus group interviews explored learners' ideas on or thinking about their experiences of learning science (echo and waves, on the topic of *sound*) through dances. For instance, I was interested to know whether they thought the dance helped them understand science concepts better or not. Additionally, I also conducted stimulated recall interviews (SRI) through a video play back.

3.6.3.2 *Stimulated recall interviews*

Shubert and Meredith (2015) viewed stimulated recall interview as a suitable technique for assessing a curricular intervention and found evidence that epistemological resources suitably describe learners' epistemologies. A sub-sample of 15 grade 10 Physical Science learners was purposefully selected to take part in a stimulated recall interview conducted after the diagnostic test and traditional dance. The selection was based on their performance during the diagnostic test and after watching video footage of the traditional dances.

The stimulated recall interview provided a contextual and interpretively valid scheme to access learners' epistemologies that complemented existing methods to mediate learning. This might seem impossible in practice; how can learners engage in authentic learning and reflect deeply on that learning simultaneously, without changing what I hoped to explore in the study? I argue that a stimulated recall interview using a new methodology, moved closer to accessing this rich, privileged data.

3.6.4 Intervention plan on integrating traditional music and dance

The first aim of this intervention was to give a theoretical overview of aspects of the conceptual framework regarding learning through a social context as espoused by Vygotsky (1978). According to Steenbeek, Van Geert and Wetzels (2016), acquiring conceptual skills is a continuous process of learning growth and encompasses all types of facilitated learning opportunities. In this study, informal learning opportunities situated in practice were considered an integral part of the learning atmosphere in teaching echo and sound waves. Informal learning opportunities were necessary because, firstly, they enabled learners to learn and use the knowledge acquired during traditional music and dance; and secondly, they helped to align with developments in society and the production of sound.

Therefore, I designed a learning plan through which learners worked on activities that integrated traditional music and dance. I see this programme as resonating with (Christen & Murphy, 1991) the notion of '*activating prior knowledge*' in these ad hoc practices. My approach to designing a learning plan is similar to that used by Balocnit (2016) in connection with the Physics involved in the traditional musical instruments of the Kalingas from Luzon, in the Philippines. Balocnit (2016) focused on the records of the different traditional and cultural dances of the Kalingas and their relation to Physics. In this way, he was able to create an opportunity for learners to align playing of Gongs and Toppaya for the rhythm and melody of the *sound* produced.

The learning program that I designed supported learner-centred approach to learning. Nyambe and Wilmot (2012) described learner-centred pedagogy (LCP) as one where the teacher becomes a facilitator, while the learner becomes an active pedagogic agent. This means that teachers plan tasks and various activities for learners and then facilitate these in class or any arena where learning is taking place. Teachers facilitate learning and, at the same time, give assistance and direct the learning as proposed by Vygotsky's (1978) socio-cultural theory. Learner-centred pedagogy is an approach that gives teachers the opportunity to empower learners so that they can be actively involved in class and do things for themselves instead of getting it from the teacher all the time (Nyambe & Wilmot, 2012). So, when we talk about learner-centred pedagogy, we think in terms of making learners to be involved in the whole teaching and learning process. Particularly during the classroom situation, you do not want to see the learners seated, listening to the teacher all the time and at the same time taking notes, and sometimes they do not even understand those notes. There should be some sort of movement, talking, working and engaging learners in the traditional music and dance to illustrate *sound* wave are part of the LCP.

Through the implementation of the learning programme in my study, learners became actively involved in their learning by performing dance and singing. During the performing, learners were clapping hands and playing (beating) drums- *Ngoma* placed near to the microphone connected to oscilloscope to observe the elements of *sound* namely; amplitude and wavelength.

The design of using traditional music and dance in the approach described above to learn about the Physics concepts, specifically echo and waves on the topic of *sound*, is aligned to the theory of enactivism. Enactivism is a theory of the mind that encapsulates the full human system.

It considers that the human mind consists of -and is clued-up by- the complex and hectic interactions between the brain, body, and environment in the process of sense making (Wright-Maley, 2016). In this study, this system was deployed for learning Physics concepts – *sound* and its associated concepts in the classroom situation. This study relied on traditional music and dance to produce *sound* and its influences. Bartlett's (2016) idea was incorporated: that cognition is reliant on the kinds of experience that come from having a body with distinct sensor motor capacities.

The notion that learners' experiences can be used to enhance their learning is the foundation of the theory behind experiential learning of for example, *sound* properties. Experiential learning is a process of constructing knowledge that involves a creative apprehension along the cycle of four stages of learning styles and learning spaces, namely: reflecting, thinking, experiencing and acting (Ching, Forte, Aitchison & Earle, 2016). Linked to their experience, learners are able to reflect, think and act on situations they come across through the process of learning. Thus, in this study learners reflected on their experiences of performing traditional music and dances. They recalled and thought about the rhythm and melody of the sound produced and the phenomena of sound observed on the oscilloscope. This encouraged them to take some action to explore and discover different Physics concepts.

The researcher's role during the implementation of the learning programme became that of a facilitator, with the purpose of developing learners' thinking and/or reasoning skills. This was performed by posing questions which probed learners' knowledge deeply, constantly asking: "Why"? "What do you mean?", "How do you know that's true?" (Mbusi, 2011, p 20). This approach is consistent with socio-cultural theory which formed my theoretical framework.

Gerber (2001) described the learners' behaviour in each phase of the learning cycle. For instance, in the first phase, (exploration), learners participated in activities associated with science concepts such as waves. Primarily, learners were unaware of specific science concepts to be learned. The intervention of this study was based on the science process skills of the activities that had to be demonstrated during the dance performance. Learners shared their newly acquired data with other learners and the teacher/researcher, and concepts were defined. Science terminology of the concepts was presented usually during the lesson presentation (ibid).

As a result, learners expanded their newly learned concepts to additional experiences. This learning program encouraged learners to use appropriate science terms associated with the science concepts as they extended their knowledge and skills to similar activities, such as, traditional dance. Each lesson included an additional, unique reference feature to attest how the science concepts were crucial to traditional dance in this study. Through each class lesson, learners were shown slides of the dance performances; and they had to point out how the science concepts in the lessons related to the properties of sound such as amplitude, wave length, and frequency.

3.6.5 Brainstorming and discussions

Brainstorming is an exploratory method that is open to the creation of new ideas (Homateni, 2012). During the brainstorming session, learners were divided into five groups, each of six learners. Learners were tasked to discuss their everyday experiences about echo and waves, on the topic of sound. The groups were actively engaged and they discussed what they heard from their communities and their own experiences. The discussions were mainly in English, but learners decided to discuss in their vernacular language as well (that is Rukwangali) to express the meaning of echo. The term for echo in Rukwangali is *sikumo*.

Table 1: Data gathering strategies at different stages

Stage	Methods used to gather data	Data to be gathered	Purpose
Stage 1	Brainstorming, diagnostic test and discussion (The lesson was videotaped) Preparing for traditional music and dance	Learners' prior knowledge of the concepts of echo and waves on the topic *sound*	To align science embedded in traditional music and dance; To integrate the prior knowledge of learners;
Stage 2	Unit of work and observations	Learners' sense making of science concepts - including drawing waves and use of echo	Execute the IK into waves and echo during the lessons on sound
Stage 3	Summative test and stimulated recall interview	Factors influencing learners' sense making towards science	Analysis of the summative test and the stimulated recall interview provided data to answer sub-question 4

Stage 1: In this stage, I divided the learners into six groups of five and asked them to brainstorm and discuss about their traditional music and dance, while thinking about the formation of sound. Through group interactions, learners were able to share their range of everyday knowledge across domains and epistemologies including cultural practice, community and theoretical, spiritual and experiential knowledge (Stears & Malcolm, 2005).

A diagnostic test (see Appendix E) sourced from Caleon and Subramanian (2010) on waves was modified and administered to the whole class of 30 learners to assess the level of relevant prior knowledge they had gained from earlier grades. Diagnostic testing is an in-depth test to discover particular strengths and difficulties that a learner is experiencing (Cohen et al., 2011). It is important to determine the level of prior knowledge learners have since that enables them to learn new concepts on echo and waves, in the context of this study (Taylor & Fedoroff, 1999).

Stage 2: A unit of work on waves and echo, on the topic of *sound* was developed for this stage. An expert was asked to critically review the unit of work checking for clarity and convenience of the language used, precision of concepts and alignment with the grade 10 Physical Science curriculum (see Appendix F). Within the unit of work were tasks on echo and waves in which learners had to work collaboratively. These tasks were used to explore how learners made sense of the drawing of waves and uses of echo. The data gathered through video recording, observation and analysis of written work were used to answer sub-questions 2 and 4. Traditional dance took place at this stage and a cathode-ray oscilloscope and sound system was used to allow the observation of the wave form. These instruments enabled learners to align the wave pattern studied during lessons taught and those formed on the oscilloscope during performance.

Stage 3: The whole class wrote a summative test to get a better understating of the difficulties faced by learners. I then watched the video and undertook stimulated recall interviews (Lyle, 2003). Analysis of the summative test and the stimulated recall interview provided data to answer sub-question 4.

3.7 Data Analysis

The technique used to analyse data depends on the purpose of the research (Cohen et al., 2011). Qualitative data analysis involves organizing, accounting for and explaining the data (ibid). The videotaped interviews were transcribed verbatim so that information is not lost. According to Cohen et al. (2011), transcription can be a reliable source of detailed information and an accurate record of interviews. Qualitative data was colour coded and then categorized into themes. The outline of this study noted that learning takes place in a social context and that learners' dispositions are essential for analysing the data. The theoretical framework was thus a guide to the entire data analysis process. The lens of the socio-cultural theory of learning requires the identification and analysis of social interactions of both learners and teachers within the communities. This involved language, culture, beliefs, attitudes, perception, disposition and experiences. Additionally, for the purpose of analysing the data, I adopted indicators on the conceptions and dispositions from Atallah, et al. (2010).

Table 2: Indicators on conceptions and dispositions

CONCEPTIONS	
C1	Describing what learners think the subject is - their ideas or thoughts about the nature and source of the topic (e.g., universal beliefs, social patterns and elements of the topic *sound*)
C2	Sketching what the concepts are - the imagination of the elements of sound; amplitude, echo, wavelength etc.
C3	Describing what they believe is appropriate to learn on the topic *sound* (inside classroom or outdoor activities)
C4	Describing what they think is the purpose of studying the topic *sound* (why is it included in the school curriculum, its usefulness in everyday life such as echo)
C5	Describing what they believe indicates that they have learned the concepts of sound (how do they know that they have learned?)
DISPOSITIONS	
D1	Describing their ability in science and on the concepts related to sound (themselves as learners)
D2	Describing their attitudes towards science in the delivery of lesson on the topic of *sound*
D3	Describing their expectations about the elements of sound. (What will it help them achieve?
D4	Describing the learning approaches used to study echo and waves on the topic *sound* (for example, deep/surface learning)
D5	Describing the perceived value of the subject (everyday uses of sound - echo)
D6	Describing the evidence that they would provide to others as a "proof" that they have learned the sound related phenomena, such as echo and waves etc.

Source: Atallah, Bryant and Dada (2010, p. 48)

3.8 Ethical Considerations

Bertram and Christiansen (2015) emphasised that consent means agreement reached after discussion between the researcher and the research participants. In this study informed consent forms were signed by learners who are at the age of 18 and older before the data gathering process took place. According to Cohen, et al. (2011), informed consent involves the signing of a participation contract. Concurring, Ramasike (2016) stated that researchers should be mindful of ethics by considering the nature of the study, research questions, participants, context and the entire research process. To this end, ethics entailed informed consent, anonymity as well as confidentiality. As alluded to above, participants signed the consent forms after the research highlights and expectations had been discussed (see Appendix C).

Protecting individual autonomy occupied a central place in the study, particularly seeing that it involved human participants. Ramasike (2016) argued that when selecting a research site, it is crucial to obtain permission to access the site and conduct research among the respondents (see Appendix A). In addition, a researcher should indicate clearly in the letter requesting permission who he or she will be collaborating with, when, how and who needs to be present. Before implementing this research, letters were written requesting permission from the regional Director of Education, Inspector of Education and the school principal to conduct research at the selected school (see Appendices A, B & D).

Letters of consent were also delivered to the parents of the learners informing them about the aim of the research and asking for permission to involve their children in the study. Since the traditional dance and music was conducted after school hours, parents were invited to watch the performance and they motivated learners to build self-efficacy (Bandura, 1977) during the traditional music and dance. Rosnow and Crandall (1997) argued that informed consent is a procedure in which individuals choose whether to participate or not. Throughout the process of data gathering, data analysis and discussion, I kept in mind the issues of confidentiality and anonymity of the participants and research site (Bell, 2014).

3.9 Validity and Trustworthiness

In qualitative research, validity and trustworthiness might be addressed through honesty, depth, richness and scope of data achieved, the participants approached and the extent of triangulation, defined as the use of a variety of methods for data collection (Cohen, et al., 2011). Triangulation of data and member-checking are considered as ways to ensure that the data is valid and trustworthy as reiterated by Cohen, et al. (2011).

The interview transcripts were given back to the respondents to ensure the accuracy of the information. Basically, piloting of data gathering instruments was used for validation purposes. It was recognized, however, that even though all the requirements to ensure validity and trustworthiness of qualitative data were secured, there were bound to be some limitations.

The main purpose of conducting the diagnostic test in this study was to measure the learners' prior knowledge of conceptual content. This was to guide intervention instruction. Ideally, the diagnostic test should have pinpointed the level of knowledge and skills relating to echo and waves on the topic *sound*. Learners were not graded as in a traditional test. The summative test was designed to measure the conceptual development in the topic of echo and waves on the topic *sound*. These tests were validated by colleagues to assess the appropriateness of their level and the data gathering instruments. The stimulated recall interview while watching the video was to access the rich, privileged data using a new methodology.

3.10 Research Limitations

The results of this study were limited to the selected circuit, the Physical Science grade 10 learners, and therefore, they cannot be generalized. However, some insights on how to incorporate IK in science classrooms were obtained from this study. Furthermore, the presence of the video camera and its operator in the classroom might have changed the natural interaction among the participants. To address and minimize this possible interference, it was arranged that other lessons were videotaped before this main research took place, so that the learners became familiar with the recorder.

3.11 Concluding Remarks

This chapter discussed the methodological approach followed in this qualitative case study. The case study method used was presented, and its strengths and weaknesses highlighted. The research site and participants were described, as well as the sampling procedures. Data gathering techniques were discussed in the context of the purposes they served. Finally, the chapter discussed the purpose of undertaking a qualitative case study on how grade 10 Physical Science learners made sense of the concepts of echo and waves, on the topic of *sound*, when the topic was mediated through an intervention in the form of traditional music and dance. The data gathered is presented and analysed in the next chapter.

CHAPTER 4: DATA PRESENTATION, ANALYSIS AND DISCUSSION (PHASE ONE)

4.1 Introduction

The main goal of this study was to explore the possibility for the integration of traditional music and dance into the design and delivery of lessons on the concepts of echo and waves on the topic of *sound* in grade 10 Physical Science, and how such integration influences (or not) learners' sense-making and dispositions towards science.

This chapter accordingly presents, analyses and discusses data generated from a diagnostic and a summative test, classroom observations and interviews. The identification of themes was guided by the socio-cultural theory which formed the theoretical framework of this study. The data generated provided answers to the following research sub-questions:

- What factors enable or constrain grade 10 Physical Science learners' understanding of the concept of waves and echo on the topic of *sound*?
- What factors influence grade 10 Physical Science learners' sense making and dispositions towards science when taught the topic of echo and waves in a traditional way?

4.2 Diagnostic Test Results

The main purpose of the test in this study was to assess the learners' prior knowledge in the topic of *sound*. This was intended to provide direction to the intervention instruction. Figure 8 below shows the outcome of the diagnostic test as was written by 30 grade 10 class of Physical Science learners at the research site (see Appendix I).

