AN INVESTIGATION INTO TEACHING MATHEMATICS USING A VISUALISATION APPROACH TO RE-CONTEXTUALISE INDIGENOUS KNOWLEDGE

A thesis submitted in fulfilment of the requirement for the degree of:

MASTERS IN EDUCATION

of

RHODES UNIVERSITY

By

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November 2017

ABSTRACT

It can be argued that the Namibian curriculum is largely influenced by a Western epistemology. However, many studies suggest that learners make powerful meanings of mathematical concepts they are learning if they visualise these and experience them in relation to what they already know from their own cultural backgrounds. According to the Namibian National Curriculum for Basic Education (NNCBE, 2010), it is not only important for learners to acquire mathematical knowledge and skills, but also to develop and grow their identities, cultures and values as individuals.

The aim of this study was to explore and investigate how selected mathematics teachers employ visualisation as a teaching approach to re-contextualise indigenous knowledge (IK). The study set out to explore how conceptual understanding is enhanced by participation in an intervention programme. The use of visualisation is considered an important mediating and pedagogical tool in the mathematics classroom to enhance the mathematics learning of learners.

The research is informed by a socio-cultural theory of learning and is located within an interpretive paradigm. The study was conducted at four schools in the Oshana region of Namibia and involved four mathematics teachers who were purposefully selected due to their willingness to use visualisation-IK approaches in their teaching, based on their responses to the survey. The methodologies used are qualitative and quantitative case study. To gather data, document analysis, a survey, lesson observations and focus group interviews were used.

The study found that most teachers in the Oshana region have an understanding of the effective use of visualisation-IK approaches. However, the study revealed that visualisation-IK approaches are mostly used in grades 4 to 7 mathematics classrooms. It also discovered that most of the visualisation approaches that teachers employed aligned well with the curriculum and promoted conceptual understanding in the teaching of mathematics. The results of the study showed that teachers have experience of the enabling and constraining factors in using a visualisation-IK approach to teaching mathematics.

ACKNOWLEDGEMENTS

I would like first and foremost to thank the Almighty God for giving me a mind that is able to reach up to this level of study and for giving me wisdom, power, courage, strength and perseverance during the time I was carrying out this study. Had it not been His wish I would not have completed this exercise.

I would also like to express my sincere gratitude to my supervisor Professor Marc Schäfer for his professionalism, expertise, patience, guidance and support as well as encouragement that he gave me while I was carrying out this research. Had it not been for these qualities, this dissertation would not have been completed to the standard it is today. I really value all that I have learnt from him.

I would also like to thank my wife Mrs Priska Nakasole-Tshithigona together with my children Etuhole and Talohole for their patience and for the time and attention that I stole from them when I was studying abroad. Thank you for supporting and encouraging me emotionally. Even if I had to be isolated from you for a long time because of this study, your patience, love and support meant a lot to me and my studies. A special thanks to my beloved grandmother Kuku GweEmvula, my mother Meme GwaSimon and Uncle Ketsho Albertus Negongo for always valuing education, supporting and encouraging me to further my studies abroad.

I would also like to thank my colleagues Mrs Nuusiku Nankelo Shindaadhi, Mr Williahem Hanga, Mrs Anna Shingwandja and Ms Loide Theofilus for opening doors to further knowledge in my studies, and for their support during the time that I was studying abroad. Mrs Julia Kapia and Mrs Theopolina Thomas-Amakali, I cannot afford to forget you, thank you so much for the support and encouragement that you always gave me when the going was tough and rough. I would also like to thank the Inspector of Education Oluno circuit Mr Levi Vries, the Director of Education Oshana region Mrs Hileni Amukana and the Deputy Director Mr. Gerhard Ndafenongo for the administrational support and for always making sure that matters regarding my study were attended to in a professional manner.

I would also like to thank my participant teachers. Thank you very much for your willingness to participate and support me in my study. Your support and patience have made an enormous contribution to the success of this study.

DEDICATIONS

This thesis is dedicated to my beloved Grandmother Scholastik Nekulu Namutenya GweEmvula, who celebrated her 100th birthday on the 19th September 2017.

DECLARATION OF ORIGINALITY

I, Gaus Tshithigon, student number 15T8851, hereby declare that this thesis is my own work, composed in my own words. It has not been submitted in any form for any other qualification or any assessment to another University or institution. Where I have drawn on the words or ideas of others, these have been fully acknowledged in accordance with the Rhodes University, Education Department reference guide.

Gaus Tshithigona November 2017

Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

This chapter introduces the research study of an investigation into the teaching of mathematics using a visualisation approach to re-contextualise indigenous knowledge stimulated by a teacher intervention programme in Oshana region of Namibia. The first section of the chapter provides the background to the study, followed by the research goals and questions. The research methodology is also highlighted, and the significance of the study is revealed. The limitations of the study are also listed, and the chapter concludes with a short outline of the structure of the thesis.

1.1 BACKGROUND OF THE STUDY

Namibia is a multicultural country with the majority of the population sharing common cultural values, norms and practices. The Namibian National Curriculum for Basic Education (NNCBE, 2010) states that the goal of Basic Education is to empower learners for the development of a future Namibia as a knowledge-based society. Some of the characteristics of a knowledge-based society are the effective and wise use of existing knowledge, the creation of new knowledge and the sharing and using of knowledge effectively through a dynamic information infrastructure (NNCBE, 2010). This goal also encourages the incorporation of indigenous knowledge (IK) into the teaching of mathematics. The NNCBE (2010) explicitly promotes multiculturalism, and suggests that mathematics teachers should understand the cultural and historical backgrounds of their learners and incorporate these into the mediating of knowledge. The NNCBE (2010) also emphasizes that schools have a special responsibility to use the curriculum guide together with various subject syllabi to identify locally relevant content within a common framework so that learners can experience their education as being meaningful for them. This curriculum is intended to allow teachers to use the indigenous knowledge of learners that is relevant to the classrooms concepts.

Including IK in the classroom is a step towards recognising diversity in the class in the sense that it acknowledges the home background of the learners. It also acknowledges that there are different ways of knowing mathematics as well as recognising the value of indigenous knowledge itself (Ogunniyi & Ogawa, 2008). Acknowledging the role of IK, the NNCBE

(2010) further states that preparation for a knowledge-based society requires a learner-centred approach to teaching and learning. It can thus be inferred that the point of departure for teaching any knowledge should, as far as possible, be the IK. All other knowledge can then be built upon this in relevant, meaningful and innovative ways. The NNCBE (2010) further states that knowledge is not learnt for its own sake, but must always lead to new understanding and new skills, and the creation of new knowledge. Mukwambo, Ngcoza & Chikunda (2014), in their call for the Africanisation of the curriculum state that IK promotes teaching and learning scenarios in which both teachers and learners engage in knowledge construction in the full diversity of cultural, racial, ethnic and religious practices of all people, thereby bringing about a common understanding (p. 72).

In my experience as a mathematics teacher for 14 years, I have observed that learners grasp new knowledge if a good foundation is laid for the concepts they are learning at school. Such a foundation includes local practices and artefacts to which learners can relate in order to supplement what is documented in their classroom mathematics. Looking at the proposed teaching approaches that the Namibian curriculum inherited in 1990 and which was implemented in 1993, a learner-centred approach is highly recommended. This approach requires learners to construct their own knowledge using the knowledge they have acquired from their cultural backgrounds. I have often experienced how well learners related to their indigenous arithmetical knowledge and experiences from home. However, in my experience, many teachers ignore IK in their teaching and rely solely on textbooks or even national examination question papers for their class activities, which in most cases is modelled on Western knowledge.

Most of the mathematics teachers in Oshana region might not have been exposed to any training on how to incorporate indigenous knowledge in their teaching. Instead, they might still be relying on the textbook as the only resource available for the learners to construct mathematics knowledge. Looking at the results of the National Standardised Achievement Tests carried out in grades 5-7 in English, Mathematics and Science, the Namibian learners are performing poorly, particularly in Mathematics (Sasman, 2014); see Figure 1.1. It is asserted that inadequate basic numeracy knowledge is one of the major factors contributing to the poor performance in mathematics in the grades 10 and 12 national examinations (Wolfaardt, 2005). This experience triggered my interest in investigating how teachers incorporate IK, and their views, experiences and perceptions of the use of visualisation-IK as a pedagogical tool to enhance conceptual understanding.

Table 1.1 Average percentage scores by urban/rural comparison

Subject	Location	2009	2011	2013
English	Rural	37%	40%	36%
	Urban	56%	59%	54%
Mathematics	Rural	40%	39%	41%
	Urban	52%	51%	51%

Source (Sasman, 2014)

Thus, the purpose of my study is to investigate the teaching of mathematics using a visualisation approach to re-contextualise indigenous knowledge. Firstly, a survey and interviews were used to explore the views, experiences and perceptions of the mathematics teachers in Oshana region of Namibia. Secondly, I engaged four teachers from the surveyed population in an intervention program. During this program each teacher planned three lessons with regard to the inclusion of IK and visualisation processes. Thereafter, observations were carried out, focussing on how the teachers used a visualisation approach to re-contextualise indigenous knowledge in their classrooms.

1.2 RESEARCH GOALS AND QUESTIONS

The first goal of this study was to explore teachers' views, perceptions and experiences of teaching mathematics using a visualisation approach to re-contextualise indigenous knowledge. The second was to investigate how selected teachers use a visualisation-IK approach as a pedagogical strategy, stimulated by a teacher intervention programme. To achieve these two goals, the four questions below framed this study:

- How widely is IK included in the teaching and learning of mathematics in the Oshana region of Namibia?
- In cases where IK is used, how is it used to promote conceptual understanding in mathematics?

- As a result of an intervention programme, how is IK used in conjunction with visualisation processes to promote conceptual understanding?
- What are the participating teachers' experiences of the enabling and constraining factors in using a visualisation-IK approach to teaching mathematics?

1.3 RESEARCH METHODOLOGY

This study is located within an interpretive paradigm using a mixed method approach, utilizing qualitative and quantitative methods (Bertram & Christiansen, 2015). According to Bertram and Christiansen (2015), interpretivist researchers aim to understand how people make sense of their worlds. (p. 26). Cohen, Manion and Morrison (2011) explain that:

> ...the central endeavour in the context of the interpretive paradigm is to understand the subjective world of human experience. To retain the integrity of the phenomena being investigated, efforts are made to get inside the person and to understand from within. The imposition of external form and structure is resisted, since this reflects the viewpoint of the observer as opposed to that of the actor directly involved (p. 17).

In the context of this study, an interpretive paradigm enabled better interaction with the participants during the data gathering process. Moreover, knowing the background culture of the research participants gave me insight and access, allowing me to collect more detailed data.

Additionally, Hussain, Elyas & Nasseef (2013, p. 2375) assert that "interpretive research seeks to understand values, beliefs and meaning of social phenomena and they extract knowledge or an empathetic understanding of human social activities and experience". Through using an interpretive paradigm, I worked closely with my participants regarding their views and experiences on the inclusion of IK in their lessons. Thus, within the interpretive paradigm, I employed a case study approach.

A case study approach was appropriate in this study as it allowed me to focus on a specific objective rather than looking at a broad picture. Gay, Mills and Airasian (2011) define a case study as a "qualitative research approach in which researchers focus on a unit of study known as a bounded system" (p. 444). The case study in my research was to investigate how selected teachers use a visualisation-IK approach as a pedagogical strategy stimulated by a teacher intervention programme.

The study used a mixed method i.e. both qualitative and quantitative data and I focused on teachers' views and experiences in the use of a visualisation-IK approach as a pedagogical tool to mediate the teaching of mathematics, as my unit of analysis. Using a mixed method helps the researcher to gain complete understanding and comprehension of results, discover new perspectives, or develop new measurement tools (Tashakkori & Teddlie, 2003).

In this study a variety of data collection techniques and methods were used i.e. document analysis and survey questionnaires with 60 teachers. The study further involved observation and interviews with four selected teachers as main participants. I collected data by video-recording three lessons from each teacher; a total of 12 lessons were recorded and transcribed. The recorded videos were then analysed to help me gain insight into teachers' practice and experiences. After the lesson observation, all four participants were interviewed. During the interviews, participating teachers were asked to reflect and give their perceptions and experiences while they were using a visualisation-IK approach as a pedagogical tool to enhance conceptual understanding. These interviews were also audio-recorded and subsequently transcribed for analysis purposes.

1.4 SIGNIFICANCE OF THE STUDY

Two important aspects that are of significance were highlighted in this study. Firstly, this study opened up the issue of IK that has been ignored and rarely included in the teaching or in the curriculum in Namibia. Secondly, this study allowed the participants to critically reflect on their own practice with regard to the use of a visualisation-IK approach as a pedagogical tool to mediate learning. Thus, this study is set to inform various education stakeholders in the Namibian education system at different levels. It is hoped that the findings of this research project will be useful and informative for teachers, teacher-trainers, curriculum designers, researchers/scholars and textbook authors. It is also hoped that policy makers will gain insightful information about the importance of recommending a visualisation-IK teaching approach in the curriculum in a more explicit manner.

1.5 LIMITATIONS

The findings of this study about the teachers' views, perceptions and experiences are limited to 25 teachers who returned the survey questionnaires and four teachers who took part in the study as main participants. As only 25 survey questionnaires were returned, this affected how representative the findings are of all the teachers in the Oshana region although the data from the survey questionnaires were complemented and triangulated with interview data. The other limitation was time constraints, as some of the teachers had been postponing the due date (retrieval date) and I was only able to receive the survey questionnaires at the end of June 2017. One teacher subsequently withdrew from the study, thus the number of main participants was reduced from five to four. Therefore, the findings of this study cannot be used to generalise for the whole region or country. However, despite these limitations, useful insights on the use of a visualisation-IK approach in the teaching of mathematics have been provided by this study.

1.6. STRUCTURE OF THE THESIS

This thesis is composed of five chapters:

Chapter one

This chapter provides a brief introduction to the thesis.

Chapter two

This chapter discusses the literature that has informed my research. It reviews the literature about indigenous knowledge (IK) and visualisation. It also reviews the role that visualisation plays in the teaching of mathematics as a mediating tool for IK re-contextualisation. Thereafter, it reviews the literature about the possible enabling and constraining factors on the use of IK and visualisation in the teaching of mathematics in the Namibian context. The chapter concludes with a discussion of socio-cultural and social constructivism theories which underpin this study.

Chapter three

This chapter deals with the research process and the research methodology that was employed. It gives a detailed description of the research context, the tools used for data collection, how these tools were used and why they were used.

Chapter four

This chapter deals with the data analysis and discussion of findings. The chapter begins by outlining the findings from the NNCBE (2010) document analysis, the survey, 12 lessons observed and the two interviews conducted. The analytical tools that were used to analyse the data that was adapted from the work of Bishop (1991a) and Presmeg (1991), were also presented in this chapter.

Chapter five

Chapter 5 presents a summary of the dominant themes draws conclusions from the findings and makes recommendations and suggestions for future research. The chapter ends with my personal reflections of my research journey.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews the literature about indigenous knowledge (IK) and visualisation. It defines IK and visualisation. It also discusses how visualisation as an approach can be used to re-contextualise IK for making mathematical connections and enhancing conceptual understanding. I review the literature from the Namibian National Curriculum for Basic Education (NNCBE, 2010), which advocates the use of existing knowledge, experiences and their relationship with IK. Further, I elaborate on the role that visualisation plays in the teaching of mathematics as a mediating tool for IK re-contextualisation. Thereafter, I look at the literature about the possible enabling and constraining factors when using IK and visualisation in the teaching of mathematics in the Namibian context. The chapter concludes with a discussion of socio-cultural and social constructivism theories which underpin this study.

2.2 INDIGENOUS KNOWLEDGE

The term indigenous knowledge (IK) has been defined as "the knowledge or way of knowing, reflecting the dynamic way in which people living within a given geographical locality have come to understand themselves in relation to their environment and how they organize that folk knowledge of flora and fauna, cultural beliefs and history to enhance their lives" (Semali & Kincheloe, 1999, p.3). It involves wisdoms that have been developed and passed on over generations (Kibirige & Van Rooyen, 2006). It is a local knowledge that developed from interactions between the people and their environment as a result of community practical engagement in everyday life. All sorts of knowledge can be acquired in a unique way. IK can also be acquired in its own way. Boven and Morohashi (2002) suggest that:

> Indigenous knowledge is the information base for a society, which facilitates communication and decision-making. Indigenous information systems are dynamic, and are continually influenced by internal creativity and experimentation as well as by contact with external systems.

Activity and understanding that respond to ecological and social contexts, and are locally validated, have enabled communities to successfully farm animals, cultivate and harvest plants, and process and conserve local resources (Rodil, Winschiers-Theophilus, Bidwell, Rehm, & Kapuire, 2011). The way people behave, act, react and respond to the environment depends on the IK they have. For instance, the younger generations in communities learn or get knowledge from elders through instruction, observation and interaction.

Kibirige and Van Rooyen (2006) define indigenous knowledge (IK) as inherited information and practices that are unique to a particular culture. It is established and handed down from one generation to the next. In the same vein, Snively and Corsiglia (2001) refer to IK as traditional knowledge (TK), indigenous knowledge systems (IKS) or traditional ecological knowledge (TEK). IK encompasses human experience, which has been modified through practice (Kibirige & Van Rooyen, 2006). Further, IK is confined to a particular culture and is locally bound. It can also be understood without the use of words. Often, it is passed on orally or by actions and is generally not documented. IK is constantly changing and is linked to the survival of the people (ibid). In addition, IK is holistic and depends on collective knowledge rather than hypothesis and analysis (Shizha, 2007).

Knowledge is known to all members of a community and transmitted within the community and through interaction (Boven & Morohashi, 2002). It is thus important for children to grow in their local environment to assimilate the knowledge that drives the community system. This implies that knowledge is hardly borrowed from another local or culture, but rather it is passed on from generation to generation within the culture as reiterated by Kibirige and van Rooyen (2006). Hence, it might be difficult to find the origin of such knowledge (Ogunniyi & Ogawa, 2008). However, within the same community, IK may vary from one group of people to another. It is for these reasons that Ogunniyi and Ogawa (2008) posit that there is much IK in a certain society that is hardly accessible to another group in another society.

In addition, Kibirige and Van Rooyen (2006) point out that IK is a legacy of knowledge and skills unique to a particular culture and community. Additionally, IK is characterised by containing wisdom that has been developed and passed on over generations. In support, Ogunniyi and Ogawa (2008) explain that IK implies that knowledge has not been borrowed from another locality or culture. Instead, it is about knowledge of the indigenous people of a particular geographical area in which they have been surviving for a long period of time (Mapara, 2009).

Further, Kibirige and Van Rooyen (2006) suggest that incorporating IK into teaching and learning makes concepts more interesting to learners. These authors maintain that the passing on of information from generation to generation, promotes communication. Thus, IK stimulates a communicative approach to education. Anderson (1980) argues that teaching mathematics in a way detached from cultural aspects and in a purely abstract and symbolic way, is very harmful to the learners, to society, to mathematics itself and to future generations. Furthermore, the exchanges between the elders and the students improve classroom interactions (Lemke, 2001). Lastly, the interaction of IK facilitates starting from what the learner already knows, which makes teaching and learning easier.

According to Kibirige and Van Rooyen (2006), learners creatively and selectively recall, use, and shape both mathematical wisdom and traditions of their culture of origin and make the connections to new mathematics concepts independently. Such wisdom is derived from interactions between people and their environment (Cocks, Alexander & Dold, 2012). Furthermore, to pass knowledge on to the younger generations, members of a community share knowledge and new discoveries with other community members, especially those bringing up the young ones (Mukwambo, Ngcoza & Chikunda, 2014). This entails learners sharing their IK through interactions with others from different cultural backgrounds, and making connections to new learning concepts.

IK shows similarities with desirable classroom practices (Ogunniyi & Ogawa, 2008). For example, its strong link to everyday life makes it relevant, leading to active participation in classrooms. In addition, the holistic nature of IK encourages enquiry and allows learners to see that learning is not fragmented (ibid). The authors agree that as the elders recall with enthusiasm their practices, the younger generations learn to respect their traditions. Moreover, it is essential in supplementing new mathematics knowledge aesthetically and morally.

Furthermore, IK eliminates the gap between classroom knowledge and everyday knowledge that causes schools and individuals to be dysfunctional (van Wyk, 2002). The study contends that IK can be used to develop higher-order thinking skills in a cohesive manner by giving learners an opportunity for construction of knowledge (ibid). For Shizha (2007), learners easily engage with knowledge and use it to develop their societies when teaching is related to their culture. This study proposes that the inclusion of IK in the curriculum helps the young learners to maintain their culture.

Le Grange (2007) strongly advocates the integration of new knowledge and IK, while Mukwambo et al. (2014) increasingly call for locally developed programmes to address the development needs of the region. To this end, Mukwambo et al. (2014) realise the benefits of Africanisation in teaching and learning, such as using familiar knowledge to introduce new concepts and engagement in knowledge construction, in order to achieve a common goal and understanding. Gay and Cole (1967) claim that in order to build effective bridges from indigenous mathematics to the new school mathematics: "...the teacher should begin with materials of the indigenous culture, leading the child to use them in a creative way and from there advance to the new school mathematics" (p. 578).

2.2.1 Traditional knowledge

According to Berkes, Colding and Folke (2000), traditional knowledge (TK) is a cumulative body of knowledge and beliefs, handed down over generations by cultural transmission. It is about the relationship of living beings (including humans) with one another and with their environment (ibid). Hansen and Van Fleet (2003) define TK as the information that people in a given community possess, based on experience and adaptation to a local culture and environment, have developed over time, and continue to develop. This knowledge is used to sustain the community and its culture and to maintain the genetic resources necessary for the continued survival of the community (ibid). Even though indigenous knowledge (IK) and traditional knowledge (TK) have been indicated as being very similar, TK is more specific and distinct than IK. Convention on Biological Diversity (CBD, 2006) asserts that:

> Traditional knowledge refers to the knowledge, innovations and practices of indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation. It tends to be collectively owned and takes the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local language, and agricultural practices, including the development of plant species and animal breeds.

From the definition above, it is clear that all people have traditions that shape their lifestyle, and that their knowledge acquisition is informed by this traditional background. One of the sources of the acquisition of knowledge results from our contact with the material world, "the world of cultural artefacts which surrounds us, and in which is found the historically deposited knowledge from the cognitive activity of past generations" (Radford, 2008, p. 230).

As I have indicated above, IK and TK are intertwined, and it is difficult to separate the two concepts as they essentially refer to the same thing. The two concepts can thus be used interchangeably. What is common in the two concepts is that they refer to knowledge that is acquired through the interaction with the environment and that is transferred orally from generation to generation (Kibirige & Van Rooyen, 2006). The word 'traditional' does not mean 'old knowledge'; rather it refers to the way knowledge has been acquired that reflects the traditions of the communities (Hansen & Van Fleet, 2003). That is, it does not necessarily relate to the nature of the knowledge itself, but to the way, in which that knowledge was created, preserved and disseminated (Cocks, Alexander & Dold, 2012; Hansen & Van Fleet, 2003).