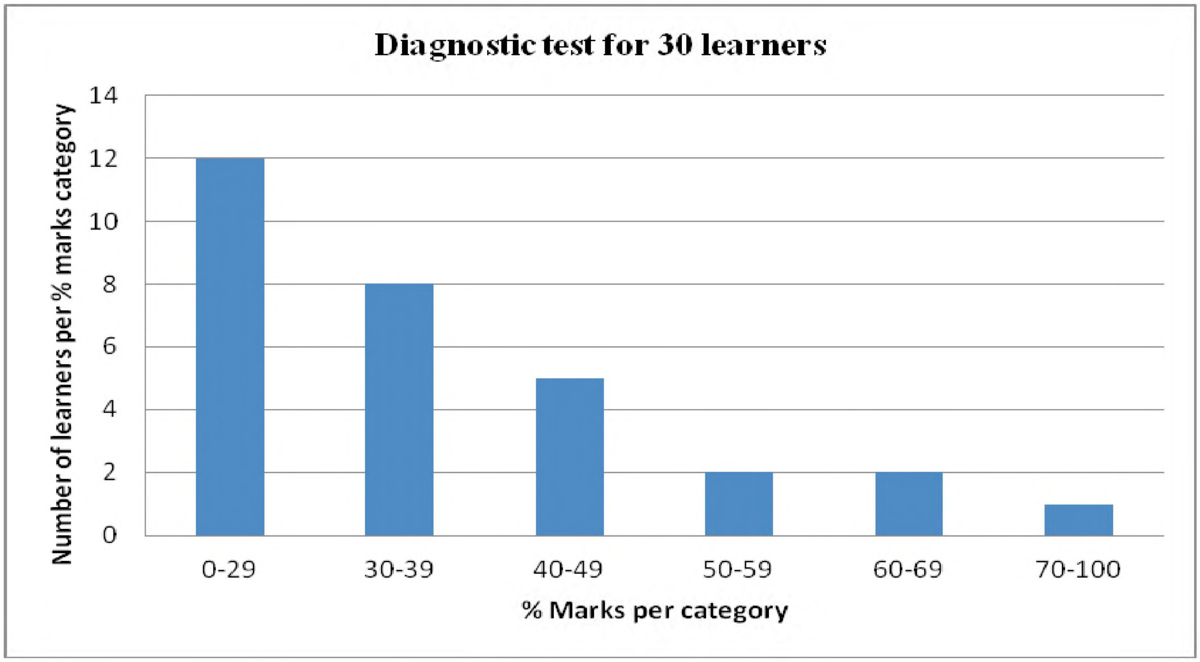

Figure 8: Diagnostic test results

Figure 8 shows that only three of these 30 learners managed to score 60% and above in the diagnostic test. Note that the pass requirement in Physical Science in Namibia is 40% (an E grade or better).

A sample of 15 learners based on their diagnostic performances was chosen for a detailed analysis. The diagnostic test results for these fifteen focus group learners are shown in Table 3 below.

Table 3: Detailed scores for diagnostic test

		Marks to be awarded in each part of question is shown below										
		Question 1				**Question 2**			**Question 3**		**Total Marks**	**%**
Pseudonyms: Given by learners themselves		a)	b)	c)	d)	a)	b)	c)	a)	b)		
		2	**3**	**3**	**2**	**2**	**2**	**3**	**4**	**4**	**25**	**100**
1	Shikulimanga	0	3	3	0	0	0	0	0	4	**10**	**40**
2	Hegel	2	3	3	0	2	2	2	3	4	**21**	**84**
3	Kim	1	0	0	1	2	2	2	3	4	**15**	**60**
4	Ndambu	2	2	3	0	2	0	1	2	0	**12**	**48**
5	Tulinendi	0	0	0	0	2	2	0	3	4	**11**	**44**
6	Kandindi	1	0	3	0	0	0	2	2	2	**10**	**40**
7	Sirenga	1	3	3	0	0	0	0	0	2	**9**	**36**
8	Naiye	2	0	0	0	2	0	0	3	2	**9**	**36**
9	Tokki	0	0	3	1	0	0	0	0	4	**8**	**32**
10	More	0	0	0	0	2	0	1	1	2	**6**	**24**
11	Mukucha	0	0	0	0	2	2	0	1	2	7	**28**
12	Lala	1	0	0	0	2	0	0	0	2	**5**	**20**
13	Imaneni	0	0	0	0	0	1	0	1	4	**6**	**24**
14	Sapira	0	0	0	0	0	2	0	1	4	7	**28**
15	Tumona	1	0	0	0	0	0	0	0	2	**3**	**12**
Average											**9**	**36**

It can be seen from the above table that some questions were answered well, whereas others were poorly answered and while some were not attempted by some learners. In sub-questions 1b-c, 2a and 3a-b learners managed to score 50% or more. The diagnostic test results for the focus group learners are ranked in Figure 9, below.

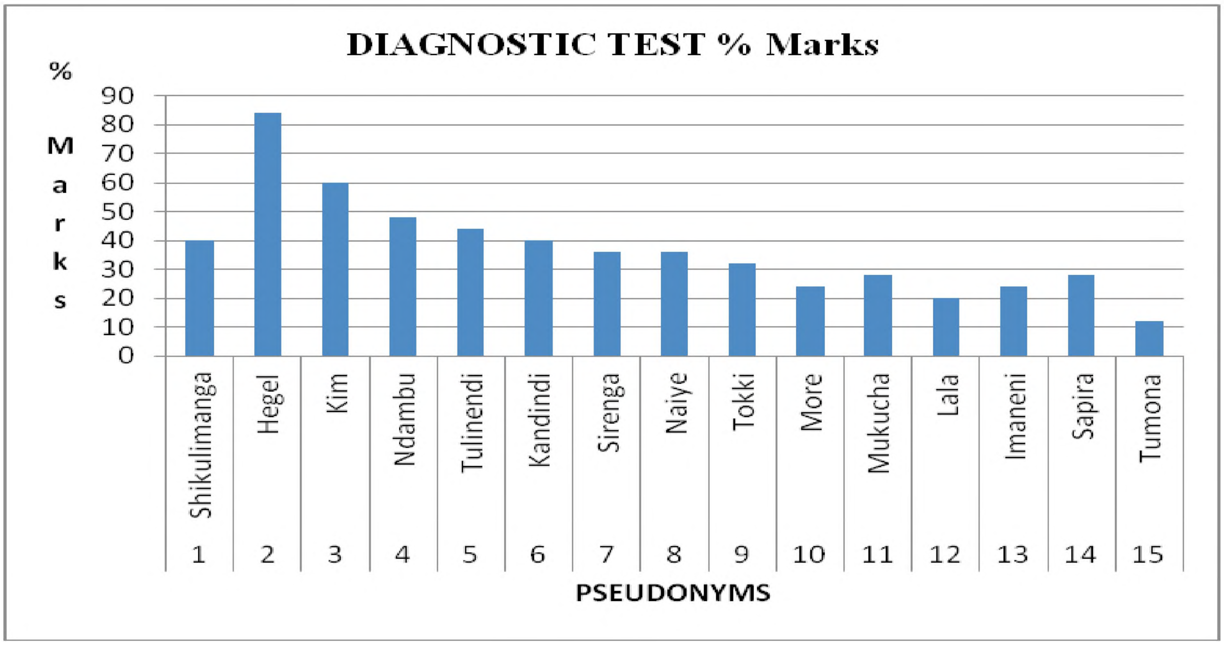

Figure 9: Diagnostic test results for the focus group members

From these scores, the following learners *Ndambu, Hegel, Tulinendi and Kim* were identified as higher achievers whereas *Shikulimang, Kandindi, Mukucha, More, Sirenga, Naiye and Tokki* were identified as average achievers at an E grade according to the Namibian standards. And *Tumona, Lala, Imaneni and Sapira* were identified as low achievers. In terms of abilities, it could be argued that these fifteen learners formed a heterogeneous focus group.

Five of these 15 learners (33%) were able to explain how the sound waves reach bats. Ten learners (67%) were able to identify the common name of a reflected sound-echo. Five learners (33%) provided a correct formula when calculating *sound* phenomena such as wavelength, speed of sound in air, echo and so forth. The diagnostic test revealed that 12 learners (80%) were able to identify the amplitude, crest, wavelength and trough of the wave.

The best answers were obtained for question 3b where only one student failed to achieve 50% (2 out of a possible 4). The poorest answers were for question 1d where only two learners (13%) achieved a mark.

Based on the Table 4, it is clear that even the low achievers managed to score some marks in the diagnostic test. That is, most learners were able to demonstrate partially how a bat uses echo to detect its prey and estimates the distance between it (bat) and the prey. The diagnostic test responses thus informed the planning of the intervention.

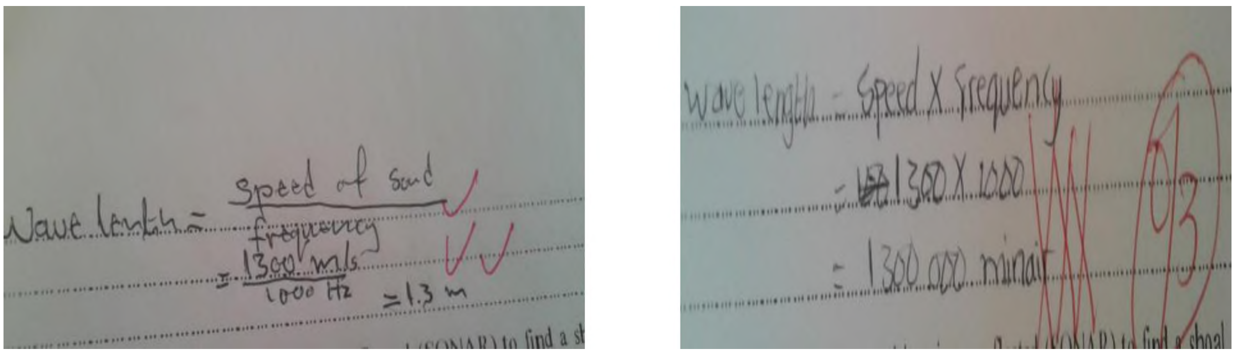

Figure 10: A sample of how two learners calculated the wavelength of a sound wave

The learners were expected to calculate the wavelength of a sound wave as shown in Figure 10 above. All learners correctly identified the actual speed and frequency as required when calculating wavelength. However, two learners (13%) swopped the formula for calculating wavelength. This indicated an alternative conception that these learners had with regard to the calculation of the reflected sound-echo of the ship. Apparently it was not easy for learners to recognize the formulae for calculating distance from the time taken to receive the echo (0.2s after transmission). Since *speed of sound in water is 1300 m/s therefore 1300m/s ÷ 0.2s = 260m*. So, distance from vessel = *260m ÷ 2 =130 m.* Even though many of the learners did not manage to find the distance travelled by the reflected sound after transmission, they did manage to name the common name for the reflections of sound - *echo.*

The diagnostic test enabled me to identify the content gaps and misconceptions amongst these learners. From the results of the test, a unit of work was designed and implemented (see Section 3.6.1.1 and Appendix F). The results of the summative test for the focus group learners are presented below for comparison with the diagnostic test results to indicate the achievement growth of learners.

4.3 Summative Test Results

At the end of the intervention, a summative test was administered to assess changes in learners' sense making of echo and wave on the topic *sound*. Figure 11 below shows the summative results of the focus group learners

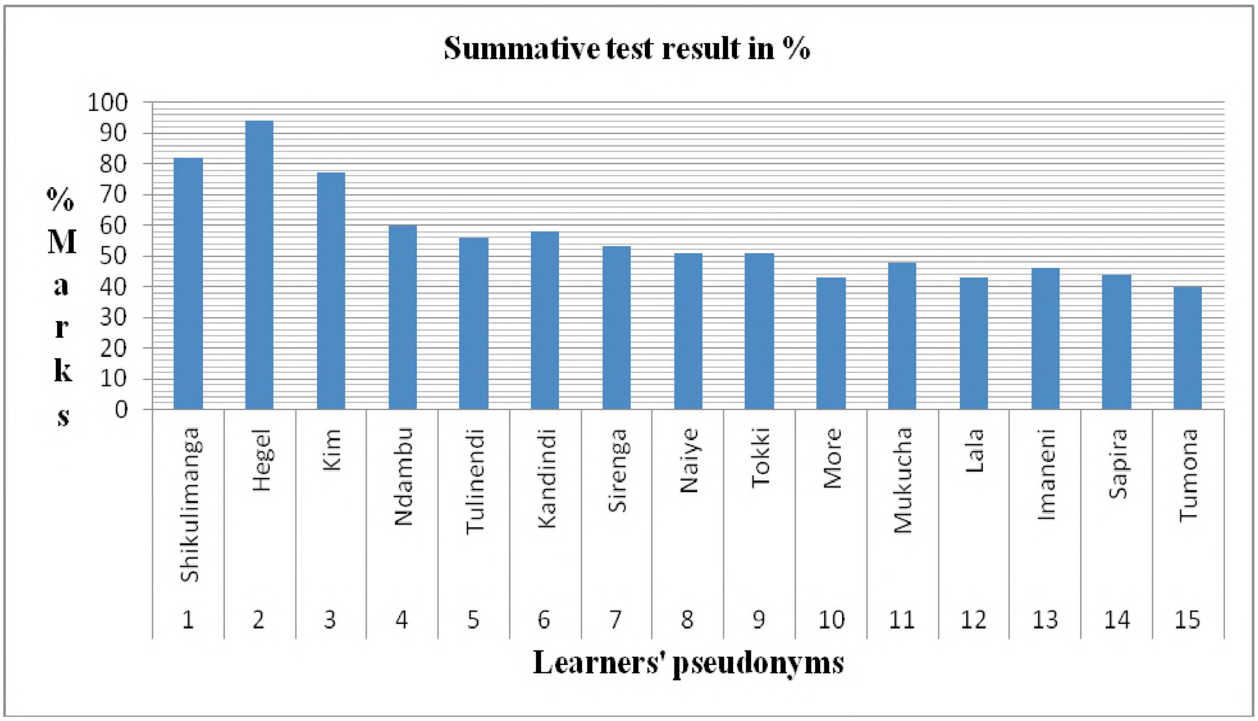

Figure 11: Summative test results for the focus group members

The following section discusses the specific individual changes in scores for the two assessments. The summative test results showed that all learners had improved compared to the diagnostic test results.

4.4 Diagnostic Test and Summative Test Variation

Table 4 shows specific individual change in scores for the two assessments.

Table 4: Difference in scores between diagnostic test and summative test

PSEUDONYMS		DIAGNOSTIC TEST % MARKS	SUMMATIVE TEST % MARKS	VARIATION
1	Shikulimanga	40	**82**	**+42**
2	Hegel	84	**94**	**+10**
3	Kim	60	77	**+17**
4	Ndambu	48	**60**	**+12**
5	Tulinendi	44	**56**	**+12**
6	Kandindi	40	**58**	**+18**
7	Sirenga	36	**53**	**+17**
8	Naiye	36	**51**	**+15**
9	Tokki	32	**51**	**+19**
10	More	24	**43**	**+19**
11	Mukucha	28	**48**	**+20**
12	Lala	20	**43**	**+23**
13	Imaneni	24	**46**	**+22**
14	Sapira	28	**44**	**+16**
15	Tumona	12	**40**	**+28**

The degree of the variation was used to ascertain the effectiveness of the intervention and to choose sample learners for interviewing.

The quantitative data from both tests was used to demonstrate the degree to which learners made sense of learning through their iterative learning process. Heterogeneous grouping based on the variations shown in Table 4 were used when selecting interviewees.

Figure 12 below reflects individual changes in performance as measured by diagnostic test and summative test scores for the 15 focus group members.