2.2.2 Cultural practices

In various communities around the world, there exists IK. This knowledge is acquired from cultural practices that are carried out in the community. It is the basis for local-level decision-making in agriculture, health care, food preparation, education, natural resources management, and a host of other activities in rural communities (Warren 1991:1). Different cultural practices are executed in society for a variety of reasons. According to Robbins (2007), communities develop knowledge within their environment, yet the knowledge can be advanced to a certain level through interaction, communication or activities, and influenced by cultural, institutional or historical factors. The use of traditional knowledge helps learners to learn effectively and assists them in border-crossing during their learning (Aikenhead & Jegede, 1999). "Even if teachers choose to ignore the large scale of social context in which people work, they cannot ignore the way in which their students' learning is embedded in that context" (Lemke, 2001, p. 301).

I argue that when a teacher uses knowledge that learners have acquired from home and links it to topics in the syllabus, he/she is re-contextualising IK. When the teacher invokes cultural or traditional practices to teach mathematics concepts, for example, the construction of a traditional hut to teach concepts such as circumference, radius, PI, area of a circle and so on, the teacher is re-contextualising this local, traditional or indigenous knowledge into a mathematical context. Boven and Morohashi (2002) clarify that "indigenous knowledge is the local knowledge that is unique to a given culture or society, in addition local knowledge focuses more on agriculture, health care, food preparation, education, natural resource management, and a host of other practices in rural communities" (p. 12).

2.2.3 IK in mathematics

Discussions about the incorporation and inclusion of IK in school subjects are often raised at different levels in Namibia. Kasanda and Kapenda (2015) claimed that, as efforts are being made to mainstream IK into formal education, there is a need to document available IK in order to ensure its effective instruction, learning and preservation. Mathematics is around us, we use mathematics knowledge in our everyday life activities, and therefore school mathematics should be relevant to the world around us. Bishop (1988) asserts that mathematics is a cultural product and is therefore created by humans in the interconnected midst of culture. The interactions are dialectical: people's daily practice, language, and ideology affect and are affected by their mathematical knowledge (Gerdes, 1997). It is important that the learning of mathematics requires one to have IK as a fundamental pedagogic starting point. This existing knowledge is the starting point for any interpretation of the process of information that advances to learning as a construction of knowledge (Roschelle, 1995). Various theories have been put forward to explain the interaction between IK and formal school mathematics knowledge.

Bishop (1991a) emphasises that mathematics is a product of culturally-based human activities. He further stresses that the inclusion of existing knowledge in mathematics contributes to the development of individual children. Bishop (1988) outlines that many activities carried out in traditional society such as cooking, weaving, making bead necklaces and clothing design, can provide interesting starting points for leaners to re-contextualise mathematics within a broader society. Looking at some fundamental activities and processes, Bishop (1991b) asserts that mathematics can be underpinned by different cultural norms and values through counting, locating, measuring, designing, playing and explaining.

To comprehend the social context of learning mathematics, Zaslavsky and Sullivan (2011) note that all societies have developed mathematical practices appropriate to their daily lives and their cultures play a pivotal role in the teaching and learning of mathematics. I agree with Zaslavsky and Sullivan in the sense that learners do not come to school as empty vessels; their cultural backgrounds hold their potential to approach new mathematics knowledge they find in schools. However, the usefulness and re-contextualisation of the knowledge learners bring to school are basically influenced by the role of the teacher; teacher's beliefs and values; and teacher's background knowledge (Matang, 1998). The level of the teacher's IK determines how effective the teacher can facilitate learners to make use of their IK and re-contextualize it for new knowledge. Kreisler & Semali (1997) suggest that teachers should take account of the interaction between what is actually learned as new knowledge in relation to a particular situation or problem, and the understanding and dispositions which learners themselves bring to school.

Graven and Schäfer (2013:4) assert that it is important to affirm what learners know because they acquire new knowledge through relating new things to what already exists in their knowledge schema. By incorporating real-life activities and IK artefacts into the classroom, concepts become more accessible and relevant to learners as they visualise and relate these activities to their experiences and cultural practices (Lemke, 2001). In addition, to help learners make the most of new experiences, educators need to understand how existing knowledge affects learning (Roschelle, 1995). In this case teachers need to design tasks that will enable learners to gradually develop new mathematics concepts and make connections between the 'old' and the 'new' knowledge while effectively being involved with tasks (ibid). This means that teachers need to use different strategies to work with learners, since they come with rich IK.

The content of a multicultural curriculum must be created using a variety of resources, most of which can be easily found in the community outside the school (Gay, 2010). Cultural heritage should play a significant role in the creation of this curriculum where the goal is to connect school mathematics and the personal experiences of students (Scott, 2001) i.e. re-contextualising local and personal experiences and knowledge into a curriculum context. The goal of such a curriculum is student success. Gay (2010, p. 127) states that "to be effective, knowledge must be accessible to students and connected to their lives and experiences outside of school". Integrating familiar objects and contexts in the teaching of mathematics can facilitate learning (Kaahwa, 1999). It is therefore important to create relationships that link the indigenous knowledge of students to the teaching of mathematics (Eglash, 1999).

Recognizing the knowledge students have assimilated from home or from the community can provide mathematical contexts that are significant and relevant to any student (Cobb & Hodge, 2007). The learning situation then becomes familiar and has meaning for students. Scott (2001), states that "no multicultural classroom operates successfully without community involvement" (p.120). Zaslavsky (1996) informs us that multicultural education is the responsibility of the family and the community as well as the school. Silver, Smith & Nelson (1995:125) recognize the importance of culturally relevant teaching in which important characteristics of the students and their local community culture are linked to classroom instructional practice. It is thus essential that students and teachers recognize cultural diversity and to this end, elements of diverse cultures need to be integrated into a school curriculum (Zaslavsky, 1996).

It is further emphasized that "culture comprises a network of relatively stable practices that capture daily life within a group or community that are passed from one generation to another" (Cobb & Hodge 2007, p.161). Community participation is important for a number of reasons: it strengthens the link between home, school and community; it strengthens the link between school and the cultural diversity of students, and it demonstrates the importance of incorporating cultural elements in the teaching of mathematics (ibid). Those strengths motivate students to learn about their culture and that of others while also learning mathematics. According to Wiest (2002, p. 53), exposing students to the contributions of members of their own and other cultures can help them to gain confidence, self-esteem and a sense of belonging as well as respect for the mathematical thinking of other cultures". Culturally relevant pedagogy validates students' cultural backgrounds and history, and provides ways for teachers to support cultural connections between the school and the community (Rosa & Orey, 2013).

However, there are some challenges that may affect the implementation of the use of IK in the teaching of mathematics. Those challenges could be a different understanding amongst teachers and other education stakeholders towards IK, its position in knowledge construction, or the sustainability of multiculturalism. According to Turnbull (1997), IK can only achieve full status as knowledge if it is absorbed into the Western canon; otherwise it will remain mere tradition or belief. Such belief may prevail amongst the majority of the teachers and demoralise them from implementing the use of IK. Shizha (2007) asserts that many teachers are believed to be unsuccessful in multicultural classes because they have a limited knowledge of the history and culture of the learners. It is important that teachers in multicultural classrooms, with learners from different cultural backgrounds, should first recognise the traditional indigenous base of the learners.

2.2.4 Enabling and constraining factors of incorporating IK

Despite the positive aspects associated with the inclusion of IK however, a lack of documentation and lack of proven procedural explanations and perceptions of IK in classroom mathematics have been identified as constraining factors in enhancing conceptualisation (Agea, Lugangwa, Obua, & Kambugu, 2008). It is against this backdrop that some of these constraining factors may discourage teachers from including IK in their mathematics teaching. Mukwambo et al. (2014) emphasises the benefits of Africanisation in teaching and learning by using familiar knowledge to introduce new concepts and engagement in knowledge construction, in order to achieve a common goal and understanding. However, their study further states that despite the benefits, there exist some challenges in integrating IK into the school curriculum. They found that IK is often implicit in nature and is often accompanied by some myths that are not scientifically proven.

A research study by Cocks, Alexander and Dold (2012) reveals the threatening of South African biodiversity. In this regard, the Rio Conventions call for an integrated approach to conservation that incorporates local environmental knowledge and practices. Their study found that the inclusion of IK into the mainstream curriculums could promote conservation as well as cultural revitalisation for indigenous people. According to Cocks et al. (2012), this is very important because it encourages young people to respect their culture and use natural resources wisely.

Many African countries have failed to include IK in their classrooms, and this makes teaching and learning more difficult by not starting from where the learner is and building on what they already know (Kibirige & Van Rooyen, 2006). Yet, learners enjoy the process of linking new knowledge to their IK and making new meanings that they can claim as their own. Kibirige and Van Rooyen (2006) posit that owning a type of knowledge brings joy and satisfaction to learners and it is highly likely that such learning will increase their retention of the new knowledge. Incorporating IK into lessons encourages learners to change the meaning of their experience, and that meaning is then constructed through shared experience. However, IK can have negative implications if not included in an appropriate way in lessons.

Not all IK is valuable or useful in lessons. Some IK creates contradictions between the curriculum and the IK people possess. Mukwambo et al. (2014) argue that we need to be aware that IK is not a bag of knowledge waiting to be tapped into and dispensed. Instead, there is a need to critically analyse it before it can be used, to expose any contradictions that might come with it, or be entailed by it. Many concepts are not yet developed in the indigenous language and according to Mukwambo et al. (2014), classroom concepts are not always explicit in most indigenous practices, but the Africanisation of the school curriculum calls upon the teachers and learners to attach scientific explanations to IK. They believe that the Africanisation of the curriculum may allow more examples of IK to be used in the classroom. In my experience however, teachers feel that the curriculum does not give that freedom to them to include or test IK Teachers are too influenced by the curriculum. In my view they over-rely on and over-comply with the curriculum, and they do not see the need for IK in school subjects. Teachers should be more critical of the curriculum and feel empowered to incorporate IK into the curriculum.

Similarly, Shizha (2007) argues that hesitancy was detected when teachers in Zimbabwe were asked how they incorporated IK, culture and traditional beliefs and customs into their lessons. This hesitancy was influenced by the national curriculum that does not explicitly recommend the incorporation of IK into school subjects. IK and language were viewed as irrelevant to the understanding of knowledge and skills that are practiced internationally (ibid). Furthermore, textbooks can be a hindrance to the successful integration of IK because they document facts and truth. Teachers rely on documented information and accept it as legitimate knowledge (Shizha, 2007). Since IK is not documented, tested and proven as valid, it is difficult for teachers to include it in their lessons unless they have extensive knowledge about it.

Textbooks might not support teachers in including the IK of local people as they are the only sources that teachers use to teach and implement the curriculum. Since not all teachers are teaching in their local environment, it might be difficult for them to integrate the culture or traditional knowledge of the culture as different cultures have different IK. For the authors to include IK in the textbooks, curriculum designers need to include it in the curriculum. Ogunniyi and Ogawa (2008) point out that although curriculum developers recognize the obstacles in the way of implementing such curriculum changes, they nevertheless call on teachers to create the courses themselves and make the curriculum work.

According to Aikenhead and Jegede (1999) the cultural clash between the learners' life-world and the world of Western knowledge challenges teachers. Cultural clashes can occur, and teachers have to be sensitive when learners cross from their life-world (IK) into the modern world of knowledge. When confronted with this disagreement, learners understandably invent ways to avoid constructing scientific knowledge, or store the constructed scientific knowledge in their mind out of harm's way to prevent it from interfering with their IK (ibid). This change from one world of knowledge to the other requires the teacher to manage the two through collateral learning.

Lastly, the dilemmas and contradictions that arise from the integration of new knowledge and IK into teaching are complex, not only in terms of curriculum transformation but also in terms of teachers' education and pedagogical practices within lessons (Mhakure & Mushaikwa, 2014). For IK to be integrated into the curriculum, teachers need to have the background knowledge from that local community in order to be able to teach. IK is context-dependent (Kibirige & Van Rooyen, 2006) and defines community members' identities (Mhakure & Mushaikwa, 2014). The term identity refers to a person's beliefs, attitudes, emotions and dispositions towards IK and the role these factors play in lessons (ibid).

Hence, Mhakure and Mushaikwa (2014) posit that to produce teaching and learning materials on the inclusion of IK and new knowledge to instruct pre-service and in-service teachers on multicultural learning and teaching environments, may require time and resources that most African governments are not willing to give. Research needs to be carried out to determine which IK can be linked to specific topics in the curriculum. In the same vein, Mukwambo et al. (2014), propose that Africanisation of the school curriculum might encourage teachers to embrace cultural beliefs in their science lessons and to engage with them. Thus, teaching materials that involve IK need to be developed not only by curriculum designers, but teachers from different cultures also need to be involved so that the materials suit their respective cultures. Teachers should arrange for learners to visit and experience life with knowledgeable people in their communities such as elderly people, scientists, community leaders and scholars of folklore (Klein, 2011). This type of project provides many opportunities to teach IK (Ogunniyi & Ogawa, 2008).

Ogunniyi and Ogawa (2008) further showed that the most effective way of encouraging teachers to emphasize new knowledge and IK in their classrooms is to engage them in a long-term mentoring process in the form of dialogue, argumentation, role modelling, and explicitly reflective instruction approaches within a conceptual change framework. Teachers need to have in-depth knowledge of the curriculum for them to be able to merge IK with its contents for presentation in their lessons. They need to be more knowledgeable about the culture and the IK of the learners before attempting to integrate it into their lessons. IK has a strong link with the culture, traditional beliefs and the environment where people live.

Maselwa (2004) argues that for the teachers to be able to incorporate IK into their lessons, they need to be knowledgeable about the subject content and be mindful of the elicitation and incorporation of learners' existing knowledge into their teaching and learning. This would encourage confidence in front of the learners, and would help to clear all the misconceptions that might come with IK. These misconceptions can distract the learning process if neglected by the teachers.

In short, teachers need to be educated about the importance of integrating IK into their mathematics lessons. This can only be done if the institutions of higher learning include IK in their curriculum and train teachers on how to use IK in mathematics

2.3 VISUALISATION

2.3.1 Definition of visualisation

According to Arcavi (2003, p.217) visualisation is:

> the ability, the process and the product of creation, interpretation, use of and reflection upon pictures, images, diagrams, in our minds, on paper or with technological tools, with the purpose of depicting and communicating information, thinking about and developing previously unknown ideas and advancing understandings.

Tall (1991:10) suggests that visualisation is a powerful process that conveys a large amount of data holistically and enables an individual to change focus from one part of the picture to another so that relationships may be observed visually and pictorially. While Guzman's (2002) version of mathematical visualisation is, "…a way of acting with explicit attention to the possible concrete representations of the objects one is manipulating in order to have a more efficient approach to the abstract relationships one is handling"(p. 2). Zimmermann and Cunningham (1991) defined visualisation as mental images formed either mentally, with pencil and paper, or with the aid of technology. In this study, Arcavi's (2003) aforementioned definition is critical.

2.3.2 Visualisation in mathematics

Using visualisation in mathematics teaching provides teachers with an interesting and meaningful approach to mediate many mathematical concepts, and allows students access to new ways of understanding their own mathematics (Elliott, Hudson & O'Reilly, 2000). Rodríguez, Caligaris and Laugero, (2014) argue that students can conceptualise and imagine ideas, compare their problem-solving methods, and analyse the pros and cons of applying these to discover new mathematical solutions. For Zimmermann and Cunningham (1991), visualisations can supply depth and meaning to understanding, serve as a reliable guide to problem-solving, and inspire creative discoveries. In this sense, visualisation cannot be isolated from the rest of mathematics. In other words, symbolic, visual and numerical representations are key components in connecting mathematical ideas (Zimmermann & Cunningham, 1991).

Furthermore, Hershkowitz et al. (1989) claim that learners cannot form an image of a concept without visualising it and/or its elements. It is generally recognised that individuals constantly engage in making internal mental images of artefacts or things of interest. Schäfer (2017) refers to visualisation being a process of forming a picture (mental or otherwise) of something in order to help make sense of that something. Generally, it is agreed that visualisation plays a number of important roles in learners' capacity to solve problems. According to Rösken and Rolka (2006) visualisation can be a powerful tool to explore mathematical problems and to give meaning to mathematical concepts and relationships between them. Thus, visualisation is taken to include processes of constructing and transforming both visual mental imagery and all of the inscriptions of a spatial nature that may be implicated in doing mathematics (Presmeg, 1991).

2.4 VISUALISATION AND IK

According to Rodil et al. (2011), knowledge is constituted within the social and ecological rhythms of daily life for the 12% - 25% of rural residents who have never been to school. Such knowledge is then constituted in books and classrooms according to subjects and study time-tables for those attending school (ibid). People share such IK orally by talking, telling stories and by participating in ordinary activities and rituals. Rodil et al. (2011) further stress that members of the community can more easily identify cultural icons through visualisations than by using text-based technologies. When they come to school, learners have a very strong visual or spatial sense accompanied by strong visual memories of their cultural background (Presmeg, 1991). Visualisations of cultural artefacts have a history dating from the earliest human activities, which suggests that modern visualisations, which go beyond graphic icons, offer opportunities to organize information in ways that are compatible with rural IK (Rodil et al., 2011).

In any case one has to be aware that our visualisations contain many aspects that have to do with tradition, implicit cultural behaviours and consensus that makes them dependent

(Guzman, 2002). Visualisation and IK are often interchangeable and interconnected. I wish to argue that the role of IK must be acknowledged especially during visualisation processes, or else the overall account of mathematics will be incomplete. Since IK is social, and not a self-subsistent entity existing in some ideal realm, this knowledge must, like all aspects of culture, be reproduced and transmitted from generation to generation with the aid of artefacts such as text books (Kibirige & Van Rooyen, 2006) and, this study argues, visualisation processes. According to the social constructivist account, traditional knowledge is what sustains and structures new knowledge, whether it is in mathematics or any other discipline (Hall, 2000). Thus, IK can play an important role in mathematical visual representations and vice versa. Using this argument, teachers can develop a mathematical concept starting with an out-of-school situation and linking it in a number of steps with formal school mathematics (Presmeg, 1991).

2.5 VISUALISATION, IK AND TEACHING

Mosimege and Onwu (2004) suggest that teachers should be appropriately placed according to their mathematical knowledge to create linkages between various activities embedded with mathematical concepts. This is to ensure that learners' experiences are enriched through daily experiences of what they encounter outside the classroom (ibid). Their claim comprehends the inclusion of IK in the teaching of mathematics, which can rarely happen with the exclusion of visualisation.

In addition, Roschelle (1995) suggests that teachers should always look for opportunities to connect mathematics with the real world by conceptualizing, analysing, interpreting, and validating conclusions in order to make decisions about situations in everyday life, society, or the workplace. Both IK and visualisation work with spatial relationships and they complement one another in the construction of new knowledge. According to Hawkins & Pea (1987:294), a child is surrounded by a rich cultural setting such as objects and events which play a crucial role in the construction of knowledge that the student brings into the classroom. "Such objects and events are unique to each individual's culture and locality, and may include the interaction of visual media, people, plants, animals, buildings, informal learning situations, and the practices of institutions such as churches or schools" (Hawkins & Pea 1987, p. 294).

Mathematics is composed of a large set of highly related abstractions (Fennema & Franke, 1992). Thus, visualisation is an important way to re-contextualise mathematical concepts, and may be used to represent mathematical objects that do not have a real existence. Zimmerman and Cunningham (1991) insist that visualisation supplies depth and meaning to understanding, serving as a reliable guide to problem-solving, and inspiring creative discoveries. However, in order to achieve this understanding, they propose that visualisation cannot be isolated from the rest of mathematics, implying that symbolical, numerical and visual representations of ideas must be formulated and connected.

Rösken and Rolka (2006) also acknowledge the role that visualisation plays in mathematics learning. They state that visualisation can be a powerful tool in exploring mathematical problems and giving meaning to mathematical concepts and the relationships between them. They further articulate that, "visualisation allows for reducing complexity when dealing with a multitude of information" (Rösken & Rolka, 2006, p. 458). This infers that complexity reduction can be done when teachers use what learners already know, which can be referred to as IK, in order to approach what is unknown. Mosimege and Onwu (2004) echoed that educators can therefore help to close the gap that always seems to exist between classroom activities and activities outside the classroom. This is to ensure that mathematical concepts learned in classrooms are not done in isolation but take visualisation and IK into account.

2.5.1 Visualisation-IK teaching approach

Visualisation can be a powerful tool in modelling various problems, learning approaches, activities, and so on. According to Guzman (2002), visualisation is a very powerful tool to grasp in a unitary and holistic way the different contexts that constantly arise in the different tasks connected with the mathematics theories. It can also be useful in helping learners to reason, and engage in higher order thinking around problem solving by using a variety of artefacts (Chiappini & Bottino, 1999). In this current educational climate, educators should try and make the role of visualisation during problem-solving clear to the learners if the learners are to take maximum advantage of it during problem-solving (Makina & Wessels, 2009). According to Makina (2010), visualisation is regarded as a very important keystone in teaching for understanding in mathematics, because it helps the teacher with facilitation of lessons and with the ability to engage learners in realistic situations. In order for mathematics teachers to appreciate the role of visualisation, the teachers themselves need to be aware of the role that visualisation plays in the teaching and learning of mathematics (ibid).

In order to make learning relevant to the learners, a change in the education process is necessary. Seepe (2000) suggests that a paradigmatic change that recognises, locates, and identifies skills, knowledge and processes embedded in the cultural practices of the learners, is necessary. Any conceptualisation of IK must suggest that the mathematics syllabus has to focus on the relational dimension of cultural life (van Wyk, 2002). Osaki (1994: 63) argues that IK is "actually a paradigm of enquiry" and there is an important need to put in place strategies that harness IK in order to address challenges in education. Seepe (2000: 134) contends that learners find an intellectual home in culture and language and if these are used they may be a "key to unlocking the door that has prevented the masses from accessing mathematics, science and engineering". Scharping and Gorg (1994) in Beck (1999) refer to such an approach as 'interdisciplinary' since it creates a new relationship between natural and social sciences. It also allows interaction between two ways of knowing what Beck (1992) in O'Donoghue (2002) calls "inter-epistemological dialogue". Both indigenous and propositional ways of knowing are brought together for a better understanding of how both exist and operate.