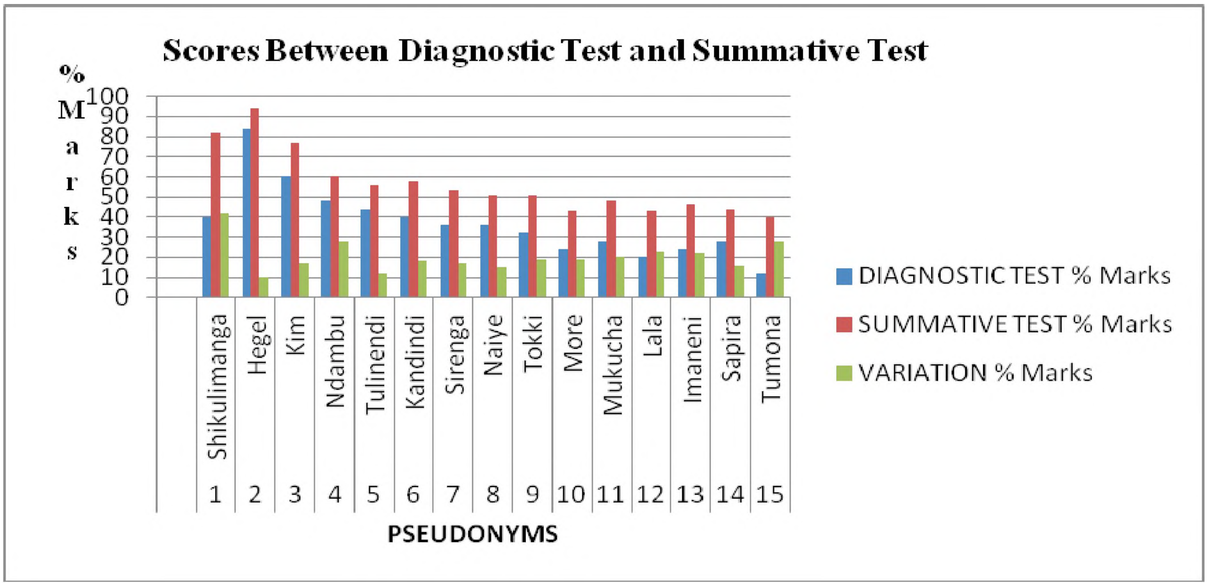

Figure 12: Diagnostic test and summative test scores

Figure 11 above demonstrates that there was a marked overall improvement in performance by the learners. All learners achieved above 40% in the summative test though only four learners managed to score 60%. Overall, the summative test scores were much better than the diagnostic test in which 40% of the 15 focus group learners scored in the range of 12% to 29%. The improvement was particularly clear in the following learners: *Lala* and *Tumona*. These learners had been categorized as lower achievers from the diagnostic test *and yet Shikulimanga* whose moderate diagnostic score is doubled. It could be argued that the improvement was considered to be influenced by the use of different meditational tools such as traditional music and dance, activity on the formation of echo, analogy and observation of the wave pattern (*sinusoidal waves*).

The diagnostic test had been used to elicit learners' prior knowledge on echo and waves. Assessment serves a primarily advantage in helping students meet certain standards; identify strengths and weaknesses in learners' performance, and to improve the quality of teaching and learning through effective designing of the following intervention. Rennie et al. (2011) pointed out that learners use prior knowledge to make sense of experience. The learners' responses on the topic of *sound* properties are discussed below.

In the diagnostic test, problems with calculation skills and applied science knowledge were identified. The inability to correctly label the wave patterns of the sound may lead to loss or distortion of scientific meaning. Nonetheless, some learners correctly provided answers based on the required questions in the diagnostic test, hence, demonstrating their understanding of some scientific ideas.

Admittedly, the responses to the diagnostic test indicated some strengths and weaknesses in concepts and calculation skills. Such responses needed to be considered when constructing new knowledge, attitudes and behaviours on the learning of echo and wave in sounds. So, learning began primarily from prior knowledge and only became secondary learning when new learning materials were introduced to strengthen the learning weakness (Roschelle, 1997).

4.5 Mediation

Lesson 1 (40 minutes)

The lesson began with the subject teacher introducing the researcher to the class and reminding learners about the aim of the visit. There was a great interest among learners and most of them wanted to demonstrate that they were capable of showing their competence on the concepts of echo and waves. Thereafter, the teacher further told learners that, I would spend time with them until at the end of the two lessons on echo and waves were completed. Thereafter, there would be a concert that would take place after these two lessons on echo and waves on the topic *sound*.

The teacher started by recapping the previous lesson on sound before going on to introduce the lesson of the day on echo. He started with the actual lesson by reading out to the learners the objectives of the lesson. The main idea was to tell learners what was expected of them as stipulated in the syllabus in this topic of *sound*.

Learners were then introduced to the definition of *sound* and key concepts were also identified, for example, *reflection, sound, energy* and *vibration*. The teacher explained what each of the identified concepts entailed. For instance, he said "*energy is the ability to do work – so, you* *(learners) are capable to hear my voice because sound is travelling in the form of energy to your eardrum*".

When he explained the meaning of echo, he had to contextualize it by asking learners:

1. *What do you hear when shouting at the riverbank?*
2. *How does a bat catch its prey?*

One learner explained that *"there is always sound shouting after us and bat use echo to find its food"*. The teacher then explained to the class that the reflected *sound* is known as echo. A bat sends sound and this sound is then reflected. That is, the sound is sent back when it hits an object that could be a prey. The reflection of sound was demonstrated during the dance (see the activity 1 for the reflection of sound (Figure 15)

Lesson 2 (80 minute-double periods)

The lesson of the day was building on the previous lesson. In other words, the teacher wanted to lead learners from the known aspect to unknown - i.e. eliciting prior knowledge. The teacher connected the reflection of sound – echo, to the lesson of the day 'types of waves' and further continued to engage learners in groups in order to develop their knowledge and understanding.

Learners were introduced to the properties of sound when studying waves: Amplitude; Crest; Wavelength; Trough; and Frequency.

I was able to probe the skills that supported learners in making sense of the discussions. It was observed in nearly all the video-recorded lessons that learners used the vernacular language (*Rungwangali*) to make sense, and showed an active commitment in undertaking the science knowledge.

During the discussions, learners used either English as the language of learning and teaching as per curriculum or they used *Rungwangali* as the home language in meaning making. The excerpts below demonstrate that sometimes learners used *Rukwangali* to make sense of meaning. (GR1 represents Group 1 Response).

GR1: *"Yinke ono dimburura mosi rongwa"* (Translation: What did you notice for the lesson) "Yeah when you pull the slinky, so, the slinky spread and make ring and rings, ok! *"Dize komeho no ko nyima"* (Translation: goes forward and backward (refers to the rings)).

GR2: "Naan!" (Translation: Oh! It is very interesting the slinky made us easier to "*temwinina"* (Translation: tracing the pattern of waves). Pencil usually goes up and down and then later crest, trough, wave length and amplitude for the wave were identified.

GR3: *"Hahaa!"* (laughing). Slinky was very easy to use when showing the example of *sound* and water wave. *"Uuwawee!" (*Translation:Enjoyable). When I pushed in s stick through slinky and this was representing period of the wave.

GR4: *"Eeno"* (Translation: Yeah). *Ove* (Translation: you) go and draw the wave pattern on the chalkboard. "*Damu-damu"* (Translation: exactly), plastic slinky shows the wave as that was displayed on oscilloscope. Ok! Tara (Translation: look) when 'Kim' speaks laud the amplitude become bigger as seen on oscilloscope- CRO.

This showed that learners made more sense when expressing GR4. So, that made it easier to align the relation between loudness and amplitude. Learners had an opportunity to demonstrate their experiences by drawing the wave patterns for low and high pitch on a green board. The excerpt revealed how learner made sense from the demonstration activity. The main object was to convey a message to the others through their home language of *Rukwangali.*

GR5: *"Nawa!, Ntani kuvhura kuwapa sene kuziguruka enkupi alyo Kunene pa"* (Translation: Well!, will be right to say the loudness cause the wave to become bigger?)

The diagram led the learner to explain his understanding of the concepts to fellow learners. GR5 further suggested the reason was the loudness of the sound hence; large amplitude and short wavelength was expressed through a sketch as shown on the chalk board.

The process was observed to be helpful in constructing scientific knowledge. Learners showed active engagement in discussions when explaining on the plastic slinky and sinusoidal waves observed on CRO. So, the discussions were specifying the development of science reasoning. The excerpt showed that reflection occurred as the learners did a presentation to the group members. The sharing of ideas was extended to the support offered to one another as highlighted in the discussions of GR4 and GR5.

The ability to align a plastic slinky and wave displayed by CRO showed cognitive development and the assistance offered to less able learners was done through scaffolding. Below is the extract from worksheet response.

4.5.1 Extract from worksheet responses

During the intervention, learners had to complete worksheets while working in small groups of 4 members on practical activities involving longitudinal wave patterns. A plastic slinky was used to establish motion of sound.

The following excerpt was taken from Appendix J where the responses from different groups are indicated by bulleted points.

Predict what will happen to the motion of the plastic slinky when stretched?

There will be a force of attraction among the rings;

Once it is stretched the distance between coils will be enlarge;

Both coils will travel in one direction;

The coils will retain its position when released after been stretched; and

There be a shadow pass through coils as it vibrates.

One learner had to hold her end of the plastic slinky standing in front. While holding the slinky, A second learner shook the end of the slinky, *in a single motion*, back and forth very quickly (left and right, like a snake crawling), perpendicular to its stretched length. In this way a transverse wave was made.

All the groups managed to make connections from the activity to the targeted concepts. For example, a longitudinal wave vibrates parallel to (moves in the same direction of) wave travel (a good example being sound waves). A transverse wave vibrates perpendicularly (moves at right angles) to the wave travel (water waves are a good example). With reference to the plastic slinky, 12 learners (78%) from the focus group managed to trace and relate it to the wave pattern as was later demonstrated in the classroom observation using a CRO to display the *sound* phenomena whereas three learners (22%) aligned the motion to a force meter. The results showed that learners were able to make sense of the activity. Learners went to the extent of sketching the general wave properties.

Some learners expressed that they experienced a conscious excitement from being encouraged to cooperatively achieve the learning objectives. Also, more knowledgeable learners felt excited to be given an opportunity to assist their peers and during the process they discovered the benefits of social learning.

4.5.2 Sound Properties

General property of sound. A cathode ray oscilloscope (CRO) enabled the learners to see a wave moving back and forth. The horizontal axis represented time and the vertical axis represented the displacement of air molecules as they oscillated back and forth. The centre line represented the equilibrium position of molecules and as we spoke louder the maximum displacement increased. The sinusoidal waves observed on a CRO are a result of the microphone changing sound energy to electrical energy which in turn agitates the flow of electrons.

Sound emitter and the human hearing range. Humans can hear frequencies as low as about 20 hertz and as high as about 20 000 hertz. However, if a speaker, in this case, the drum's diaphragm oscillates back and forth more than about 20 000 times per second or so, we would not be able to hear such *sound* produced at high frequency. But, animals such as dogs can hear frequencies up to at least 40 000hertz.

What does a sound wave look like? Another key aspect of sound waves is the wavelength of the sound wave which is the distance between two compressed regions of the sound waves measured in metres [m]. Sound waves travel through air as a medium in much the same way as water waves travel through water.

Visualization on cathode ray oscilloscope (CRO). Sound waves can also be shown in a standard x axis vs y axis graph. This allows us to visualize sound and the resulting curves are known as the 'waveform'. In fact, since sound waves are easy to see and understand, we can often use an analogy to illustrate how sound waves behave. The wave form on the CRO led learners to make meaning and identify the phenomena of sound.

4.5.3 Discussion of observations

This section discusses the use of a plastic slinky to enable learners to make sense of the sound properties. A predict-explain-explore-observe-explain (PEEOE) approach was followed as proposed by Maselwa and Ngcoza (2003). Learner responses were probed by their active engagement in the demonstration activity of prior sketching explanations of the sound phenomena.

The activity revealed that all the groups managed to make connections from the activity to the targeted concepts. For example, a longitudinal wave moves in the same direction as wave travel (this is a good example of sound waves). A transverse wave vibrates perpendicularly to the wave travel (water waves are a good example). The activity led learners to identify and sketch the following: Amplitude; Wavelength; Crests and Troughs.

Learners were able to see these attributes of the wave from movements of the slinky and could connect them to the wave concepts. Thus, they experienced conscious excitements when learning was handled through collaboration leading them to achieve the learning objective. Such reflection led to redoing the activity for the purpose of mastering the concepts and completing the worksheet. To this end, Hegel commented that (see Appendix M):

> *"Both plastic slinky activity and oscilloscope visualization brought an effectively mediation in the learning of sound waves. I was excited to see how the slinky swing back and forth and the visual for the wave form. I enjoyed and it supported me on how to identify the sound properties such as amplitude, wavelength, crest, trough and period. I am convinced that science is around and anything can be used as long as it makes one to make sense out of it".*
>
> *"Traditional dance is not only useful during ceremony such as marriage and healing but, it has a role to play when learning sound in the classroom" (Lala).*

Khuri and Holzapfel (2001) suggested that the use of visual and sound in teaching:

Provide resources that help learners interpret the graphical representation; and

Adapt the knowledge level of the user- novice learners can become quickly overwhelmed by too many details.

Learners built their own visualisations and such construction enables them to gain insights and align with sound concepts in the textbooks. During the activity, some scientific process-skills were also experienced, namely, predict, sketching (drawing) and observation. The responses given by learners helped to identify their level of cognitive development and to process reasoning as extracted by observing the slinky demonstration. The idea of using the slinky was to reduce emphasis on drill and memorization- rote of sound phenomena and instead use demonstration.

4.6 Concluding Remarks

This chapter presented the data gathered through diagnostic and summative tests and lesson observations. The visualization on cathode ray oscilloscope CRO created a social context and motivated learners to use both their home language and the language of learning and teaching (LoLT) in developing their science language. A video recording was confirmed to be a useful technique for data gathering and provided an opportunity for playback at any time.

The next chapter presents and discusses the qualitative data of the study.

CHAPTER 5: DATA PRESENTATION, ANALYSIS AND DISCUSSION (PHASE TWO)

5.1 Introduction

The previous chapter presented, analysed and discussed data generated through the diagnostic and summative tests as well as lesson observations. This chapter presents, analyses and discusses data generated from the intervention which integrated traditional music and dance in relation to echo and waves in the topic of *sound*. The data sought to answer the following research sub-questions:

- What are grade 10 Physical Science learners' dispositions towards the integration of traditional music and dance in the design and delivery of lessons on echo and waves on the topic sound?
- In what ways are grade 10 Physical Science learners' sense-making and dispositions towards science influenced when traditional music and dance is integrated in the teaching of concepts on echo and waves on the topic sound?

5.2 Traditional Music and Dance

Traditional music and dance are cultural activities that are enjoyed by most people in rural communities in Namibia. Hence, during this study, both learners and teachers were present to watch the singing and dancing during the intervention. The parents, also included mothers who were at the school as voluntary members of the Namibian School Feeding program (NSFP), who ululated during the traditional performance. Some even sang along. Learners were encouraged to sing the common songs and to do dances such as *Epera, Ukambe and Unyanga.*

The girls' group entered in the playground first, all dressed in their traditional attire (see Figure 13).

Figure 13: A picture showing how the dancers entered the stage in the play ground

The songs that accompanied the dancing described the typical cultural rural living style. They first sang an independence song first, namely, "*Sam gawiza sirongo sinalitura*" (Translation: Sam came and the nation is free and harmony) and *"Mvhura roka tulye makunde"* (Translation: rain has to fall so we eat beans).

Almost all the dance performances managed to create the reflection of sound-echo since they were demonstrated next to a building. The vibration and transfer of particle motion led the sound to be heard. Performers were beating the drums and clapping hands. So, beating of drums helped the drums' skins to vibrate and by doing that sound was transmitted to the audiences' ears from the drums.

Figure 14: Picture shows movement of dancers and rhythmic patterns

The traditional music and dance performances consisted of echo and melody productions. The performance was done next to a wall and learners were able to experience the reflection of sound-echo. There were movements of the dancers to the left and to the right, backward and forwards and up and down.

In all the dance performances, the supporting singers clapped their hands in rhythmic patterns, with slow tempos in some songs and fast tempos in the others. During the dance performances, I used tempos to describe the frequency of the songs. Learners were encouraged to take notes about the science concepts when watching their video clips as discussed in Section 5.2.1.

5.2.1 Science concepts embedded in the traditional music and dances

All the songs consisted of clapping of hands and beating of drums depending on the type of dancing, some with a faster beat and others slower. The dances provided opportunities to learn about science concepts, in particular, the echo and sound waves. The sound phenomena were brought about by the dances and led learners to align these phenomena with the science lesson presentation they had been taught before. These concepts are detailed below as they applied to particular dances.

5.2.1.1 Frequency versus tension

A skin is stretched across the mouth of the drum by warming and this makes it to have tension. Tension refers to how tightly the skin is stretched as was explained by the science teacher. The drum player altering the tension of the drum by warming on fire and as the skin is warmed it stretched; this gives the drum a good tone and it is known as *Kurunda* as he explained to learners. So, this creates a high pitched tone. Learners further explained the changing of pitch. A skin on a drum *vibrates* with a particular frequency. It is possible, however, to produce pitches with different frequencies from the same skin on the drum - *Ngoma*. The four properties that affect the frequency of the cow skin used on a drum are length, thickness, tension, and density. These properties are described below:

When the length of a string (skin in the contest of the study) is changed, it will vibrate with a different frequency. Shorter diameter across the mouth of the drum has higher frequency and therefore higher pitch. When a drum player presses his finger on a stretched drum, he shortens its length. The shorter he makes the vibrating length, and the higher the pitch will be.