In learner-centred pedagogy, the teacher is viewed as someone who assesses learners' needs and interests. He plans learning activities that address learners' needs and builds on those interests and needs (Namibia, MEC, 1993:60). Thus, the approach a teacher uses is redefined once learners are seen as partners in the pedagogic process. The concern though, should be more about whether learning occurs and on the role of the teacher as a mediator. Potenza (2002:1) argues that being a mediator "requires one to be very sensitive to the diverse needs of one's learners, to construct appropriate learning environments and demonstrate sound knowledge of your learning area or subject". We should therefore view the role of the teacher as not merely transferring knowledge to the learners, but creating conditions in the classroom where learners can construct different understandings of the concepts being taught by using their own knowledge (Roschelle, 1995).

2.5.2 Visualisation as mediating tool for IK re-contextualisation

Mediation is one of the basic principles of cultural historical activity theory (Cole, 1996). Artefacts or visual representations are the tools that can be used to mediate the modification of human activity (IK) into new mathematics knowledge (Katić, Hmelo-Silver, & Weber, 2009). They may be either external or internal mediators. Goldin and Kaput (1996, p. 400) define external representations as "physically embodied, observable configurations such as words, graphs, pictures, equations, or computer micro worlds". In an attempt to distinguish between the two visualisations, Goldin (2002) defines internal visualisation as "the internal systems of representation that are created within a person's mind and used to assign mathematical meaning" (p. 10).

Katić et al. (2009) further noted that mediating tools exert a strong influence on the physical and mental operations of an individual. Mediating tools serve a communicative purpose and can be used by individuals to exchange knowledge with their peers (Goldin, 2002). Thus, visual tools and representations are more than just inert equipment. They are imbued with cultural meaning and become key mediators that partially direct resulting human actions (Engeström, 1999). Paivio (1971) suggested that the way a task is tackled by an individual depends on the following: the task itself (in this case whether it is presented in visual form or not); instructions to do the task in a certain way; and finally, individual differences (the IK of both teachers and learners). I would add a fourth item to his list: the sociocultural climate of the classroom (whether or not visualisation is promoted, accepted, encouraged or valued). This aligns with the argument that the learning environment should include the learners' social-cultural background which they bring to the classroom (Mosimege & Onwu, 2004).

The effective re-contextualisation of IK depends on how the teacher deals with such knowledge in the classrooms, and how the curriculum design allows the consideration of such knowledge (Mosimege & Onwu, 2004). Further, Kaino (2013) observed that artefacts that are available in the local environment are important tools that can be used to mediate (to bridge the gap) between what is usually taught in the classroom and what exists outside the classroom, that is, in society.

2.5.2.1 Making connections

Frigo (1999) defines contextualising mathematics as recognising and building on the mathematical knowledge that indigenous students utilise outside the classroom. The *National Statement on Mathematics for Australian Schools* (1991) stated that "students are more likely to respond to the experiences they have in school if they feel that those experiences relate to the lives of their communities" (p. 24). According to Frigo (1999) contextualization and making connections to the experiences of learners are powerful processes in developing mathematical understanding. Against this background, Aikenhead and Jegede (1999:272) talk about 'border crossing'. They explain the term as a process where a child tries to integrate the new learned knowledge at school to the knowledge and experiences he got from home (IK).

When mathematical ideas are connected to each other or to other real-world phenomena, students begin to view mathematics as useful, relevant, and integrated (Adams, 1998). The brain is constantly looking for and making connections. Roschelle (1995) also noted that learning within contexts and making connections relevant to learners can validate past experiences and prior knowledge, and increase children's willingness to participate and be actively engaged.

According to Chiappini and Bottino (1999), the use of visualisation in the study of mathematics provides learners with opportunities to understand mathematical concepts and make connections among them. Makina and Wessels (2009) emphasise that visualisation can often provide simple, elegant and powerful approaches to developing mathematical results and solving problems, in the process of making connections between different areas of mathematics (indigenous mathematics and classroom mathematics). In addition, Rosken and Rolka (2006) stated that being able to create, interpret, and describe a visual representation is part of spatial sense and spatial reasoning. Piggott and Woodham (2008) assert that spatial visualisation and reasoning enable students to describe the relationships among and between 3-D objects and 2-D shapes including aspects such as dimensions and measurements. They further emphasised that visualisation provides a connection between the concrete, physical and pictorial, and the abstract symbolic. Visualisation is fostered through the use of concrete materials, technology, and a variety of visual representations as well as the use of communication to develop connections among different contexts, content, and representations (Fennema & Romberg, 1999).

Kilpatrick et al. (2001) advocate that effective instructional approaches and learning activities, drawing on students' prior knowledge, are likely to capture their interest and encourage meaningful practice both inside and outside the mathematics classroom. This means "students' interest will be engaged when they are able to see the connections between the concepts they are learning and their application" in real-life situations (Ontario. Ministry of Education, 2005, p. 8). Understanding gained through linkages and concepts connected to real life situations give learners power over mathematics (Ball & Hill, 2008). This is likely to increase students' disposition and comfort level in their ability to reason mathematically, set up problems, value the variety of approaches and techniques, make the conceptual leap from concrete to abstract reasoning and develop meaningful understanding of fundamental mathematical concepts in problems (Speer, 2011).

2.5.2.2 Conceptual understanding

According to Kilpatrick et al. (2001), conceptual understanding is described as “the comprehension of mathematical concepts, operations, and relations” (p.5). It involves the ability to integrate and connect mathematical ideas (ibid). These may be ideas about shapes and space, measures, patterns, functions, connections, proofs etc. Further, conceptual understanding enhances learners’ confidence, which then provides a base from which they can move to higher levels of understanding (ibid). Different authors define conceptual understanding differently and sometimes refer to it as conceptual knowledge. Wiggins (2014) defines conceptual understanding as “the ability to justify, in a way appropriate to the student’s mathematical maturity, why a particular mathematical statement is true or where a mathematical rule comes from” (p. 1). Learners with conceptual understanding can carry out activities procedurally and generate new knowledge independently. Kilpatrick et al. (2001), acknowledge that:

> Students with conceptual understanding know more than isolated facts and methods; understand why a mathematical idea is important and the kinds of contexts in which it is useful; have organized their knowledge into a coherent whole which enables them to learn new ideas by connecting those ideas to what they know; remember with ease, reconstruct and use facts and methods learned; monitor what they remember and try to figure out whether it makes sense; attempt to explain the method to themselves and correct it if necessary; verbalize connections among concepts and representations; represent mathematical situations in different ways and know how different representations can be useful for different purposes; see connections among concepts and procedures and explain why some facts are consequences of others; and avoid many critical errors in solving problems, particularly errors of magnitude. (pp. 118-119)

On the other hand, Gabriel et al. (2012) define conceptual knowledge (or conceptual understanding) as “the explicit or implicit understanding of the principles ruling a domain and the interrelations between the different parts of knowledge in a domain” (p. 137). This includes “knowledge of central concepts and principles and their interrelations in a particular domain” (Gabriel et al., 2012, p. 137). According to Balka and Harbin (n.d.), conceptual understanding is a reflection of students’ abilities to reason in settings that demand the careful application of concept definitions, relations, or representations of either. Conceptual understanding in mathematics makes “learning [of] skills easier, less susceptible to common errors, and less prone to forgetting” (Kilpatrick et al., 2001, p. 123).

Furthermore, mathematical concepts are abstract and one needs highly cognitive achievements to assimilate them (Baki, 1998). By using a visualisation approach to teaching, many mathematical concepts can become concrete and clear for students to understand. According to Kickbusch (2000), teaching for understanding requires teachers to educate students to exhibit what they know and what they can do with what they know in real-life situations. Konyalioglu (2003) noted that with a visualisation approach, students can perceive relations between abstract concepts and semi-concrete structures and make sense of abstract concepts in mathematics. This approach thus facilitates students' understanding of abstract concepts.

Guzman (2002) affirms that a visualisation process has proved to be extraordinarily useful in better understanding and manipulating the common structures of many real things. Visualisation is also a very powerful tool for grasping in a unitary and holistic way the different contexts that constantly arise in the different tasks connected with the theory (Rosken & Rolka, 2006). Further, Guzman (2002) asserts that visualisation is an effective vehicle for the communication of ideas and an auxiliary tool for the unconscious activity around the most obscure problems connected with it.

Learners are assumed to construct their mathematical conceptual understandings as they participate in cultural practices and whilst interacting with each other in their communities (Jojo, 2015). IK and visualisation are linked and intersect at developing conceptual understanding for learners. Piaget (1966) advocates that learners build their mental representation of their world through progressively reorganising (re-contextualising) prior active manipulation of an environment. This implies that relations, such as connectedness, enclosure, and continuity, are constructed through re-contextualisation of IK.

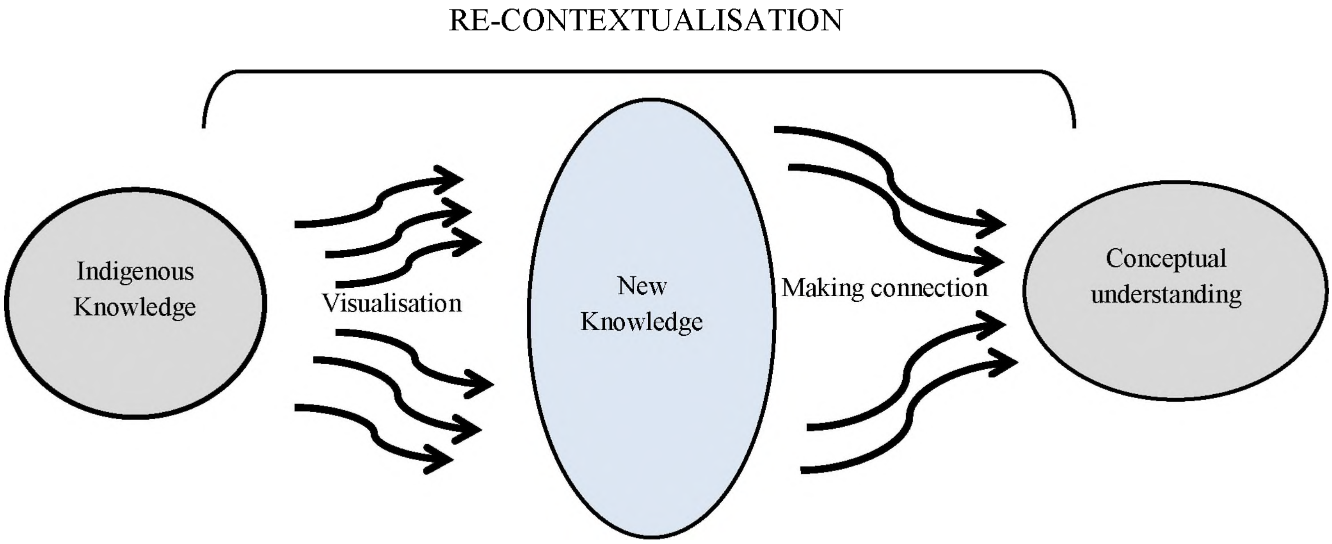

Figure 2. 1 Processes that take place during a visualisation-IK approach

According to Jojo (2015), as learners construct diagrams, pictures and shapes whether physically or mentally, conceptual understanding is enhanced. If, for example, we consider mathematical knowledge as internally represented information, understanding occurs when the representations achieved are connected by progressively more structured and cohesive networks (Hiebert & Carpenter, 1992). In addition, a learner with conceptual understanding will immediately visualise the nature of the two variables to connect the two in order to solve the problem. D'Ambrosio (1985) emphasises the crucial role of culture in mathematics (ethnomathematics) within a curriculum, presenting learners with the effective opportunity to combine and integrate self-generated methods they use in 'real' situations with school-taught algorithms. The effective re-contextualisation of IK depends on how the teacher deals with such knowledge in the classrooms, and how the current curriculum design allows the consideration of such knowledge (Mosimege & Onwu, 2004). Kaino (2013) observed that artefacts that are available in the local environment are important tools that can be used to bridge the gap between what is usually taught in the classroom and what exists outside the classroom, that is, in society.