Thickness of the skin. A goat's skin is thinner than that of a cow. A thick skin vibrates slower and has a lower tone than a thin skin.

A skin stretched across the drum through warming the drum as explained above, will have tension. Tension refers to how tightly the skin is stretched. Tightening the skin gives it a higher frequency while loosening it lowers the frequency. When the drum players tighten or loosen their skin, they are altering the pitches to make them in tune.

Learners expressed their views on the amplitude and the wavelength on the softness and loudness of a sound wave. RL represents a response by a particular learner:

> *"Loudness is the way in which our ears perceive sound wave amplitude, and the larger amplitude is, the louder the perceived sound. Amplitude refers to the magnitude of the sound wave. Reduces the size of the wavelength" (RL1).*
>
> *"Is the way that the ear drum perceives a sound. When the amplitude is increased, sound gets louder, and when it is decreased, sound gets quieter and wavelength become short" (RL2).*

"The loudness of a sound wave can be determined by the amplitude of the sound wave" (RL3).

"The effect is that the longer the amplitude the more energy in the wave influences the wavelength to become short. While the shorter the wavelength the more energy in the wave due to the loudness of the sound" (RL4).

"The CRO makes the amplitude of the waves bigger and the distance between two crests became shorter when one learner spoke lauder" (RL5).

These responses pointed to sense making as learners explained the effects and relationship between amplitude and loudness. Learners showed recognizable cognitive development. In particular RL1- RL3 made sense of the science concepts by using mathematical concepts such as using magnitude to explain the size of sound components of amplitude and wavelength.

The level of identification of sound components displayed the ability of learners to work through concrete tasks. These learners would be motivated to assist others toward understanding echo and sound waves.

5.2.1.2 Production of sound

The skin or diaphragm of the drum produces sound once it is beaten. It moves back and forth rapidly. Scientists often use the term oscillation to refer to the back and forth motion of an object. However, the drum oscillates too fast for human eyes to see but by placing a finger on it a learner can feel the oscillation or vibration. The oscillation of the diaphragm also moves the air in front of the diaphragm back and forth and this vibration is transmitted to the air further from the drum, so the sound is transferred to the audience through particles' vibration.

Therefore, the sound properties can be expressed as follows ($f = (T/m/l)^{1/2}/2l$; where f is the frequency, T the tension, m/l is mass per unit length and l is the length of the spring - skin in the context of the study. $f = v/\lambda = (T/m/l)^{1/2}/2l$ (see Appendix F). The formula for wavelength of sound is given by $\lambda = vf$ where v is the velocity and f is the frequency as noted earlier.

In symbols: *Let speed be denoted by v, frequency by f, wavelength by λ.*

Then, $\lambda = v/f$ *If v is 1300m/s and f is 1000Hz*

Then, $\lambda = 1300m/s / 1000Hz = 1.3\ m$ *for the wavelength*

Sound is originally compression wave in a medium like air. The higher the frequency, the shorter the distance takes place between each successive rarefactions or compressions in the incoming sound wave. This distance is referred as wavelength. We know that the wavelength of a sound depends on the frequency of the sound source. That is sound from the same source will have the same speed in either medium.

5.2.1.3 Summary of the dances

Many science concepts were found to be illustrated by the different dance performances. Essentially, the many different dance songs provided an opportunity for learning about science, especially echo and waves on the topic *sound*. Most activities in both the boys' and the girls' dances were related to science concepts, which led me to select traditional music and dance for the intervention programme.

I had to ask learners who were more knowledgeable about the unique and the correct movement (steps) to explain these to me and to the rest of the group members when I engaged them in the intervention programme. During the intervention programme learners were asked to explain the correct moves; however, they could not reach agreement because they had no firm idea about the background of the intervention programme. They eventually decided to focus on the sounds that learners would hear, whether these came from handclap or from drums.

5.3 Lesson on Echo and Waves on the topic Sound

In the lesson on echo and waves, learners were asked to redo some of the moves in the dances to emphasize specific science concepts in relation to echo and sound waves. Learners had an opportunity to watch their video clips on the monitor screen so that they could have an overview of the traditional dances and align the activities to scientific concepts. This video recording was done earlier in order to provide an opportunity for video playback so that learners could master concepts for the duration of the intervention programme.

Involving indigenous dances to teach science emphasizes the importance of identifying traditional cultural activities for their possible value to the curriculum. A decisive and deliberate effort for adapting the learning programme in order to lay a strong ideological foundation in the hearts and minds of the learners of the science is embedded in the traditional music and dances. It was informed by the curriculum requirements for the grade in which the study is based on.

The dancers' movements particularly their directions, backwards and forwards, up and down were more relevant for the concepts of waves, both longitudinal and transverse waves. For this reason, these concepts formed a considerable part of the learning programme. Also, the rhythm and melody in the songs made by the clapping of the hands and vibration of the drum skins led to the recognition of sound production. For the period of the learning programme, learners were asked to form groups and work on the activities in the learning course. The learning activities that were positively influenced by the learning programme are presented below.

Worked example for echo. It was observed that the dancers at points A receive a reverberation from point B and the reflection of sound covered an equal distance in a given time as explained in Figure 15 below. This provided an opportunity to explain, define and calculate echo. Scientifically, dancers send a sound wave which is then reflected by the wall (point B). Dancers receive the reverberation while performing at point A that is why halls are fitted with soft absorbent materials to prevent echoes.

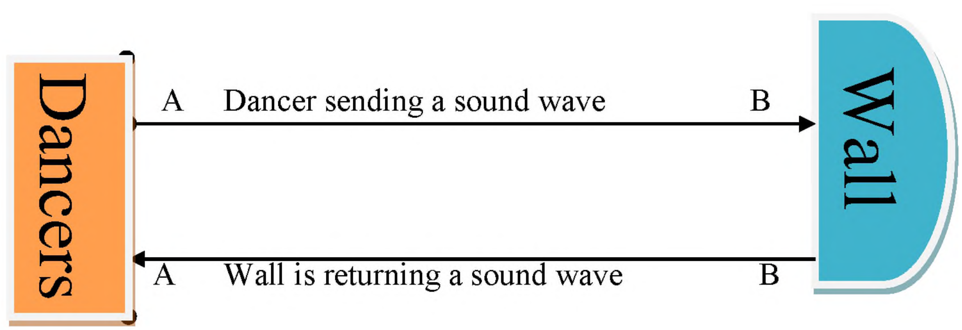

Figure 15: Example to demonstrate echo

The dance activity, presented an opportunity to integrate the dances with the curriculum in the context of echo. Admittedly, learners expressed that a delay of sound repeatedly sung after them; this is considered to be their reflected sounds. An echo is a reflection of sound that arrives at the listener with a delay after a direct sound. The delay is proportional to the distance of the reflecting surface from the source and listener (Ando, 1977). In this case the source of the echo was point B that acted like a wall and point A was the listener of the echo and also the source of sound. The activity led learners to make meaning of how some animals such as bats and dolphins navigate to their prey using echolocations. It was revealed in the Examiners' reports for 2012 and 2014 that learners were unable to recognize how the sound between the bat and prey is reflected (see Section 1.5).

The picture below was used to explain how a bat uses echo to catch its prey.

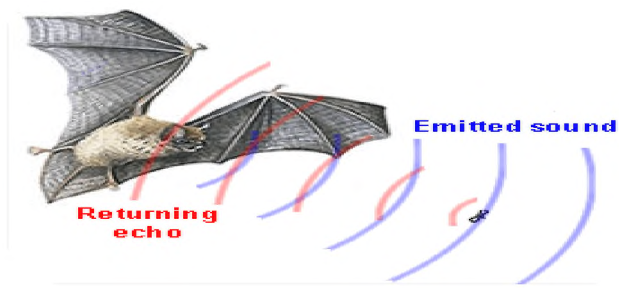

Figure 16: Bat emitting sound and returning echo (Source: www. guardian.co.tt)

As bat emits very high pitched sounds that are reflected by insects, the very sensitive ears of the bat pick up the reflected sound, and the bat begins to navigate the prey. Learners had an opportunity to realize that bats' ears are more important than their eyes at night. As a bat flies it make a sound. The returning echoes give the bat information about anything that is ahead of it, including the size and the shape of an insect and which way it is going. So, the insect is forewarned if it can hear ultrasound. This incidentally exerts considerable selection pressure against an insect that either cannot hear or does not react (Miller, 1982).

So, for a bat to notice whether the prey is moving towards or away from it and the sound waves travel between the bat and the prey is determined by wavelength that seems to be changed if one or both of them are moving. This is known as the Doppler Effect. The Doppler Effect process causes the received frequency of a source to differ from the sender if there is motion that is increasing or decreasing the distance between them (the source and the receiver). During the dance as learners were moving closer to the wall whereby they tended to receive a high frequency of the sound waves from the reflector (the wall in the context of the study) due to the decrease in distance between the dancers and the wall.

5.4 Qualitative Results

Data from the stimulated recall interviews were analysed from purposively selected learners. Interview transcripts were analysed and broad categories of data that emerged from the transcripts were identified, these were sorted based on their similarities and differences (see Appendix K). The research questions in the study led to classifying sub-themes and themes which served to show how learners made meaning through traditional music and dance in echo and waves on the topic *sound*. Four preliminary themes emerged from this grouping (see Table 5).

Table 5: Creating preliminary sub-themes from codes

Marked Text	Description of marked text	Sub-themes	Sub-questions
L1, L3	Learning with meaning/explanation helped researcher to connect the lessons	Sense making	4
L3, L4, L9, L10	Environment and teamwork/ group work	Cooperative learning	3
L9, L11, L14, L15	Visualisation/ demonstrate the sound characteristic/ different learning resources	Learning and teaching support materials	2
L4, L8, L9, L11, L13,	knowledge for the topic/ positive contribution/ better performance/ improvement	Participation and achievement	1

Common preliminary sub-themes were then combined to form themes. Four main themes emerged as representing the factors that influence grade 10 Physical Science learners' sense making and dispositions towards science when traditional music and dance is integrated in the teaching of concepts on echo and waves on the topic *sound*. The four themes are:

- Connecting to everyday life;
- Relaxing and non-threatening environment;
- Pedagogical strategies; and

- Content knowledge.

These four themes are described with supporting theory/literature as shown in Table 5. Direct quotes from the interview transcripts were used in the narrative to provide a sense of the learners' own words and to allow interpretations in relation to the research sub-questions.

Table 6: Themes and supporting theory/literature

Themes	**Research sub-questions**	**Theory/literature**
Theme 1: Connecting to everyday life		
Learning with meaning/explanation helped researcher to connect the lessons	4	Roschelle and Teasley (1995); Nussbaum(1989) Warren, Ballenger, Ogonowski, Rosebery and Hudicourt-Barnes (2001); Barab and Luehmann (2003); Rivet and Krajcik (2008), Otero and Nathan (2008); Rennie et al. (2011)
Theme 2: Relaxing and non-threatening environment		
Environment and teamwork/ group work	3	Vygotsky (1978), Vogel (2008); Millar (2009)
Theme 3: Pedagogical strategies		
Visualisation/demonstrate the sound characteristic/ different learning resources	2	Shulman (1987); Majeski and Stover (2007); Storey, Musen, Silva, Best, Ernst, Fergerson and Noy (2001)
Theme 4: Content Knowledge		

Knowledge of the topic/ positive contribution/ better performance/ improvement	1	Shulman (1986, 1987)

Each of these themes is discussed below.

5.5 Factors that Influence Grade 10 Physical Science Learners' Sense-Making and Dispositions Towards Science

In this section, the qualitative results are discussed with the view to answering research sub-question 3 and 4. These themes are presented in Table 5 and direct quotes from the transcripts are included to clarify that the interpretations are appropriate to the research questions.

5.5.1 Connecting to everyday life

It was found that connection with concepts that connect with learners' everyday life helped participants to make meaning. Learners explained that their experience influenced their understanding of science concepts especially the study of echo and wave in the topic of *sound*. Some example learners' comments are:

> "*Ee, sir this time I was courage. Nonkango (the words were easy for me to understand the meaning and relate them sir). Ntani udano, (and the dance) helped me a lot to connect sound with dance" (L1).*
>
> *"Activity, traditional dance, beating drums and the explanation after the dance helped me to connect lesson with traditional dance" (L3).*

Contextualizing science teaching involves the use of learners' everyday experiences as a mechanism for conceptual attainment (Otero & Nathan, 2008). Otero and Nathan (2008) further argued that eliciting and building on learners' everyday knowledge plays an essential role in enhancing meaningful learning. Nussbaum (1989) asserted that conceptual development is not the mere replacement of one theory by another. Thus, conceptual development occurs slowly and engages a complex reforming of the prior knowledge to encompass new ideas, findings and requirements.

In addition, learners were encouraged to understand the concepts and to relate them to sound and dance. They commented that the traditional dance in particular and the explanation after the dance enabled them to connect the lesson of sound with their everyday life. To this end, learners were able to align the concepts of sound with that of their daily life (Oloruntegbe & Ikpe, 2010 Kuhlane, 2011) and without any substitution of their authentic knowledge. Concurring, Rennie et al. (2011) pointed out that learners use prior knowledge to make sense of experience.

Everyday experience and ways of talking and knowing are seen as alternating with those of science and as barriers to form hearty learning. Two main variants of this tradition are research on misconceptions and studies of cultural congruence. Thus, research on misconceptions has found that students' everyday ideas are strongly held, may interfere with learning, and need to be replaced with correct conceptions (Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001). In this study, learners appreciated the explanation they received after they were engaged in the traditional dance to refine their understanding of concepts on echo and waves. This influenced their sense-making and dispositions towards the learning of science concepts.

5.5.2 Relaxing and non-threatening environment

Learners commented that environment and teamwork motivated them to take part in the group discussion freely without any fear. They expressed that they were relaxed when doing tasks and that collaborative learning encouraged them to complete the activities. They described the learning environment as being conducive, helpful and friendly to facilitate learning of science concepts:

> *"Hmm... it was an educative dance, I enjoy the dance and at the same time I was learning. It create good environment for me to interact through dance" (L3).*
>
> *"There are many things, I mean factors and environment. Teamwork in both traditional and class activities that of...Oscilloscope (CRO) assisted me to learn the sound properties. It makes me to answer the questions in the test" (L4).*
>
> *"Group work and dance as well as the patterns of the oscilloscope" (L9).*
>
> *"I enjoyed both the lesson activities and traditional dance so; these help me to work better in answering the test"* (L10).

They valued the interaction among learners and teacher, listening, explaining and supporting one another. Learners expressed themselves freely, for example by asking for assistance without the fear of being laughed at, since most of these learners were using vernacular (*Rukwangali*) in their discussions. According to Vogel (2008), a learning environment should provide a restful, restorative place and offer a sense of security. Additionally, science teachers should consider providing sufficiently inviting learning environment in which learners can make meaning. Such an environment provides sensory experiences for a learner who is nervous and easily becomes stressed, which is extremely important for classroom interactions.

Millar (2009) emphasized that it is important to make these connections in science classrooms and learning success is more likely to be successful when these links are made explicit Learning through a social environment supports development in such ways that what can be done collaboratively will be accomplished independently at a later stage. Furthermore, learners tend to enjoy learning through a relaxed environment. Learners expressed how working together and making a constructive dialogue with their peers increases in learners' understanding of science. It was hoped that learners began to navigate their own learning pathways to realize the usefulness of traditional music and dance to the curriculum in promoting a conducive learning environment.

Vygotsky (1978) emphasized the role of culture and context when constructing knowledge and enhancing a meaningful learning. He indicated that individuals construct cognitive schemes through interactions and communication with each other. That is, meaningful learning occurs by engaging in social activities. Vygotsky (1978) suggested that social interaction is an important part of the learning process where significant interactions occur while working with peers. In this study learners enjoyed cooperative learning experiences in the traditional dance. Interaction between dancers encouraged learners to participate actively and this in turn promoted constructive learning.

This finding corroborates with Agunbiade's (2015) study on the effect of context on learning science. For instance, 12 learners (75%) from the focus group emphasized that they were more comfortable and motivated in the traditional dance where there was no nervousness about the upcoming summative test because they were equipped with concepts based on sound.

Group work encouraged a relaxed and non-threatening environment which increased learners to become involved and to understand, with a resulting improvement in their summative test showing that they had mastered the concept of sound. During the research process, learners had to work in small groups which gave learners the opportunity to learn from one another, advancing the exchanging of ideas between learners from different backgrounds and with different cognitive intensities. The learning environment encouraged learners to support one another. The overall performance of focus group learners is presented in Figure 11.

In most questions of the diagnostic test learners were expected to define, calculate, give an example of a longitudinal wave and describe sound phenomena. Some learners explained in one of the summative test questions.

RL1: T*he prey hear a loud sound and also moving away because, the sound shouted loud*

RL2: *Its sound is reflected for food*

RL3: *Eardrum vibrates and sound of the prey enters the bat's ear. The bat opens its eyes to see the light whether its prey is coming from or moving away from it.*

RL4: *By using echo voice, as the sound of prey if reflect on the buildings. The bat will hear either the prey is moving away or towards the bat*

RL5: *First it screams and its sound will be reflected by the prey, later is when it will go and catch the prey.*

Although learners were able to mention the reflected *sound* sent by prey. Learners did not yet indicate the actual fact that the decrease in distance between bat and prey causes the bat to receive frequency from the source of the returning echo in a short period.

5.5.3 Pedagogical strategies

Learners' assessment of the effectiveness of the pedagogy applied in the intervention included these comments:

*"Hmmm, commitment, and this time we had lessons and traditional dance to demonstrate the sound characteristics. And in the first test I have no idea from my last grade to answer the test" (*L11).

*"Sir, this time I did understand the concepts through dancing and visualization of the oscilloscope and slinky" (*L14).

*"Oh, sir I was taught and different learning resources were used" (*L15).

Interviewees acknowledged the array of teaching strategies that they were engaged in. These learning and teaching aids provided learning opportunities for learners to understand the concepts. This finding was similar to those of Majeski and Stover (2007) who explained that significant learning includes learning how to learn, how to inquire, ask questions about a subject, and critically analyse information. In this case these steps involved the sequence of an argument, recognising and sketching the sound phenomena.

Questions were posed which helped learners to increase attentiveness during the learning process. It was observed that the visualizations provided by the oscilloscope addressed some of the typical concerns faced by the learners when adding new knowledge to their existing knowledge of sound waves (Storey, Musen, Silva, Best, Ernst, Fergerson & Noy, 2001).

Shulman (1987) argued that teaching necessarily begins with a teacher's understanding of what is to be learned and how that is taught. It proceeds through a sequence of activities during which the learners are provided specific instruction and opportunities for learning. The approach should enable learners to find out how things work by themselves. Concurring, Maselwa and Ngcoza (2003) advised that during practical activities the emphasis should be on conceptual development and learning for understanding. One learner briefly recapitulated how the approach helped her to understand the effect of drum tension on frequency: *"I benefited a lot, now I know that our dances in the community could add value in the learning of science, and I was engaged, motivated" (L11).*

Learners expressed that being engaged in a traditional dance (Mbusi, 2011 added value in their learning of science. That is, the engagement encouraged them to talk to each other in ways that demonstrate critical thinking and application of essential science concepts in their daily life. Furthermore, opportunities for collaboration had a clear relationship to a high level of learners' satisfaction through sharing the profound concepts involved in sound waves and echoes.

These findings indicate that the intervention influenced learners to focus and identify learning opportunities. The concepts learned through the intervention promoted learners to apply facts instead of recall. Learners were enthusiastic about the intervention in which they could relate sound to everyday experience as also found by Stears, Malcolm and Kowlas (2003) in their study conducted in South Africa.

5.5.4 Content knowledge

Before their engagement in the traditional music and dance, learners had demonstrated little knowledge in the concepts of sound. This was observed in their diagnostic test of echo and sound waves (see Section 4.2). Most learners commented that they did not have skills to do calculations; hence, they performed poorly in the calculations of wave length of sound. In this way the focus group interviews served the purpose of *member-checks*. Below are some responses from interviews with focus group members (see Appendix L).

Lala*'s* response on diagnostic test:

Lala: *'Tat udigu ku yi tanta ntani eswau'*. (Translation: it is very difficult to say it and it is feeling shame). "I did not expect to obtain this percentage but it was good since it not 0%. Yes I did not have a clue. It led me to leave some question unattended".

During the interview with *Lala* (*as indicated in his diagnostic test script)* it revealed that he was not able to answer all questions in his diagnostic test paper. He gave the reason that he had not been taught on most of the parts examined. This revealed that a poor foundation of prior knowledge although he did indicate that most of the questions were based on grade 10 Physical Science content knowledge. Evidently, learners can be taught well but if they cannot make meaning of the new knowledge and relate the acquired knowledge to their prior knowledge then, their understanding of prior knowledge is practically poor. This poverty was evident when learners struggled with the identification of sound phenomena, calculation of wavelength and the production of sound as well as how the audience perceives sound. I had assumed that almost all learners would master those calculations and be able to identify the sound properties such as *amplitude, wavelength, crest and trough*.

The summative test revealed that learners were constantly exploring their social and material environment and learned during communication with others through their social interaction at homes. Bringing prior knowledge learnt to school is a requirement for learners to be able to construct concepts correctly. The diagnostic test revealed the actual level of prior knowledge learners had about sound phenomena. They felt that science required a high level of intelligence that involved a lot of calculations, used difficult terminologies that they were not familiar with. After the intervention, however, the summative test revealed that learners did demonstrate the knowledge based on echo and wave (see Section 4.3). For instance, four learners commented that:

> *"There are many things, I mean factors and environment. Teamwork in both traditional and class activities that of...Oscilloscope (CRO) assisted me to learn the sound properties. It makes me to answer the questions in the test"* (L4).
>
> *"Lessons and traditional dance played role in answering the test than the first test"* (L8).
>
> *"I enjoyed both the lesson activities and traditional dance so; these help me to work better in answering the test"* (L10).
>
> *"Hmmm, commitment, and this time we had lessons and traditional dance to demonstrate the sound characteristics. And in the first test I have no idea from my last grade to answer the test"* (L11).

The context of the research showed that content knowledge was crucial to the improvement of teaching and learning. Additionally, traditional music and dance was a radical departure from learning science concepts in the formal manner to a focus on engaging learners' daily experiences as emphasized by Kuhlane (2011).

Shulman (1987) provided a brief overview on the effects content knowledge and pedagogical content knowledge have on determining the domain of science knowledge for teaching. This context-based approach leads to a greater achievement in terms of knowledge advancement towards science content. Certainly, the findings of this study resonate with the two central dimensions of the pedagogical content knowledge identified by Shulman (1986):

- The conceptions and preconceptions that learners of different ages and backgrounds bring with them to the learning of the most frequently taught topics and lessons; and
- The ways of representing and formulating the subject matter that makes it comprehensible to others.

5.6 Concluding Remarks

This chapter discussed the four main themes emerging from the data sources and their contexts - stimulated recall interviews, traditional music and dances and summative test analysis: connecting to everyday life, relaxing and non-threatening environment, pedagogical strategies and content knowledge. These themes clarified the factors influencing learners' sense making and dispositions toward science. The emerging themes were discussed in support or dissimilarity to the literature reviewed. In the next chapter a summary of findings, recommendations and conclusions are presented.

CHAPTER SIX: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

6.1 Introduction

This main goal of this study was to explore the possibility of integrating traditional music and dance into the design and delivery of lessons on the concepts of echo and waves in the topic of sound in grade 10 Physical Science. I was also interested in how this influences (or not) learners' sense making and dispositions towards science. This study was guided by the socio-cultural theory which is based on Vygotsky's (1978) work which emphasizes the importance of *culture* and *context* in constructing knowledge and enhancing meaningful learning. This study sought to answer the following research sub-questions:

1. What factors enable or constrain grade 10 Physical Science learners' understanding of the concept of waves and echo in the topic of *sound*?
2. What factors influence grade 10 Physical Science learners' sense making and dispositions towards science when taught the topic of echo and waves in a traditional way?
3. What are grade 10 Physical Science learners' dispositions towards the integration of traditional music and dance in the design and delivery of lessons on echo and waves on the topic *sound*?
4. In what ways are grade 10 Physical Science learners' sense making and dispositions towards science influenced when traditional music and dance is integrated in the teaching of concepts on echo and waves on the topic *sound*?

These research sub-questions helped to answer my main research question:

How does the integration of traditional music and dance into the design and delivery of lessons on the concepts of echo and waves on the topic of *sound* influence grade 10 Physical Science learners' sense making and dispositions towards science?

I now summarise and discuss the findings in relation to these research sub-questions which guided the study.

6.2 Summary of Findings

Research sub-question 1:

What factors enable or constrain grade 10 Physical Science learners' understanding of the concept of waves and echo in the topic of sound?

The findings of the diagnostic test showed that learners demonstrated little knowledge of the concepts of sound. Most learners presented that they did not have skills on calculation hence, it caused them to perform poorly in their calculation of wave length in particular. In contrast, after the intervention using the traditional music and dance, learners' performance improved in the summative test. This contrast revealed that the knowledge of learners, positive contributions and their thinking about the concepts of sound waves and echo were improved. The literature indicates that bringing forth and building on learners' everyday knowledge plays an essential role in sustaining meaningful learning (Kuhlane, 2011; Oloruntegbe & Ikpe, 2010; Otero & Nathan, 2008; Rennie et al., 2011). For instance, three learners commented that:

> *"Lessons and traditional dance played role in answering the test than the first test"* (L8).
>
> *"There are many things, like environment, Teamwork in both traditional and class activities that of...Oscilloscope assisted me to learn the sound properties. It makes me to answer the questions in the test"* (L4).
>
> *"I had an opportunity to watch the video clips on the television so, I had an overview of the traditional dances in order to align the possible movement and activities to scientific concepts" (L7).*

The above learners' comments show that they had achieved the basic competencies of echo and waves on the topic sound. Moreover, traditional music and dance was a radical departure from learning science concepts in the formal manner to a focus on engaging learners' daily experiences as emphasized by Kuhlane (2011). Stears, Malcolm and Kowlas (2003) had also contended that learners learn and appreciate formal sciences better when their everyday experiences are included in the teaching of science. In the context of this study the daily experience of the learners included traditional dance and music.

Research sub-question 2:

What factors influence grade 10 Physical Science learners' sense making and dispositions towards science when taught the topic of echo and waves in a traditional way?

The findings of the study showed that the pedagogical strategies played an influential part in learners' sense-making and dispositions towards science. Designing an effectual pedagogy influenced participants to enjoy their experience and that is why they actively engaged in the various science activities while learning the relevant scientific concepts involved in sound. Indeed, learners highlighted that the knowledge had influenced their understanding of science hence improving their skills of sketching and recognizing the characteristics of sound.

One advantage of the strategy applied in this study was that it was designed to engage the whole person in learning and served as a foundation of significant learning. This served to engage learners in the dance during the learning about sound characteristics and making a good connection to their everyday life. Shulman (1987) advocated that teaching necessarily begins with a teacher's understanding of what is to be learned and how it is to be taught. The ideas of using home language –*Rukwangali* could be readily applied to the issue of learning to use scientific language authentically. While the learner brings his own socio-cultural language to the science classroom, science as a discipline brings a specialized language with particular functions (Halliday & Martin, 1993). It was revealed that the more the learners' everyday experiences reflect the experiences of those who use academic science (scientists), the higher will be the appropriation of scientific language into authentic communication.

Research sub-question 3:

What are grade 10 Physical Science learners' dispositions towards the integration of traditional music and dance in the design and delivery of lessons on echo and waves on the topic of *sound*?

The findings of this study revealed that learners' dispositions toward science were improved as a result of engaging them in traditional dance and music. Learners expressed that this environment and teamwork fascinated them and allowed them to work freely, without any fear. The finding indicates that learners were relaxed when performing a task and cooperative learning drove them to complete the activities. Evidently, when a non-threatening environment was created their dispositions toward science were influenced positively. According to Agunbiade (2015), the learning environment that a teacher creates may influence the dispositions of learners. As indicated in this study, the solution to stimulating learners when learning about echo and sound waves was to provide a positive learning experience.

The literature expressed that a non-threatening environment should feel welcoming, foster encounters, communication and relationships and offer a sense of security (Vogel, 2008). This is considered to provide a sufficient and inviting learning environment for effective learning. Certainly, every environment a learner enters should provide sensory opportunities for exploration. Thus, this intervention provided sensory experiences for a learner who might be nervous and easily stressed which is extremely important for classroom interaction.

Focus group members expressed a preference for cooperative social learning. Millar (2009)emphasized that making these connections is important in science classrooms so that practical activities that make these links precise are more likely to be successful. Learning through a social environment as proposed by Vygotsky (1978) maintains development in such a way that what can be done collaboratively will be accomplished independently at a later stage. Besides, learners tend to enjoy learning in a more relaxed environment. Learners expressed how working together and making constructive dialogues with their peers increased their understanding of science. It was hoped that learners began to navigate their own pathways to realize the usefulness of traditional music and dance to the curriculum in enhancing a conducive learning environment.

Interaction between dancers encouraged learners to become active participants and this in turn led to constructive learning. This is the main reason why learners' performance improved in the summative test compared to the diagnostic test. The comparison showed that learners are interested and enjoy science much better if it is demonstrated in a positive manner and is relevant to their daily lives and current environment. It was found that a relaxing and non-threatening environment were factors that influenced the grade 10 Physical Science learners' dispositions toward science. Most learners enjoyed interacting with both the teacher and peers because it gave them a *voice* and encouraged them to realize that they were free to express even incorrect ideas and concepts of sound properties. The opportunity to participate in the traditional dance as supplement to the formal science classroom was sufficient to develop and transform the learners' behaviour towards science.

Research sub-question 4:

What factors influence grade 10 Physical Science learners' sense making and dispositions towards science when traditional music and dance are integrated in the teaching of concepts of echo and waves under the topic of sound?

In response to the fourth research sub-question, the findings showed that appropriate explanations assisted participants to connect concepts to their everyday life experiences (Stears, et al., 2003). Millar (2009) emphasized that such connection could promote higher order cognitive skills of learners in communication and could be used in evaluating socio-scientific issues. In the context of this study, everyday life experiences used in the intervention were the traditional dance and music. Learners explained that such an experience influenced their sense-makings of the science concepts in their study of echo and sound waves. Contextualized science teaching involves the use of learners' everyday experiences as a mechanism for conceptual attainment (Otero & Nathan, 2008). The literature indicates that eliciting and building on learners' everyday knowledge plays an essential role in attractive meaningful learning (ibid).

In addition, learners were encouraged to understand the concepts and related sound with dance. They commented that the traditional dance and the explanation after the dance enabled them to connect the lesson of sound with their everyday life. This supports Mukwambo, Ngcoza and Chikunda's (2014) advocacy for the Africanisation of the science curriculum through the incorporation of examples from the local context. In other words, these authors advocate the inclusion of traditional or indigenous knowledge (IK) (Kibirige & van Rooyen, 2006; Klein, 2011) in science classrooms where possible.

The findings of the study revealed that active engagement of learners was enhanced and they could identify some science concepts in particular, echo and waves, from the traditional music and dance. There was a significant improvement in the learners' sense-making and attitude towards science. Comparing the quantitative result of the diagnostic and summative tests, the overall performance of focus group learners presented in Figure 11 demonstrated a marked overall improvement in performance by the learners. In the summative test all learners achieved above 40% and four learners managed to score 60% and above. This was a much better outcome compared with the diagnostic test where 40% of the 15 focus group members were in the range 12% and 29%.

The study thus contributes to the accessible body of research on traditional music and dance concerning what specific factors influence learners' sense-making and disposition towards science and how they befit from learning science through incorporating examples from the local context.

6.3 Recommendations

The research has provided further research possibilities. It would be interesting to carry out further research on the pedagogical strategies of teachers in the Kavango West region on mediating the learning of echo and sound waves in grade 10 Physical Science. It is also recommended that science teachers be allowed to teach their own area of expertise which might strengthen their assurance to offer stimulating learning experiences. Strategies should be designed to engage the whole-person in learning and serve as a foundation of significant learning. This finding is similar to those of Majeski and Stover (2007) who explained that significant learning includes: learning how to learn, how to inquire/ask questions about a subject and critically analyse information.

It is equally important to look at how the pedagogical strategies interact with mediating learning of echo and waves in the topic of sound. A study of how educational reforms and teaching strategies in Namibia influence the teachers' content knowledge used in planning and delivery of lessons about echo and waves concepts under the topic of *sound* is recommended. Above all, it is suggested that a further research about measuring the time delay on an oscilloscope is considered to be appropriate and this could be built on the current study of traditional music and dance in relation to echo and waves in the topic of *sound*.