According to the National Council of Teachers of Mathematics (NCTM, 2000), students should be exposed to a variety of diversified experiences that are related to cultural, historical and scientific evolution of mathematics for them to have a better understanding. Civil (2002) emphasizes the need for the creation of mathematical experiences that are related to the cultural experiences of students. These experiences are often rich in mathematical concepts and can enhance conceptual understanding in the teaching of mathematics. Teaching mathematics to a group of students with the same mathematical abilities, the same learning styles and the same cultural backgrounds would probably be easy (Dossey, McCrone, Giordano & Weir, 2002). However, this is not the reality of the classroom. Students in the same class have various lived experiences, cultural backgrounds and learning styles (Scott, 2001). The cultural realities of each school jurisdiction characterize the needs of its students which in turn determine the teaching approaches teachers have to engage in to attain conceptual understanding (Skemp, 1987).

Mathematical conceptualization implies the integration of known knowledge (indigenous, traditional or cultural knowledge) and the assimilation of new knowledge into existing schemas (Skemp, 1987). Since we have no direct way of being in touch with the thought process of someone, or allow access to our own mental universe, we must use means, whether visual or auditory, to communicate (ibid). A sound or a visual representation, which is a symbol associated with a mental image, can be used to record information (Skemp, 1987). According to Hyde and Bizar (1989: 129), one factor that influences how children learn is the education they receive at home. Using familiar objects and contexts to teach mathematics can facilitate effective learning for conceptual knowledge (Civil, 2002). For this reason, it is important to link the cultural reality of the students to the learning of mathematics for better understanding of concepts as proposed by theories.

2.6 THEORETICAL CONSIDERATION

This study is underpinned by the constructivist perspective. Constructivism is the belief that meaning is constructed and not discovered (Gray, 2004). Arksey and Knight (1999:19) also argue that this perspective concerns the way that humans individually and collectively interpret their world. Moll (2002:11) argues that "constructivism or constructionism or indeed any term for the construction of knowledge does not have, nor should it have, only one particular meaning". Atherton (2009) describes constructivism as a set of assumptions about the way human beings learn. In essence, constructivism suggests a move away from the notion that knowledge is given to passive learners, to the idea that active learners invent or co-construct knowledge as they engage with it. Two strands of constructivism are discussed: the socio-cultural perspective, and social constructivism.

2.6.1 Socio-cultural perspective

This study is informed by Vygotsky's (1978) socio-cultural theory. To Vygotsky, this perspective recognizes that culture and beliefs influence the way learners learn. This knowledge if consciously brought to class has the potential to enable meaningful learning of concepts. This theory has contributed significantly towards education. Vygotsky believes that construction of knowledge depends on the interdependence of social and individual processes (John-Steiner & Mahn, 1996). These authors submit that Vygotsky emphasises the concept that “human activities that take place in cultural contexts, are mediated by language and other symbol systems, and can be best understood when investigated in their historical development” (ibid., p. 191). According to the propounded socio-cultural theory, meaningful learning occurs when there is social interaction between learners and those with more experience. Vygotsky (1978) asserts that human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them.

The socio-cultural perspective according to Traianou (2006:835) is the understanding of concepts and ideas of a particular community in a dynamic process. It results from acting in situations and from negotiating with other members of that community. Furthermore, such understanding is constructed first on a social plane before it is internalised by the learner (Murphy, 1999:20). Socio-cultural theory also suggests that learning involves enculturation of the novice into the practice of a particular community (Traianou, 2006:835) with the support of an expert. The expert (teacher) should be more skilled than the novice (learner) in terms of having a broader understanding of the important features of a cultural activity or IK in the context of this study.

Moreover, Stears, Malcolm and Kowlas (2003:3) argue that although individuals can personally construct knowledge, it has to be socially mediated as a result of cultural experiences and personal history. They further argue that culture is a contextual lens through which learners view and understand the world and that it has direct influence on learners’ cognitive processes and understanding of concepts. It is for these reasons that in this study I opted to elicit teachers’ perceptions, views and experiences on IK and how they incorporate it in the teaching of mathematics to enhance meaning-making and conceptual understanding. Research has shown that recognizing learners’ cultural practices may help them to understand the subject matter (Stears et al., 2003).

Curriculum developers and mathematics educators should take advantage of the cultural diversity of students to enhance the learning of mathematics through social and cultural activities. According to Hyde & Bizar (1989, p.89), “we now see the student as actively constructing meaning, connecting new information to existing knowledge structures, and creating new relationships among structures". This can be accomplished by incorporating students' IK into the curriculum. Alberta Education (2007, p. 1), indicates that the learning environment should value and respect the diversity of students' experiences and ways of thinking, so that children are comfortable taking intellectual risks, asking questions and posing conjectures.

Teachers must find ways to use students' differences and strengths embedded in cultural knowledge to make mathematics meaningful to students and interesting to teach (Zaslavsky, 1996). Students should be actively involved in the mathematics class by sharing cultural experiences from which the teacher can create mathematical activities that correspond to specific mathematical concepts (ibid). It is evident that different cultures have different traditions and different histories (Ascher, 2002) and that the discussion of mathematics through the lens of one's own culture can lead one to think not only about one's own culture but that of others as well.

Due to the perpetual and constant evolving change in cultural diversity within the Namibian classrooms, the creation of mathematics activities based on traditional practices is essential. Curriculum developers, program designers and mathematics teachers should take this diversity into account to improve mathematics learning through social and cultural activities (Zaslavsky, 1996). It is clear that each culture has different traditions and different histories (Ascher, 2002) and the issue of integrating mathematical concepts into a cultural perspective can lead us to reflect on our own culture but also that of others. Cultural diversity is a force, "a persistent, vitalizing force in our personal and civic lives" (Gay, 2010, p. 15).

According to Zaslavsky (1996, p. 14), "multicultural education is many-faceted. It involves curriculum content, classroom management, assessment practices, the involvement of families and communities, teacher expectations, and professional development". The teaching of mathematics in a multicultural setting with the inclusion of IK is not obvious. Ascher (2002) asserts that adapting mathematical content to take into consideration the cultural practices and knowledge of students, and incorporating the participation of community members, is not an easy task. Gay (2010) emphasizes that most teachers are not adequately trained to teach a class consisting of students from different cultures. Gay (2010, p. 164) states that "academic success is improved by accepting the fact that mathematical and scientific knowledge is present in all cultural groups".

The multicultural dimension of school mathematics will require increased attention to students' ways of thinking and reasoning in different settings (Silver et al, 1995). An awareness of the diversity of cultures and languages in schools should be an important element of every teacher-training program (Alberta Education, 2007). Teachers need to understand their own culture and how cultural biases can influence their own teaching styles which in turn can influence student academic performance (Ryder, 2001).

2.6.2 Social constructivism

According to McRobbie and Tobin (1997:194), social constructivism recognises the social and personal aspects of learning. They argue that in the personal sense, meaning is constructed by the individual as new information interacts with existing knowledge. Learning is personal and subjective, and exists in the mind of the knower. In the social sense, the constructed knowledge is socially mediated as a result of cultural experiences and interaction with others.

The origins of social constructivism could probably be traced back to the Russian psychologist, Vygotsky. He believed that children are at their highest peak of learning when they are collaborating with more skilled partners (Vygotsky, 1978). He stated that the more knowledgeable other (teacher) helps the learner by intellectually scaffolding them, and this allows the learner to carry out more intricate tasks than when they are on their own (Wertsch, 1985). He also believed that what children do with the help of others today, they are able to do alone tomorrow. Vygotsky (1978) referred to this as the Zone of Proximal Development (ZPD). Moreover, Goos (2004) uses the term scaffolding as associated with the interactions whereby the teacher structures tasks to allow students to participate in collaborative activities.

Stears and Malcolm (2005:22) maintain that social constructivism provides an appropriate learning theory. To this end, they take an example from Vygotsky (1978), who views the development of the child as proceeding interactively from the social to the individual, in a learning process through which the child connects the spontaneous conceptual domain of the home to the formal conceptual domain of the school (Rennie, 2011). In essence, there is a tendency in most learners to differentiate between school knowledge and out of school knowledge (Stears et al., 2003). Further, Stears et al. (2003:3) argue that the curriculum should be structured in a learning cycle that firstly takes learners' everyday knowledge into account and uses it in building more formalised structures, and then links the formal knowledge back to a particular context in the learners' lives.

2.7 NAMIBIAN CONTEXT

The Namibian National Curriculum for Basic Education (NNCBE, 2010) is set to meet the needs of learners and to solve problems that they are encounter in their real-life situation. It suggests that mathematical skills, knowledge, concepts and processes should enable the learner to investigate, model and interpret numerical and spatial relationships and patterns that exist in their world (NNCBE, 2010). Mathematics as a school subject is an important body of education and should answer questions about the needs of the community. Most of the answers can be obtained through incorporating IK (ibid). Education is intelligently maintained so that it develops learners' rational abilities to deal with ideas and objects that represent reasonable achievement.

The NNCBE (2010) further outlined that it is only by local contextualization and application that younger learners will understand and appreciate the uses of mathematics. Where textbooks can only give general examples, it is up to the teacher to use and include local knowledge by developing appropriate worksheets and exercises (NNCBE, 2010). To learners, new mathematics experiences become more meaningful only if they are related to existing experiences or IK. Thus, in order to enable learners to construct a mathematical world which is coherent and useful, mathematics instruction should begin with situations from which generalisations can be made (Matang, 1998). It is clearly stated that the starting point for teaching and learning is the fact that the learner brings to the school a wealth of knowledge and social experience gained continually from the family, the community, and through interaction with the environment (NNCBE, 2010). This will not only equip the learners with the necessary contextual meaning for understanding the conceptual meaning of many abstract mathematical concepts, but also makes mathematics a meaningful, attractive and reflective subject, thereby developing critical thinking in mathematics (Matang, 1998). The incorporation of IK in visualisation can make a learner-centred approach more effective and relevant.

In order to improve curriculum relevance, the use of an IK context in mathematics curriculum teaching has been promoted in Namibia over the past decades. This was one of the main ideas behind the research study conducted by Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda and Campbell (2005:1807) in Namibia, who stated that the drive for political and social self-confidence has encouraged the building of a school curriculum based on learners' every day or cultural experiences (Stears, Malcolm & Kowlas, 2003).

Since Namibia became independent in 1990, the education system has been underpinned by the principle of learner-centred education (LCE), as in other developing countries. In Namibia, this principle is in an African context which embraces diversity, but which is emerging from a colonial past where ethnic differences were deliberately perverted and negatively exploited (National Institute for Education Development (NIED), 2003:17). A balance therefore needs to be found between the prescribed knowledge and the knowledge brought into the classroom by the learners from their own experiences and the community (Rennie, 2011). This balance was realised through the implementation of LCE. The then Namibian Ministry of Education and Culture describes the LCE approach, in its broad curriculum for Basic Education Teacher Diploma (BETD) (2003:3) as follows:

> Learner-centred education presupposes that teachers have a holistic view of the learners valuing their life experiences as a starting point for their studies. Teachers should be able to select content and methods on the basis of the learners' needs. Teachers should use local and natural resources as alternatives or to supplement ready-made materials and must develop their own and learners` creativity.

Pomuti (1999:14) further describes LCE as follows:

> LCE is a social process where the emphasis is on collaboration and the exchanging of ideas, experiences, values and attitudes. It is a negotiated process where our understanding expands through interactions and active engagement with others.

Based on the previous descriptions, this implies that the teacher must provide the settings that are appropriate for particular and desired learning experiences. In this sense, teachers are seen as facilitators, demonstrators and role models giving learners a leg-up to the next level of learning. Supporting this, Nyambe (2008) views a learner as someone whose rich experiences form the basis upon which a lesson is organised and facilitated, when he quoted:

> Every young child has a store of rich experience. Building on learners' experiences is a sound way to stimulate interest and to lead into new and more significant and practical learning. A learner-centred curriculum seeks to do just that: to begin with learners' interests and experiences and to use them to lead learners toward what is less familiar or not yet familiar (Namibia. MEC, 1993:61).

Furthermore, learner-centeredness entails teaching that "emphasizes what the student should know, understand, do and be able to become", as opposed to what the teacher educator should achieve (Meier, 2005:78). While acknowledging the teacher's central position in the teaching and learning process, LCE accords the teacher educator a non-authoritarian but active position as a guide, initiator, advisor, observer and facilitator of students` learning activities (Coetzer, 2001). LCE also values the individual needs and the interests of the students and thus accords the students a strong voice in the design and implementation of the teaching and learning process (Stears & Malcolm, 2005). The interests and life-world of the students form the basis of the curriculum, and students are actively involved in determining the content of education (Meier, 2005:77).

Learner-centred teaching is "based on democratic pedagogy, a methodology which promotes learning through understanding and practice directed towards empowerment to shape one's own life" (MBESC & MHETEC, 1998:2). According to the policy document: Towards education for all (Namibia, MEC, 1993), teaching and learning is supposed to be organized in such a way that:

- The starting point is the learners' existing knowledge, skills, interests and understanding, derived from previous experiences in and out of school;
- The natural curiosity and eagerness of all young people to learn to investigate and to make sense of the widening world must be nourished and encouraged by challenging and meaningful tasks;
- The learners' perspective needs to be appreciated and considered in the work of the school;
- Learners should be empowered to think and take responsibility not only for their own, but also for one another's learning and total development; and
- Learners should be involved as partners in, rather than receivers of, educational growth (p. 60).

Thus, teachers are expected to work together as a team and to promote a cooperative culture of learning amongst learners, encouraging problem-solving and project approach (Bernstein, 1996:56). Through this lens, Namibia is seen as developing from a 'literate society' to a knowledge-based society, where knowledge is constantly acquired and renewed, and used for innovation to improve the quality of life for all (Namibian, MOE, 2009:2). With this understanding, learners are provided with an environment that will allow them to discover and continually use their IK to construct new knowledge in order to enhance their understanding of life.

Furthermore, in a learner-centred approach, there is a greater acknowledgement of IK for teaching and learning than otherwise. The knowledge and experience of the community, the learners themselves and the teachers are recognised and used as learning resources. In another sense, relative to the richness of the learning they provide, these resources are very cost effective.

A sense of the worthiness of their culture is encouraged by taking learners to activities such as cultural festivals to observe community-cultural practices which they could not initially imagine as associated with classroom knowledge. This sense of worthiness extends to them, thus creating interest and confidence in the subject. Kasanda et al. (2005:1807), also assert that everyday contexts allow learners to take control of their own learning. Furthermore, Lubben, Campbell & Dlamini (1996) advise that using an IK-based approach would increase the learners' participation in class and help to determine what is to be learned.

Delpit (1995:141) too argues that "in a mainstream educational thinking, many teachers feel that they are losing control if learners do not fit in with their traditional teaching content and methodologies". I agree with Delpit as part of my own understanding; it means that there is still a big challenge in terms of transformation, because most teachers are still found to be clinging to the old system, hence finding it difficult to fit in and effectively implement learner-centred approaches. Perhaps, there is a need to strike a balance between teacher-centred and learner-centred pedagogies as opposed to seeing them as mutually exclusive.

Despite the introduction of LCE, there have been challenges facing its full and effective implementation. One of the reasons why learner-centred education has been perceived as a foreign element in Namibia might be that it was not coached in an appropriate African metaphor for the upbringing of children (Namibia, NIED, 2003). Thus, teachers need to be properly trained so that they can use IK-based approaches to scaffold and support their learners. Vygotsky (1978) developed a concept of the ZPD which suggests that designers (teachers) provide a scaffolding role to enable learners to participate in a more complex discourse than they could handle on their own (Brown & Ferrara, 1985). This is one of the reasons why I opted to bring in a visualisation-IK approach as a mediation tool to enhance meaning-making, conceptual development and understanding of concepts in the teaching of mathematics. The curriculum further emphasizes the role of its links with the community. As such, the community can be an important support and resource, as well as a source of knowledge. Also, there might be people with expertise in mathematics and cultural traditions that might be used to support the teaching process and other co-curricular activities.

2.8 CONCLUDING REMARKS

In this chapter, I discussed the relevant literature that supported my research. I reviewed IK and visualisation definitions and their roles in mathematics teaching. I also looked at learner-centred education (LCE) in the Namibian context and the role of teachers' approaches in LCE. I looked at the key conceptual framework, namely IK that informed my study. Under the conceptual framework I focused on visualisation as a teachers' mediation tool to re-contextualise IK. Lastly, I discussed the theoretical framework by looking at socio-cultural and social constructivism theories. This clarified my research by triangulating different theories.

Chapter Three focuses on describing and justifying the methodological framework and research techniques used in my research.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this chapter I describe the methodological frameworks that underpin the research process in this study. I decided on a mixed method design that allowed for both qualitative and quantitative data collection and analysis, but using a case study as my primary research method. I discuss the techniques that I used to collect data to answer my research questions. The study employed the following data gathering techniques: document analysis, survey questionnaires, observations and interviews. The sampling strategies, data analysis, validity and trustworthiness, and ethical considerations pertaining to the study are also considered in this chapter. The chapter ends with some concluding remarks.

3.2 RESEARCH GOALS

The first goal of this study was to explore teachers' views, perceptions and experiences of teaching mathematics using a visualisation approach to re-contextualise indigenous knowledge. The second goal was to investigate how selected teachers use visualisation-IK approaches as pedagogical strategies, stimulated by a teacher-intervention programme. To achieve these goals, the four questions below framed this study:

- How widely is IK included in the teaching and learning of mathematics in the Oshana region of Namibia?
- In cases where IK is used, how is it used to promote conceptual understanding in mathematics?
- As a result of an intervention programme, how is IK used in conjunction with visualisation processes to promote conceptual understanding?
- What are the participating teachers' experiences of the enabling and constraining factors in using a visualisation-IK approach to teaching mathematics?

3.3 RESEARCH ORIENTATION

This study is located within an interpretive paradigm using a mixed method approach, utilizing qualitative and quantitative methods (Bertram & Christiansen, 2015). According to Bertram and Christiansen (2015), interpretivist researchers aim to understand how people make sense of their worlds. (p. 26). Cohen, Manion and Morrison (2011) explain that:

> ...the central endeavour in the context of the interpretive paradigm is to understand the subjective world of human experience. To retain the integrity of the phenomena being investigated, efforts are made to get inside the person and to understand from within. The imposition of external form and structure is resisted, since this reflects the viewpoint of the observer as opposed to that of the actor directly involved (p. 17).

In the context of this study, an interpretive paradigm enabled good interaction with the participants during the data gathering process. Moreover, knowing the background culture of the research participants gave me insight and access to their practices which enabled me to collect detailed data.

Additionally, Hussain, Elyas & Nasseef (2013, p. 2375) assert that "interpretive research seeks to understand values, beliefs and meaning of social phenomena and extract knowledge or an empathetic understanding of human social activities and experience". Through using an interpretive paradigm, I worked closely with my participants on their views and experiences in the inclusion of IK in their lessons. Within the interpretive paradigm, I employed a case study research approach.

3.4 RESEARCH METHODS

A case study approach was appropriate in this study as it allowed me to focus on the specific objective rather than looking at the broad picture. Gay, Mills, and Airasian (2011) define a case study as a "qualitative research approach in which researchers focus on a unit of study known as a bounded system" (p. 444). A case study is well suited to "make sense of feelings, experiences, social situations, or phenomena as they occur in the real world, and therefore study them in their natural settings" (Rule & John, 2011, p. 60). The case in this study was four teachers engaging in a visualisation-IK intervention program and implementing this in their lessons. The unit of analysis was two-phased: firstly, I analysed the survey questionnaires that I retrieved from the teacher; secondly, I analysed participating teachers' experiences of teaching mathematics using a visualisation-IK approach to promote conceptual understanding.

Using mixed methods helps the researcher to gain complete understanding and comprehension of results, discover new perspectives, or develop new measurement tools (Tashakkori & Teddlie, 2003). It involves collecting both quantitative and qualitative data. Creswell (2003) described a quantitative research as an approach used for testing objectives, theories and models by examining the relationship among variables whereby the data is analysed using statistical procedures. On the other hand, Baxter and Jack (2008) argue that a qualitative case study is an approach to research that facilitates exploration of a phenomenon within its context using a variety of data sources. This ensures that the issue is not explored through one lens, but rather through a variety of lenses, which allows for multiple facets of the phenomenon to be revealed and understood (ibid).

3.5 RESEARCH DESIGN

This study made use of a variety of data collection techniques and methods i.e. document analysis and survey questionnaires with 25 teachers. The study further involved observation and interviews with 4 selected teachers. The data generation unfolded in five phases that are explained below.

Phase I: Consent, Document analysis and survey

In this phase I requested permission from the Director of Education as well as from the school principals to conduct this research study at schools in Oshana Region (Appendix 1, p. 111). Survey questionnaires were distributed to 62 mathematics teachers teaching at schools around Ondangwa in the Oshana region. The survey questionnaire was distributed to school principals at their respective schools for them to hand to mathematics teachers. At first only five survey questionnaires were returned. Reminders were sent out through the offices of the principals before I made a follow-up from school to school and finally a total of 25 survey questionnaires were completed and returned.

Phase II: Survey analysis and selection of participating teachers

In this phase I analysed all the returned survey questionnaires. Upon receipt of the survey and tabulating the statistical data I conveniently selected five teachers from the surveyed population. One teacher subsequently withdrew from the study. I asked the remaining four teachers to volunteer to be the main participants for my case study. I involved them in an intervention programme described below.

Phase III: Intervention

In this phase I interacted with the selected four teachers in an intervention programme. Prior to that and in preparation for the intervention programme, I conducted a focus-group interview where I explored the four teachers' views on a visualisation-IK approach to teaching mathematics, and how they could incorporate this in a teaching programme. The intervention programme involved a workshop with the four participants in which we explored visualisation-IK approaches to teaching mathematics. Teachers specifically designed lesson plans and teaching strategies that enabled the incorporation of traditional or cultural artefacts and visualisation processes in their lessons. The planned intervention program details are presented in the tables below. Detailed lesson plans can be found in appendix 6a-l.