6.4 Limitations of the Study

The results of this study are limited to the selected circuit, the Physical Science grade 10 learners and therefore, it cannot be generalized. Notwithstanding, the findings of this study provided some insights on how traditional dance and music could be incorporated during science lessons, in particular, on sound.

Another limitation was the use of the video recording as a data gathering tool. Even though it was convenient for me to ask a colleague to help with the video recording during the traditional dance as I was implementing the learning programme, learners were prevented from talking freely. Furthermore, the camera could not capture the body expressions of all learners when they spoke and when other learners spoke, due to the limited view of the camera, from the angle the activity was filmed. Another challenge was in creating a relationship with learners and encouraging them to feel at ease especially during the stimulated recall interviews. Learners feared that their scores in both the diagnostic and summative test would be taken into consideration in their continuous assessments.

6.5 Reflections and Conclusion

Bearing in mind the limitations of this study, alluded to above, with both intrinsic and extrinsic factors influencing learners' sense-making and dispositions towards science, the findings of this study do not provide a broad guideline to the learning of scientific concepts of sound. Certainly, I had the opportunity to engage seriously and vigilantly with data and participants as a researcher in the field of education. The ethical issues in research and analysis of findings in an unbiased ways were cautiously considered as per requirements. The use of the vernacular as the mode of communication during group discussions encouraged learners to surface their authentic concepts development when learning sound phenomena.

With literature, context and guidance from my supervisor during this journey, I realized that exploring the integration of traditional music and dance into the design and delivery of lessons on the topic of sound in grade 10 Physical Science could provide opportunity to learners to connect scientific concepts to their everyday life experiences. In early 2015 during a session of the Master's course, I attended a workshop facilitated by two postgraduate students Eva and Kristof using *Oshikundu* as an example of using easily accessible materials to demonstrate fermentation and the rates of reactions. That motivated me to think of focusing on traditional examples of music and dance when teaching echo and waves in the topic of sound.

On the whole, the research process introduced me to many new ideas which I had to develop in language, vocabulary and academic research writing. Sometimes it was difficult to go through the unfamiliar concepts. However, I learned a lot through revising and redrafting ideas until I understood them. The research design course at Rhodes University in Grahamstown and contact sessions with supervisors and colleagues were helpful during the entire process. This was a worthwhile two-year journey of my master's degree. It involved some experiences that were both interesting and challenging.

Making a holistic reflection of the journey, I had an opportunity to have a careful look at how learners make sense of echo and waves concepts through traditional music and dance as well as visualization through an oscilloscope (CRO). Thus, I learned from this study that there are things teachers should not overlook during their science lessons. For instance, as alluded to earlier, this study revealed that active engagement by learners was enhanced and they could identify some science concepts in relation to sound, in particular, echo and waves, from the traditional music and dance. As a result, there was significant improvement in the learners' sense-making and attitude towards science.

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APPENDICES

APPENDIX A: Letter to the Regional Director of Education (see section 3.8)

Liveve AK
P O Box 6192, Nkurenkuru
Namibia
Cell: +264812263019
Email: liveandvero@gmail.com
05 October 2015

RE: Requesting for Permission to carry an Educational research project at [redacted] Combined School in Kandjimi Circuit.

Dear Sir/ Madam

I Liveve Angelius Kanyanga a M. Ed student at Rhodes University specialized in Science Education student number **15l7775**. Hereby, requesting a permission to carry my educational research project at [redacted] Combined.

The main goal of the study: **Exploring the possibility of integrating traditional music and dance into the design and delivery of lessons on the concepts of echo and waves in the grade 10 Physical Science Sound topic.**

My sub questions of the project:

1. What factors enable or constrain grade 10 Physical Science learners' understanding of the concept of waves and echo in the topic of *sound*?
2. What factors influence grade 10 Physical Science learners' sense making and dispositions towards science when taught the topic of echo and waves in a traditional way?
3. What are grade 10 Physical Science learners' dispositions towards the integration of traditional music and dance in the design and delivery of lessons on echo and waves?
4. In what ways are grade 10 Physical Science learners' sense making and dispositions towards science influenced when traditional music and dance are integrated in the teaching of concepts on echo and waves?

Your corporation in this regard is highly appreciated

Yours Faithfully

Angelius Kanyanga Liveve

APPENDIX AA: Letter from the Regional Director of Education

REPUBLIC OF NAMIBIA
KAVANGO EAST REGIONAL COUNCIL

DIRECTORATE OF EDUCATION, ARTS AND CULTURE

OFFICE OF THE DIRECTOR

Telephone Number : 066 – 258 9000/ 258 9201
Fax Number : 066 – 258 9117 / 255 404 /267 070
Enquiries : **M.H. Nauyoma**

Private Bag 2134
RUNDU
NAMIBIA

File No. : 19/5/2

Date : 23 May 2016

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

FOR ATTENTION: **Mr. Angelius K. Liveve**

RE: PERMISSION TO CONDUCT RESEARCH IN MPUNGU CONSTITUENCY - KAVANGO WEST

1. The communiqué on the above bears reference.
2. Kindly be informed that permission is granted to Mr. Angelius K. Liveve to conduct his research in Mpungu Constituency - Kavango West Region.
3. The normal teaching and learning activities should not be disrupted in the process.

Yours sincerely,

M.H. Nauyoma
DIRECTOR: KAVANGO REGIONAL COUNCIL
KAVANGO EAST AND WEST REGIONS

23/05/2016
Date

All official correspondence must be addressed to the Chief Regional Officer

APPENDIX B: Letter to the School principal of Lyambombola Combined (see section 3.8)

Liveve AK
P O Box 6192, Nkurenkuru
Namibia
Cell: +264812263019
Email: liveandvero@gmail.com
05 October 2015

RE: Requesting for Permission to carry an Educational research project at [redacted] Combined School in Kandjimi Circuit.

Dear Sir/ Madam

I Liveve Angelius Kanyanga a M. Ed student at Rhodes University specialized in Science Education student number **15l7775**. Hereby, requesting a permission to carry my educational research project at [redacted] Combined. The commencing period will be communicating in verbal mode.

Your corporation in this regard is highly appreciated

Yours Faithfully

APPENDIX C: Consent letter (see section 3.8)

22 June 2016

Dear Research Participant

Re: The main goal of this study is to explore the possibility of integrating traditional music and dance into the design and delivery of lessons on the concepts of echo and waves, on the topic of sound in grade 10 Physical Science.

The main goal of this study is to explore the possibility of integrating traditional music and dance into the design and delivery of lessons on the concepts of echo and waves, on the topic of sound in grade 10 Physical Science and how it influences learners' sense making and dispositions towards science.

Thank you for agreeing to be a research participant in my study

The study will be conducted in **three** phases. The first phase requires participants to sit for a diagnostic test, focus group interview. The **second phase** of the study involves an intervention in the form of a traditional music and dance performance and stimulated recall interview. After the intervention, **the third phase** of the study requires volunteers for summative test.

Your participation in this research study is completely voluntary and you can withdraw at any time. The data gathered in this study will be published as a Rhodes University half thesis. The identity of each participant and their views or contributions will be treated with a high degree of confidentiality and anonymity.

Angelius Kanyanga Liveve

Rhodes University

MEd in Science Education Student

I agree to participate in the research on condition that I can withdraw at any time.

Name....LALA..

Signature...

APPENDIX D: Letter to the subject teacher (see section 3.8)

Liveve AK
P O Box 6192, Nkurenkuru
Namibia
Cell: +264812263019
Email: liveandvero@gmail.com
05 October 2015

RE: Requesting for Permission to carry an Educational research project at [redacted] Combined School in Kandjimi Circuit.

Dear Sir/ Madam

I Liveve Angelius Kanyanga a M. Ed student at Rhodes University specialized in Science Education student number **15l7775**. Hereby, requesting a permission to carry my educational research project at [redacted] Combined.

I am interested in a case study of exploring the possibility of integrating traditional music and dance into the design and delivery of lessons on the concepts of echo and waves in the grade 10 Physical Science Sound topic.

The study will benefit learners in that it will seek to explore how learners make sense of concepts through traditional music and dance in relation to echo and waves in the topic of sound. I will be able to observe your lessons on echo and waves on the topic sound.

The commencing period will be communicating in verbal mode.

Your corporation in this regard is highly appreciated

Yours Faithfully

Angelius Kanyanga Liveve

APPENDIX DD: Letter from subject teacher

NKURENKURU COMBINED SCHOOL

PO Box 6041 NKURENKURU TEL/FAX 066258001/066264825

05 September 2016

Dear Sir/ Madam

PERMISSION TO MR LIVEVE A. K. TO CONDUCT HIS RESEARCH

I, Jonas R Kalyata, the subject teacher hereby permit Mr Liveve A. K. to carry out his research with grade 10 Physical Science learners of 2016 as his research participants.

Wishing you all the best in your research!

Sincerely, Yours

J.R. Kalyata

MINISTRY OF EDUCATION
NKURENKURU COMB. SCHOOL
2016 -09- 05
P.O. BOX 6041, NKURENKURU
TEL: 066 - 258001
REPUBLIC OF NAMIBIA

APPENDIX E: Diagnostic test (see section 4.2)

Physical science **Marks: 25**

Grade 10 **Time: 1 hour**

2016

Date: ____/______/_______

Name_____________________________

Diagnostic Test instrument in the topic of sound wave and echo

Instructions to candidate

1. Write pseudonyms of your choice on the space provided.
2. Be free to answer all the questions by writing on the space provided
3. Your performance in this test will not influence your academic results in any conduct.
4. The results of the test will be strictly confidential and will only be used for the purpose of research.

---

1. The diagram shows Kanuni Haruwodi cultural troop performing during the 26th independence celebration at Siurungu village in Nkurenkuru constituency. The performers can hear the drums being beating.

(a) Explain how the sound waves travel from the instrument (drum) to the performers' ear.

....

....

....

....

....

....

....

(b) A musical instrument produces a sound wave with a frequency of 1000 Hz. The sound wave has a wavelength of 0.34 m in air. Calculate the speed of the sound wave in air.

....

....

....

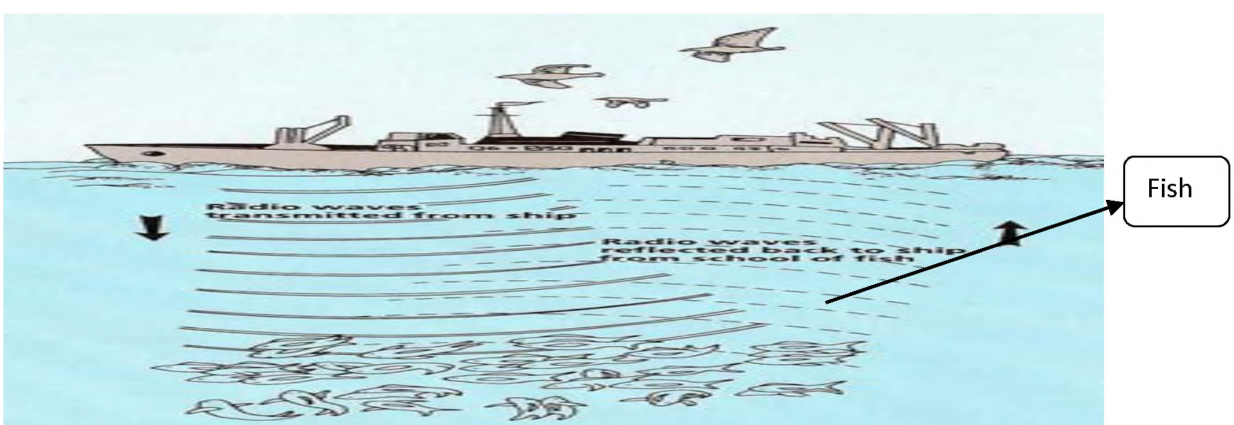
(c) In water the speed of sound is different. The speed of a sound wave in water is 1300 m/s. The sound wave has a frequency of 1000Hz. Calculate the wavelength of this sound wave.

....

....

....

2. The diagram shows a ship using a reflected (SONAR) to find a shoal of fish at Walvis Bay in Namibia. The vibrated wave is transmitted from the ship, which is then returns off the top of the shoal and is then picked up by the receiver.



Source: www.teacheratsea.wordpress.com

(a) The time taken to receive the echo is 0.2s after transmission. Calculate how deep the ship has to lower its fishing nets to catch the top of the shoal.

....

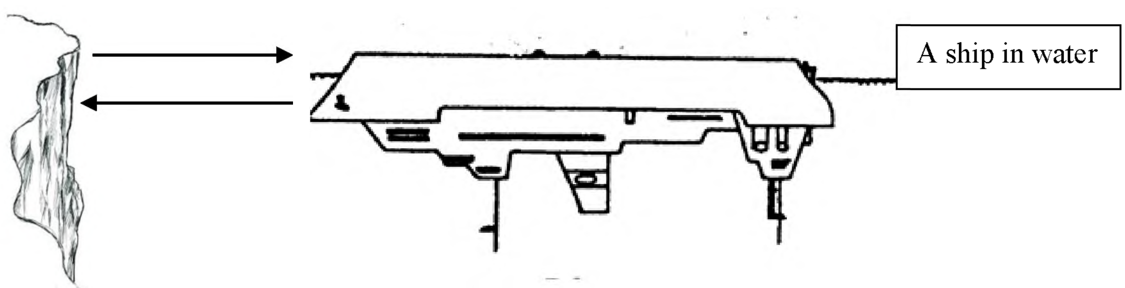
....

....

....

....

3. A ship is approaching a cliff (rock face). It can use the delay in a reflected sound from its horn to roughly tell how far away it is from the cliff.



Source: www.bloody.com

(a) What is a common name for the reflections of sounds from objects such as cliffs?

....

....

(b) Choose from the list below to complete the sentence:

30m/s

300 m/s

3,000 m/s

300,000,000 m/s

"The speed of sound in air is ______."

(c) Explain how a bat uses ultrasound to find its prey and how the bat could tell if its prey is moving away or towards the bat.

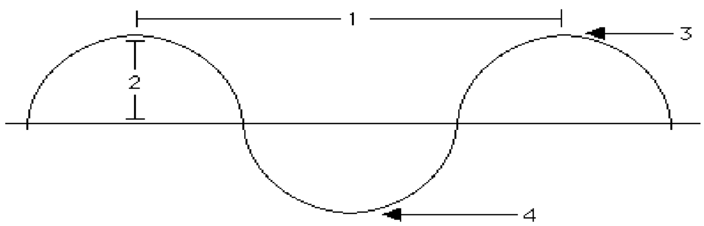
....

....

....

....

4. Below is a diagram of a wave



Source: www.distric196.org.com

(a) Name the parts of the wave labeled 1, 2, 3 and 4.

1: ....

2: ....

3: ....

4: ....

(b) The frequency of a wave is the number of cycles it completes per second.

What is the unit of frequency?

....

(ii) Sound is an example of a .... wave.

Thank You for your teamwork

Liveve@15L7775

APPENDIX EE: Diagnostic test memorandum

Physical science

Grade 10

2016

Date: 11/07/2016

Diagnostic Test instrument in the topic of sound wave and echo

1. a

- *Sound is the energy things produce when they* ***vibrate*** *(move back and forth quickly). If you bang (beat) a drum, you make the tight skin vibrate at very high speed (it's so fast that you can't usually see it), forcing the air all around it to vibrate as well. As the air moves, it carries energy out from the drum in all directions. Eventually, even the air inside your ears starts vibrating and that's when you begin to perceive the vibrating drum as a sound.*

(b) *Let speed be denoted by v, frequency by f, wavelength by λ.*

$v=f \times \lambda$

$v= 1000Hz \times 0.34\ m$

$v= 340m/s$

(c) If $v=f \times \lambda$

Than $\lambda = v/f$

$\lambda = 1300m/s\ /1000Hz = 1.3\ m$

2.

(a)

- *speed of sound in water is 1300 m/s*
- *therefore 1300m/s ÷ 0.2s= 260m*
- *260m ÷2 =130 m*

3.

(a) *Echo*

(b) The speed of sound in air is 300 m/s__.”

(c)

- *Most bat species have developed a remarkable navigation system called echolocation. A bat emits a sound wave and listens carefully to the echoes that return to it. The bat's brain processes the returning information the same way we processed our shouting sound using a stopwatch and calculator. By determining how long it takes a noise to return, the bat's brain figures out how far away an object is.*
- *The- bat can sense in which direction the insect moving is based on the pitch of the echo. If the insect is moving away from the bat, the returning echo will have a lower pitch than the original sound, while the echo from an insect moving toward the bat will have a higher pitch.*

3.

(a)

1: Wavelength

2: Amplitude

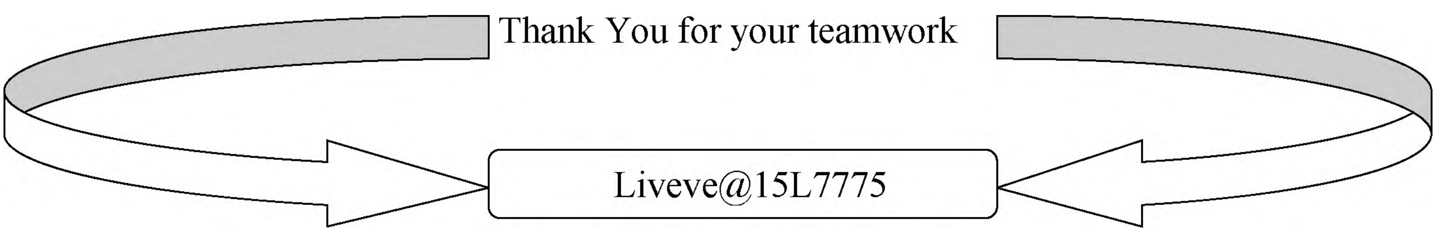
3: Crest

4: Trough

(b)

(i) ***Hertz*** *(abbreviated* ***Hz****) where 1* ***Hz*** *is equivalent to 1 cycle/second.*

(ii) Sound is an example of a ***longitudinal*** wave.



APPENDIX F: Unit of work (see section F)

Research topic:

TOPIC: Sound

Theme: Echo and Waves

What do you know already?

Grade 9: sound as a form of energy

Grade 10:

- Define sound
- Identify the example of sound wave
- Differentiate between longitudinal and transverse waves
- What is the common name of the reflected sound?

Sound phenomena:

- Amplitude
- Wavelength
- Crest
- Trough
- Frequency

What you will learn about in this topic: Echo and wave on the topic sound

- Define echo
- State the uses of echo
- Production of sound
- Determine the sound properties (Amplitude, Period, Frequency, Wavelength)
- Unit of frequency
- Properties affect the frequency.
- Sketch the wave patterns (high and low pitch)
- Calculations (wavelength of the sound wave)

Topic presentation:

Revision (definition of some concepts):

Sound: is the phenomenon we experience when our ears are disturbed by vibrations in the air or solid objects that surround us.

Echo is a reflected sound that is heard again by its initial observer

Frequency is the total number of waves produced per second

Amplitude is the distance from the point where displacement is zero (equilibrium point) to any point where the particle has reached.

Sound is originally compression wave in a medium like air. The higher the frequency, shorter the distance takes place between each successive rarefaction or compression in the incoming sound wave. This distance is referred as **Wavelength**. We know that the Wavelength of a sound depends on the frequency of the sound source. That is Sound from the same source will have the same speed in either medium.

Reference to the traditional dance the factors influence frequency when a cow skin used on a drum:

- Length
- Thickness
- Tension
- Density

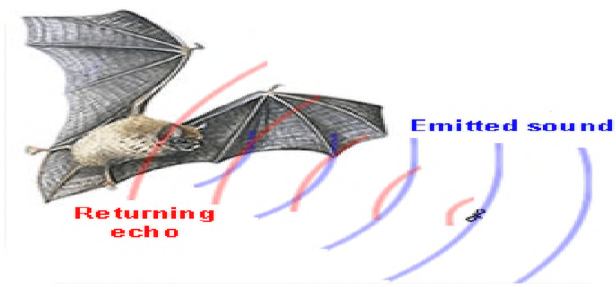
1. When the length of a string (skin in the contest of the study) is changed, it will vibrate with a different frequency. Shorter diameter across the mouth of the drum has higher frequency and therefore higher pitch. When a drum player presses his finger on a stretched drum, he shortens its length. The shorter he makes the vibrating length, and the higher the pitch will be.
2. Thickness of the skin. A goat's skin is thinner than that of a cow. A thick skin vibrates slower and has a lower tone than a thin skin.
3. A skin stretched across the drum through warming the drum as showed above, will have tension. Tension refers to how tightly the skin is stretched. Tightening the skin gives it a higher frequency while loosening it lowers the frequency. When the drum players tighten or loosen their skin, they are altering the pitches to make them in tune.

Production of sound:

Diaphragm of the drum produces sound is beaten. Scientist often uses the term oscillation to refer to back and forth motion of an object. Through particles vibration transmit sound to the audience.

Echo:

An echo is a reflection of sound that arrives at the listener with a delay after a direct sound. The delay is proportional to the distance of the reflecting surface from the source and listener. Some animals such as bats and dolphins navigate to their prey using echolocations.



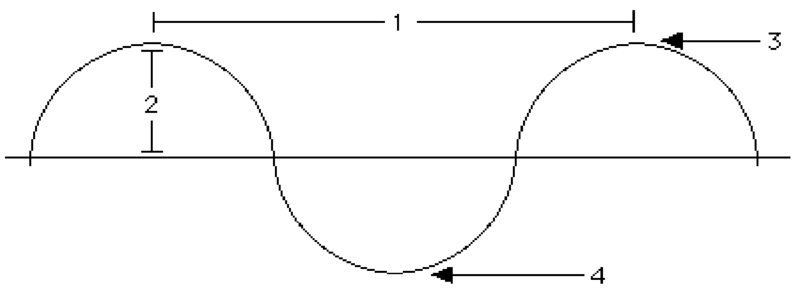
- Most bat species have developed a remarkable navigation system called echolocation. A bat emits a sound wave and listens carefully to the echoes that return to it. The bat's brain processes the returning information the same way we processed our shouting sound using a stopwatch and calculator. By determining how long it takes a noise to return, the bat's brain figures out how far away an object is.
- The bat can sense in which direction the insect moving is based on the pitch of the echo. If the insect is moving away from the bat, the returning echo will have a lower pitch than the original sound, while the echo from an insect moving toward the bat will have a higher pitch.
- So, for a bat to notice whether the prey is moving towards or away from it and the sound waves travel between bat and the prey is determined by wavelength that seems to be changed if one or both of them are moving. This is known as the Doppler effect. The Doppler Effect process causes the received frequency of a source to differ from the sender if there is motion that is increasing or decreasing the distance between them.

Example for calculating echo:

The time taken to receive the echo is 0.2s after transmission. Calculate how far is the mountain from the source?

- *If the speed of sound in air is 300 m/s*
- *therefore 300m/s ÷ 0.2s= 1500m*
- *1500m ÷2 =750 m is the distance between mountain and the source*

Graphic:



Source: www.distric196.org.com

The parts of the wave labeled 1, 2, 3 and 4. Are:

1: Wavelength

2: Amplitude

3: Crest

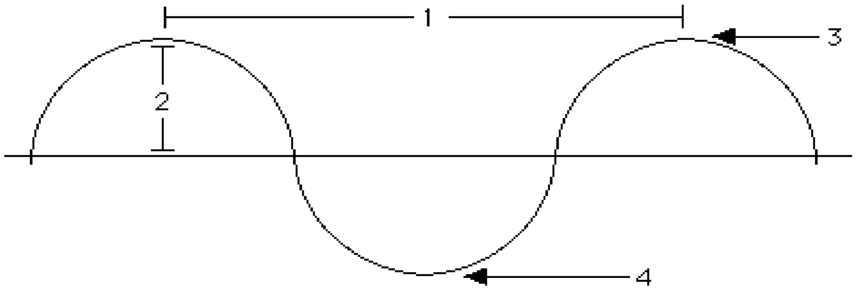
4: Trough

Therefore, sound is an example of a longitudinal wave.

Worked example

Marks: 10

1. Study the diagram below and answer the questions



a) Name the parts of the wave labeled 1- 4.

1..

2..

3..

4.. [4]

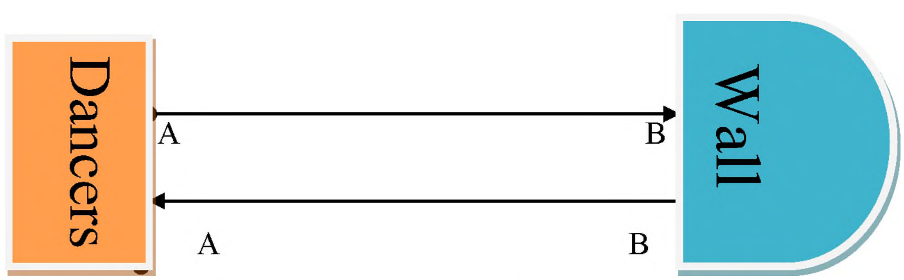
b) The frequency of a wave is the number of cycles it completes per second.

What is the unit of frequency?

....

.... [1]

2. The diagram shows the distance between the dancers and the wall



i) The time taken to receive the echo is 0.2s after transmission. Calculate how far the wall is from the dancers?

....

....

....[3]

ii) Explain the effect of frequency the returning echo when the dancers moving closer to the wall.

....

....

.... [2]

Thank You for your teamwork

Liveve@15L7775

APPENDIX FF: Worked example memorandum

1.

(a)

1: Wavelength

2: Amplitude

3: Crest

4: Trough

*(b). Hertz (abbreviated **Hz**) where 1 **Hz** is equivalent to 1 cycle/second*

2.

i) Speed of sound in air is 300 m/s

Therefore 300m/s ÷ 0.2s= 1500m

1500m ÷2 =750 m

ii) The frequency of the returning echo will increase when dancers moving closer to the wall since, the distance between wall and dancers decrease by the process of Doppler effect. Therefore, dancers tend to receive higher frequency as they move closer to the wall.

APPENDIX G: Summative test (see section 4.3)

SUMMATIVE TEST INSTRUMENT ON THE TOPIC SOUND

Instructions to candidate

1. Please write your surname, name and class in the spaces provided.
2. This is a summative test which is meant to identify your sense making in the topic of sound.
3. Your performance in this test will not affect your academic results in any way.
4. For multiple choice questions, please circle the correct option.
5. Please make sure this test is an individual work.
6. The results of the test will be strictly confidential and will only be used for the purpose of research.

Name:	
Grade:	**Time: 1hour**
Class:	**Marks: 30**

1. Which of the following is an example of a longitudinal wave?

A. Echo

B. Sound

C. Wave

D. Light

Motivate your choice____

2. What is the approximate range of audible frequencies for the human ear?

A. 2 Hz to 2 000 Hz

B. 2 Hz to 20 000 Hz

C. 20 Hz to 2 000 Hz

D. 20 Hz to 20 000 Hz

Motivate your choice____

3. Louder sound can cause damage to

A. Hearing
B. Sight
C. Skin
D. Brain
Motivate your choice____

4. Number of vibration in a second is called
A. Pitch
B. Frequency
C. Amplitude
D. Infrasound
Motivate your choice____

5. If we tighten strings of instrument pitch will be
A. Higher
B. Lower
C. Constant
D. No pitch

Motivate your choice____

6. Higher frequency greater will be
A. Pitch
B. Loudness
C. Amplitude
D. Infrasound
Motivate your choice____

7. The common name for the reflection of sound
A. Echo
B. Wave
C. Pitch
D. Wave length
Motivate your choice____

8. Voice is produced by vibrations of

A. Vocal cords

B. Mouth

C. Lungs

D. Heart

Motivate your choice____

9. Sound carry

A. Protons

B. Energy

C. Molecules

D. Electrons

Motivate your choice____

10. What happen to the wavelength of a sound when the frequency increases?

A. It decreases

B. It increases

C. It stays the same

D. None of the above

Motivate your choice____

/10

Section B

Structured Questions

1. The diagram shows Kanuni Haruwodi cultural troop performing during the inauguration of the new International University of Management (IUM) campus in Nkurenkuru, Kavango west region. The performers are considered to hear the drums being beating.

(a) Explain how the sound waves travel from the instrument (drum) to the performers' ear.

....

....

.... [2]

(b) A musical instrument produces a sound wave with a frequency of 1000 Hz. The sound wave has a wavelength of 0.34 m in air. Calculate the speed of the sound wave in air.

....

....

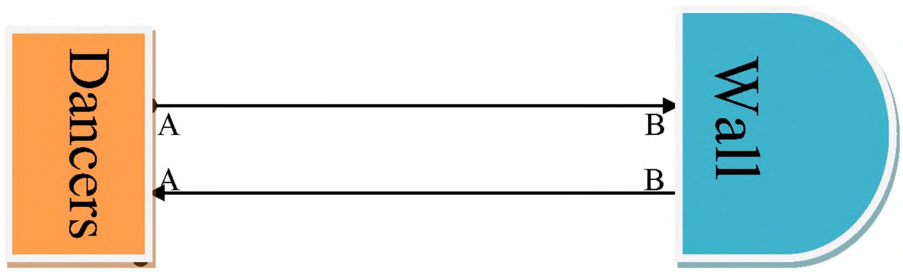
....[3]

(c) In water the speed of sound is different. The speed of a sound wave in water is 1300 m/s. The sound wave has a frequency of 1000Hz. Calculate the wavelength of this sound wave.

....

.... [3]

2. The diagram shows the distance between the dancers and the wall

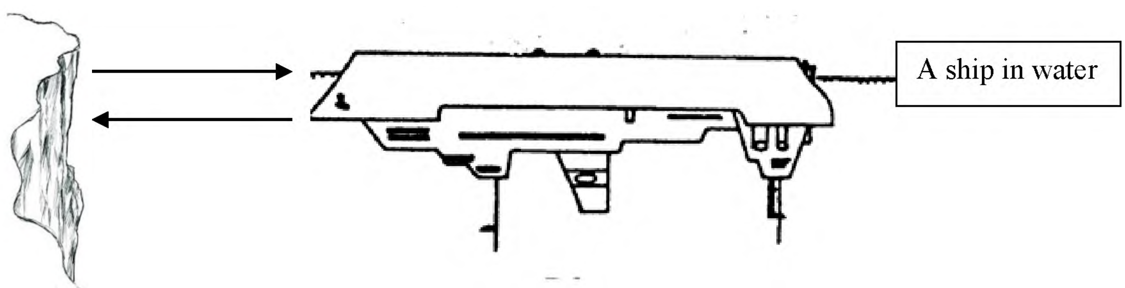


The time taken to receive the echo is 0.2s after transmission. Calculate how far the wall is from the dancers?

....

.... [3]

3. A ship is approaching a cliff (rock face). It can use the delay in a reflected sound from its horn to roughly tell how far away it is from the cliff.



Source: www.bloody.com

(a) What is a common name for the reflections of sounds from objects such as cliffs?

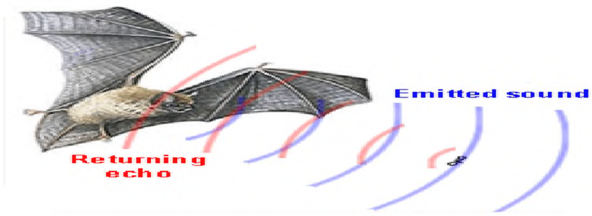
.... [1]

(b) What will happen to the frequency as the distance between the cliff and a ship decrease?

....

.... [1]

The picture below shows a bat during night catching a mosquito



(c) Explain how a bat uses ultrasound to find its prey and how the bat could tell if its prey is moving away or towards the bat.

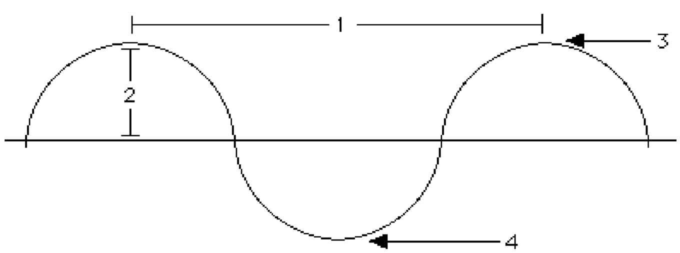
....

....

....

.... [3]

4. Below is a diagram of a wave



Source: www.distric196.org.com

(a) Name the parts of the wave labeled 2 and 4.

2..4.. [2]

(b) The frequency of a wave is the number of cycles it completes per second.

(i) What is the unit of frequency?

.... [1]

(ii) is sound an example of a ***longitudinal or transverse*** wave?.. [1]

APPENDIX GG: Summative test Memorandum

Summative test Memorandum

Section A: Multiple Choice

1. **B**, because sound waves travel in parallel to the motion of the waves back and forth.
2. **D**, beyond these frequencies human being unable to hear such frequencies
3. **A**, because laud sound damage the ear drum
4. **B**, it is a number of wave oscillate per second
5. **A**, tighten the string cause the high pitch
6. **C**, the high the frequency the greater amplitude
7. **A**, echo is a reflected sound
8. **A**, vibration of cord carry sound energy- particles
9. **B**, sound is a form of energy so, it carries energy
10. **A**, the decrease in the increases of frequency [Total 10]

Any relevancy reason/ explanation can be considered

Section B: structured questions

1. A) *Sound is the <u>energy</u> things produce when they **vibrate** (move back and forth quickly). If you bang (beat) a drum, you make the tight skin vibrate at very high speed (it's so fast that you can't usually see it), forcing the air all around it to vibrate as well. As the air moves, it carries energy out from the drum in all directions. Eventually, even the air inside your ears starts vibrating and that's when you begin to perceive the vibrating drum as a sound.*

   B)) *Let speed be denoted by v, frequency by f, wavelength by λ.*

   $v = f \times \lambda$

   $v = 1000Hz \times 0.34\ m$

   $v = 340m/s$

C) speed of sound in water is 1300 m/s

Therefore 1300m/s ÷ 0.2s= 260m

260m ÷2 =130 m

2. *speed of sound in air is 300 m/s*

   Therefore 300m/s ÷ 0.2s= 1500m

   1500m ÷2 =750 m

3. *a) echo*

   b) The frequencies increase

   c) Bat uses the frequencies to estimate the distance between the bat and its prey (mosquito). As the bat approaching the prey, the frequency increase due to the decrease in distance through the process Doppler effect. However, if the prey is moving away from bat cause the increases in frequency, when the distance between bat and prey increased.

4. a) 2- amplitude.

4- trough

b) i) Hertz

ii) Longitudinal wave

APPENDIX H: Interview schedule (see section)

1. a) What you think made it easy for you to answer most of the summative test questions?

   b) Why was it difficult for you to answer some of the summative test questions?

2. What could you think led to a difference in your performance between the diagnostic test and a summative test?

3 a) what do you think are the benefit when traditional music and dance is effectively used in learning science?

b) What do you think are the challenges of involving the traditional dance in learning science?

APPENDIX I: Lesson observation transcript 1 (see section 4.2)

Learners predicted, observed and reasons were provided as slinky stretched by other learners:

- *There will be a force of attraction among the rings*
- *Once it is stretched the distance between coils will be enlarge*
- *Both coils will travel in one direction*
- *The coils will retain its position when released after been stretched*
- *There be a shadow pass through coils as it vibrates*

GR5: wow it is shaking

GR1: *"Yinke ono dimburura mosi rongwa"* (Translation: What did you notice for the lesson) "Yeah when you pull the slinky, so, the slinky spread and make ring and rings, ok! "*Dize komeho no ko nyima"* (Translation: goes forward and backward (refers to the rings).

GR2: "Naan!" (Translation: Oh! It is very interesting the slinky made us easier to "*temwinina"* (Translation: tracing the pattern of waves). Pencil usually goes up and down and then later crest, trough, wave length and amplitude for the wave were identified.

GR3: *"Hahaa!"* (Translation: expression of laughing). Slinky was very easy to use when showing the example of sound and water wave. *"Uuwawee!" (*Translation:Enjoyable). When I pushed in s stick through slinky and this was representing period of the wave.

T: any group member to sketch the wave at the board?

GR4: *"Eeno"* (Translation: Yeah). *Ove* (Translation: you) go and draw the wave pattern on the chalkboard.

T: explain

GR5: *"Nawa"!* (Translation: Well!, it make the drawing up and down?)

APPENDIX J: Lesson observation transcript 2 (see section 4.5.1)

T: good morning class, today we will continue with sound. Who can remember example of sound wave?
Hegel: transverse and longitudinal waves
T: well, longitudinal wave is a sound wave but, transverse is example of water wave.
Tulinendi: Hmmm
Lala: wow, screen in our class
T: the traditional dance yesterday was very nice and today we will see what happen to the amplitude and wave length if frequency changes. Looking at the oscilloscope it will show the wave patterns and if you to sing loud the amplitude become high, wavelength will be short.
More: Nan karunga gwange (translation: oh my God) this allows us to see the curve on the screen teacher said it is a wave form.
Tokki: oneee, (translation: hey you). The pitches I think depend on the frequency of the sound. High frequency and amplitude become big.
T: class observe carefully let us allow Lala to talk over a microphone and see the display
Naiye: the displayed exactly like the on this page showing the high pitch
Shikulimanga: Hmmm,,, I guess if Tokki shout then the wave won't fit on the screen
T: Tulinendi please can you draw the same wave that of on the oscilloscope to the chalk board and to identify the *crest, trough, wavelength and amplitude.*
Tulinendi: Hmmm, but sir ok! "I will try".
Learners were observed helping one other particularly to sketch the waves and identifying the sound phenomena. They assisted each other to make meaning of the concepts.

APPENDIX K: Group interview transcript (see section 5.4)

Questions	Answers
What do you think made it easy for you to answer most of the summative test questions?	L1: *Ee*, sir this time I was courage. Nonkango (the words were easily for me to understand the meaning and relate them sir). *Ntani udano,* (and the dance) helped me a lot to connect sound with dance. L2: Yes sir! The activity helps me to do more and answer the question in the test L3: Activity, traditional dance, beating drums and the explanation after the dance helped me to connect the lessons with traditional dance. L4: there are many things, I mean factors and environment. Teamwork in both traditional and class activities that of,,,, "Oscilloscope" assisted me to learn the sound properties. It make me to answer the questions in the test L5: wow! Traditional dance and other classroom activities such oscilloscope (CRO) L6: I was taught before writing the test. The dancing and class activity helped me L7: sir, because I was taught so, the topic became easier. L8: lessons and traditional dance played role in answering the test than the first test L9: group work and dance as well as the visualization of the oscilloscope L10: I enjoyed both the lesson activities and traditional dance so, these help me to work better in answering the test L11: Hmmm, commitment, and this time we had lessons and traditional dance to demonstrate the sound characteristics. And in the first test I have no idea from my last grade to answer the test L12: sir, I attended the lessons and the dance. Not like the first test with less knowledge for the topic L13: hmm due to the dance and lesson activities L14: sir, this time I did understand the concepts through dancing and visualization of the oscilloscope and slinky analogy. L15: oh, sir! I was taught and different learning resources were used L15: it was easy; I manage to identify most of the sound properties than in the first test L14: hmmm, yeah the was difficulty in skill calculations but how bat navigate its pray was very easy at this time than in the first test because I had no ideas from my previous grade to answer the first test L13: shoo, in this test there were few questions seemed to be difficult compared with the first test.
Why was it difficult for you to answer some of the summative	

test questions?	L12: Hmm... This time it was better not like in the first test. I manage to answer most of the question although I did not get 100% L11: not so difficult but calculations skill when calculating wavelength L10: hmm, there was some difficulties but not like the first test, in this test the concepts explained during and after the dance L9: yes, sir! There was nothing difficult but, there was a challenge to understand some of the concepts but the first test was difficult because I had no ideas from grade 9 L8: yes but not as the first one. The first test I was not taught about sound and waves. L7: Hmm was not difficult but, I did not get 100%. L6: still sir but not much like the first test, in the first test I have ideas from my last grade on this topic L5: there was nothing much difficult, but I did not get everything in the test L4: Hmm, nothing much difficult. But there were some areas that need attentions. Such as calculations L3: sir! Not that much difficult but we need to do it again. L2: Time given for us to prepare was not enough. But I did not skip a lot of space in this test than the first ones. Because I have little ideas on the topic L1: *nanee!* Ok! Even though, I see there is changes in my score compare with the first test. *Noteminolodji* (translation: Terminologies) used in the test were easy but I was not really preparing for the test. But they are few questions that I did not answer sir.
What could you think led to a difference in your performance between the diagnostic test and a summative test?	L1: *Ya mpandu* (yeah thanks) the activities played role particularly the drum tension verse frequency and the production of sound led me to achieve better score sir,,, L2: Sir! Because, the activities had cleared some of the misunderstanding for the sound properties. I was able to make meaning during the activity. L3: Hmmm, it was because of the learning program of the traditional dance and class activities L4: thanks sir, the learning program led all this difference in my performance, there is a different of 22 marks compares with the first test. I like the traditional music and dance I enjoyed it. L5: yes sir! As I said the learning programme and the approach stimulated me to perform much better that the first test L6: group activity and traditional dance helped me a lot and my performance is greater than the first one L7: the programme I like it and I like the topic so, it helped me to do better than before. L8: wow! The, the visualization of the oscilloscope and this,,, of ,, the dance helped to identify and sketch the sound properties. Sir, this led my performance to be better than the first one.

What do you think are the benefit when traditional music and dance is effectively used in learning science? What do you think are the challenges of involving the traditional dance in learning science?	L9: most of the science concepts were explained after the dance and this helped me to connect the knowledge from the lesson and that of the traditional dance so, that is why my performance is better compared with the first test L10: ok the one of analogy and dance, group discussion also helped me to draw idea from the traditional dance L11: yes, sir! Both analogy in the lesson and traditional dance had a positive contribution in my performance. L12: The dance and activity in the lesson L13: practically, the traditional dance helped me a lot. That is why I performed much better that in the first test L14: Traditional dance and visualization of the oscilloscope. "Ee," I did well in this test with the of 28 marks L15: after the dance I saw learning in both traditional dance and visualization of the oscilloscope L1: benefit, a lot of benefits. I was involved, motivated and I enjoy the dance. Both songs and dance are not new to me. When we were watching it again I could see our movements and connected to echo as was explained in the class. L2: Sir! I was able to identify the amplitude, crest, trough and wave length when we were using that,,, one.. of ,,, oscilloscope yes! When demonstrate wave patterns. The moving from point A to B to explain the echo. L3: "Hmm"... it was an educative dance, I enjoy the dance and at the same time I was learning. It create good environment for me to interact through dance, I enjoyed the video and I am happy if all the topic can involve the type of activity we normal do in the community Sir, it reminding the home activities. Dance is playing the importance role in science as I saw it, I was involved in the traditional dance. I was motivated and now I can tell to everyone that our home activities also have science. L5: yes Mr,,, I feel more important, I was involve, motivated and I was able to contribute in the lesson of sound and,,,, waves. L6: a lot of benefits, I was engaged, motivated and my ideas were considered during group discussion. With that I was able to identify the sound characteristics- amplitude, wavelength and so on. L7: yes sir, it was easy to understand when involving aspects that normal we do at home or in the community. L8: *Mpo, Murongi!"* (Translation: Culture, teacher!). This is what normal parents do and we do during our schools cultural competition. But we do not see the science in our own traditional dances L9: very good sir, these make the way of recognizing our community idea and connect them with our science lessons. ,, good example was drum tension and the frequency and even the amplitude due to the sound produced by the drum(s). L11: I benefited a lot, now I know that our dances in the community could add value in the learning of science, and I was engaged, motivated L12: I was involved, motivated and I enjoyed the dance, the traditional dance make learning of sound easier

	L13: Telling me the role of our traditional dance plays in the learning of science, not only during the harvest and healing ceremony. L14: thank you sir, I enjoyed the traditional dance and CRO (oscilloscope) visualization it led me to connect the sound characteristics L15: I am happy that community practice could have been promoting the learning of science. So I enjoyed the dance and I was motivated L1: Yes sir! Challenges are there. It was difficult for me to link the meaning with science. Knowledgeable persons are needed. I was only enjoying the melody at first L2: sir! It was not easy to connect science and traditional (*magano*) ideas, later then it was easy for me to tell the sound waves due to our dances. L3: challenge,,, many challenge not easy to connect this skills with knowledge I have. Always we do the dance so; I only enjoy the melody without connecting it to the science lessons. L4: to interpret the traditional dance into science needs a teacher. Parents are also need to come to class if lesson like this or others to help us with the instruments L5: many challenges sir, bringing in our home knowledge into the classroom, a teacher must be present Traditional dance is not the same as ours. I was wishing more culture could be considered even one song. L7: sir myself alone cannot connect this community aspect with classroom, a teacher must be there. L8: "*nkera*" (Translation: yesterday). I was involving in the beating of the drum during the healing ceremony but, the challenge is that knowledgeable person is needed. Hmmm, it very difficult for us to connect this knowledge in the absence of the teacher, but the traditional dance it has facilitate the learning of sound (echo and waves) L10: It needs a teacher or somebody with skills to connect and explain the science and dances L11: I do not know if the dance can be used to explain other science aspects. I think a teacher is needed L12: the challenge was not able to interpret the dance into the science learning content. L13: person with knowledge for example a teacher need to be present to explain the meaning and connect them to a science meaning L14: first it was very difficult for me to understand the whole meaning. I was just enjoying the dance but later through explanations I manage to connect the dance and the lesson of the day. In this case a teacher should be present for learners to be able to interpret the dance into the science meaning. L15: I think to bring the dance during science lesson provides a learning opportunity but, somebody with knowledge must be there. Otherwise, it seems to be a normal dancing.

APPENDIX L: Individual interview transcript 1 (see Section 5.5.4)

[Interview with Lala]

Key: R= Researcher

R: yes Lala, it was observed that maybe you were unable to get scores ... marks that of above average. Why was it is difficult for you to answer some of them?

Lala: Yes sir! there was misunderstanding..... *udigu* (it was difficult) not easy to answer all questions. "I did not expect to score that such percentage and at least it was not a 0%. Yes I did not have a clue. It led me to leave some question unattended".

R: Ok, after that diagnostic test, there was teaching which took place, traditional dance intervention, and later followed by teaching and an activity on reflection of sound. Then at a later stage we had a summative test. When we compare the two, we found that the performance is not the same. What could have led to the difference in these or in your performance?

Lala: "There are many things sir, I mean factors and environment. Teamwork in both traditional and class activities that of…Oscilloscope (CRO) assisted me to learn the sound properties. It makes me to answer the questions in the second test".
Lessons and traditional dance played role in answering the test than the first test.
sir *Kayitovarere nge* (I enjoyed) both the lesson activities and traditional dance so; these help me to work better in answering the test.
"Hmmm, commitment", and this time we had lessons and traditional dance to demonstrate the sound characteristics. And in the first test I have no idea from my last grade to answer the test.

R: Wonderful. It means it brings excitement to.........not only dancing but also the dance being close to the wall led the returning sound. Can you tell me how to call the common name of this returning sound (reflection of sound)?

Lala: yes sir! The returning sound is known as echo

R: Can you think of challenges of including traditional dance when learning the concepts of echo and waves in sound?

Lala: Wow, when involving dance in the learning of sound requires a knowledgeable person-teacher. *Mpandu* (thank you).

[End]

APPENDIX M: Individual interview transcript 2 (see Section 4.5.3)

[Interview with Hegel]

Key: R= Researcher

R: yes Hegel, it was observed that maybe you were unable to get scores ... marks that of above average. Why was it is difficult for you to answer some of them?

Hegel: Yes sir! There were a lot of challenged questions..... *udigu* (it was difficult) not easy to attend all questions. Yes I did not have a clue. But I did not leave many questions unattended.

R: Ok, after that diagnostic test, there was teaching which took place, traditional dance intervention, and later followed by teaching and an activity on reflection of sound. Then at a later stage we had a summative test. When we compare the two, we found that the performance is not the same. What could have led to the difference in these or in your performance?

Hegel: There are many things sir! Both plastic slinky activity and oscilloscope (CRO) visualization brought proper assistance in the learning of sound waves. I was excited to see how the slinky swing back and forth and the visual for the wave form. I enjoyed and it supported me on how to identify the sound properties such as amplitude, wavelength, crest, trough and period. "I am convinced that science is around and anything can be used as long as it makes one to make sense out of it".

R: Wonderful. It means it brings excitement to.........not only dancing but also the dance being close to the wall led the returning sound. Can you tell me how to call the common name of this returning sound (reflection of sound)?
Hegel: yes sir! The returning sound is called echo

R: Can you think of challenges of including traditional dance when learning the concepts of echo and waves in sound?

Hegel: *Mpandu*! (Thank you), to involve dance in the learning of sound requires a knowledgeable and trained person like a teacher. *Mpandu* (Thank you).

[End]