Table 3.1 Teacher 1 lesson 1-3

Teacher	Details of the lessons planned	IK	Visualisation
TI	**Lesson 1** Subject: Mathematics Grade: 4 Time allocated:40min Topics/theme: Data handling	• The use of local sources to collect data e.g. shoes sizes or types of animals.	• Reading, drawing and interpreting pictograms and bar graphs.
	Lesson 2 Subject: Mathematics Grade: 4 Time allocated:40min Topics/theme: Units of time	• The use of traditional ways of recording and measuring time.	• Using digital and analogue clocks to read and record time.
	Lesson 3 Subject: Mathematics Grade: 4 Time allocated:40min Topics/theme: Mensuration	• Ways of estimating and measuring perimeters and areas of the traditional house, kraal, etc.	• Measuring and calculating perimeters and areas of squares and rectangles in hand-outs.

Table 3.2 Teacher 2 lesson 1-3

Teacher	Details of the lessons planned	IK	Visualisation
TII	**Lesson 1** Subject: Mathematics Grade: 5 Time allocated: 40 min Topics/theme: Measuring and recording	• Use of traditional artefacts to measure length, mass and capacity. E.g clay pot for capacity.	• Use of different containers to measure capacity.
	Lesson 2 Subject: Mathematics Grade: 7 Time allocated: 40 min Topics/theme: Measuring and recording	• The use of baskets *(Elilo)* and clay pots *(Okayo)* as traditional capacity measuring utensils.	• Learners use 30cm rulers in groups to measure the length of a 1m ruler. • A poster with metric units of length, mass and capacity was prepared.
	Lesson 3 Subject: Mathematics Grade: 7 Time allocated: 40 min Topics/theme: Mensuration	• Local examples such as construction of traditional houses and kraals.	• Use of measuring tapes to measure the dimensions of the classroom and calculate the area.

Table 3.3 Teacher 3 lesson 1-3

Teacher	Details of the lessons planned	IK	Visualisation
TIII	**Lesson 1** Subject: Mathematics Grade: 11 Time allocated: 40min Topics/theme: Linear equations	• Local examples scenarios to construct linear equations.	• Use of rectangles to construct simultaneous equations.
	Lesson 2 Subject: Mathematics Grade: 9 Time allocated: 40min Topics/theme: Mensuration	• Use of traditional houses and huts constructions as examples of circular shapes.	• Calculate the perimeter, area and volume on 2 and 3-dimensional shapes.
	Lesson 3 Subject: Mathematics Grade: 10 Time allocated: 40min Topics/theme: Trigonometry bearings	• Use of local places as points of bearings	• Use of pictures to find bearings of different points

Table 3.4 Teacher 4 lesson 1-3

Teacher	Details of the lessons planned	IK	Visualisation
TIV	**Lesson 1** Subject: Mathematics Grade: 4 Time allocated: 40 min Topics/theme: Units of time *(planned same as TI lesson 2)*	• The use of traditional ways of recording and measuring time.	• Use of digital and analogue clocks to read and record time.
	Lesson 2 Subject: Mathematics Grade: 4 Time allocated: 40 min Topics/theme: Mensuration *(planned same as TI lesson 3)*	• Estimating and measuring the perimeters and areas of the traditional house, kraal, etc.	• Measuring and calculating perimeters and areas of squares and rectangles in hand-outs.
	Lesson 3 Subject: Mathematics Grade: 4 Time allocated: 40 min Topics/theme: Approximation and rounding	• Use of local open markets as an example where people estimate the size of a portion for a certain sum of money.	• Use of poster with examples on how to round decimal fractions

Phase IV: Implementation and observation

This phase consisted of the implementation of the three planned lessons using a visualisation-IK approach for each teacher. The contents of the lessons varied depending on the grades and the topics chosen by the teachers. I video-recorded three lessons from each teacher. A total of 12 lessons were videotaped for analysis purposes.

Phase V: Interview

After the teaching intervention, I conducted a semi-structured focus group interview with all the participating teachers. Morgan (1988) says that focus groups are unnatural settings which are very focused on a particular issue and therefore will yield insights that might not otherwise have been available in a straightforward interview. Interviewing is a useful method since it allows the researcher to ask probing questions and to discuss research participants' perceptions and understandings (Bertram & Christiansen, 2015). The focus of this interview was to explore the teachers' views, perceptions and experiences after using visualisation-IK as a pedagogical tool for enhancing conceptual understanding in their lessons. The interview was audio-taped and transcribed.

3.6 SELECTION OF PARTICIPANTS

The study was carried out in the Oshana region of Namibia. Sixty-two survey questionnaires were distributed to mathematics teachers of all grades. I chose the Oshana region because this is the region where I teach. Further, I anticipated that this region would provide me with enough teachers to distribute my survey questionnaires. The larger the sample the better, as this not only gives greater reliability but also enables more sophisticated statistics to be used (Cohen et al, 2011).

For the case study of this research I purposefully selected four teachers to participate in this research project. Bertram & Christiansen (2015) emphasised that in "purposive sampling, a researcher makes specific choices about which people, group or objects to include in the sample (p. 60). The criteria for selecting these four participants were based on their responses to the survey questionnaire and the distance between their schools and the school where I teach. All four selected participants teach within a radius of 5km from the school where I teach. I selected participants that had shown evidence of some understanding and experience of integrating IK in their teaching of mathematics, as reflected in their responses to the survey questionnaire. In addition, I looked at participants that had some experience in using visualisation materials in their teaching. Further, all four participants were willing to voluntarily participate in this research project.

Tables 3.5 The profiles of the teacher participants

Teacher	**Gender**	**Qualification**	**Experience in teaching mathematics**	**School location**
TI	Female	B.Ed. Honours in Mathematics Education	3 years	Rural
TII	Male	BETD + ACE in Mathematics education	14 years	Rural
TIII	Male	BETD + ACE in Mathematics education	14 years	Urban
TIV	Male	BETD + ACE in Mathematics education	10 years	Urban

3.7 DATA-GATHERING TECHNIQUES

The following data-gathering techniques were used to collect data for my research:

- Document analysis
- Survey questionnaires
- Observation
- Focus group interviews.

I used these data-gathering techniques for validation purposes, a process known as triangulation (Cohen et al., 2011). These techniques were chosen based on the advantages they have, even though they have some weaknesses, but their strengths were considered first. The advantages of survey questionnaires are: the questionnaire can be administered to a large number of people and it can reach a large group of geographically spread-out respondents within a short time (Bertram & Christiansen, 2015).

This research is a mixed method design and I needed more numerical data generated from survey questionnaires that I received from 25 teachers. The semi-structured (focus group) interviews were used to offset the weaknesses of the survey questionnaires and to have first-hand information and probe more information where it was needed, which could not be done with survey questionnaires. I chose semi-structured interviews to be able to have person-to-person contact and make sense out of something that they perhaps could not express in writing. More focus was thus placed on the qualitative data obtained from the open-ended questions in the survey questionnaires and triangulated with the data from semi-structured interviews (Appendix 5, p. 120).

3.7.1 Document analysis

Document analysis is a research technique which enables "a researcher to obtain the language and words of participants" and the data is "thoughtful, in that participants have given time to compiling" (Creswell, 2003, p. 187). Document analysis reveals what people do or did and what they value. In this study, two documents were analysed, namely: the general curriculum document for the Namibian National Curriculum for Basic Education (NNCBE, 2010) and an extract document of the mathematics syllabus for grades 1-12. These documents revealed the policies regarding the use of visualisation processes, indigenous knowledge and socio-cultural theory (Appendix 7, p. 127). This data informed my understanding of teachers' perceptions, views and experiences in visualisation-IK approaches in mathematics classroom practices.

3.7.2 Survey questionnaires

The survey questionnaire is a widely used and useful instrument for collecting survey information, providing structured, often numerical, data as well as being able to be administered without the presence of the researcher and often being comparatively straightforward to analyse (Cohen et al., 2011). Lending support, Rule and John (2011) add that survey questionnaires are prepared sets of field questions to which participants respond on their own, not in the presence of the researchers.

The survey questionnaire was divided into three parts (A, B and C). Part A consisted of 11 questions which sought teachers' views, perceptions and experiences in the use of visualisation materials in mathematics teaching. Part B consisted of 10 questions which sought the teachers' views, perceptions and experiences in the use of indigenous knowledge (IK) in mathematics teaching. Part C consisted of 4 questions which sought the teachers' opinions and understandings in the use of a visualisation-IK approach as a mediating tool for making connection and enhancing conceptual understanding. The survey questionnaire can be found in Appendix 4, p. 114.

In this study, 62 survey questionnaires were sent to teachers and only 25 survey questionnaires (40%) were returned. It took time to get the survey questionnaires back as the teachers were busy with their schoolwork and some were not willing to return them. I thus had to follow-up via the school principals. The process was very slow. It took me about four weeks during the month of June 2017 to obtain the 25 survey questionnaires that were then analysed and used in this research. This affected the time allocated to collecting data and the plan of the research.

3.7.3 Observation

Observation is a "systematic process of recording the behavioural patterns of participants, objects and occurrences without necessarily questioning or communicating with them" (Maree, 2010, p. 83). My specific focus was on four teachers' teaching practices in terms of how they incorporated visualisation and IK in their mathematics teaching. Observation enables the researcher to understand the context of programmes, to be open-ended and inductive, to see things that might otherwise be unconsciously missed, and to discover things that participants might not freely talk about in interviews situations, to move beyond perception-based data and to access personal knowledge (Cohen et al., 2011). In this research, I used a structured observation.

In order to investigate the use of a visualisation-IK approach in the teaching of mathematics, I observed this practice in the four different mathematics classrooms. Classes were observed several times but only three lessons for each teacher were transcribed for the purpose of this thesis. The observations were used with the aim of answering the second and third questions of this research project which were: in cases where IK is used, how is it used to promote conceptual understanding in mathematics? And, as a result of an intervention programme, how is IK used in conjunction with visualisation processes to promote conceptual understanding?

3.7.4 Focus group interviews

Two interviews were conducted in this research study. A pre-intervention focus-group interview was conducted before the classroom intervention and audio-recorded to find the views, perceptions and awareness of teachers about the use of a visualisation approach, and their views on IK in general. After the lesson observations, a post-intervention focus-group interview (the stimulated recall) was also conducted and recorded to reflect on the lessons. This was done to find out from the teachers how the use of a visualisation-IK approach had an effect on the practices during the teaching processes. In other words, the videos from classroom observation were transcribed and participating teachers were interviewed. A semi-structured interview was employed. Thomas (2011, p. 163) states that semi-structured interviews provide room for further questions for clarity. I chose semi-structured interviews because they allowed me to elicit more information from the participants and to see how the participants reacted when asked about the inclusion of visualisation and IK in their lessons. It also allowed me to have eye contact with the participants and observe their facial expressions and actions.

During the interviews I referred specifically to the videos and used them for stimulated recall. By engaging in depth with the teachers, insights were obtained that complemented the information collected through the document analysis, survey and observation. Even though some structured questions were used, much focus was on open-ended type of questions. Woods (2006) suggests that it is wise for a researcher to embrace open-ended questions to permit the cropping up of data which might be very useful in the research. Such an approach enabled me to have in-depth data. Bell (2010) suggests that "the more standardized the interview, the easier is it to aggregate and quantify the results" (p. 93). The interviews were audio-recorded and transcribed. Data is presented as authentically as possible. I felt this to be important as it added richness and validity to the data presentation.

Table 3.6 Summary of data-gathering techniques

Stages	Techniques	Data generated	Purpose
1.	**Document analysis** - Analysis of the NNCBE curriculum document - Analysis of syllabus document grade 4-7 and 8-12	-Finding frequencies in which visualisation-IK approaches are included. -Suggestions on how IK can be incorporated in the teaching mathematics -Theories on which learning and teaching is based.	-Locating the teaching paradigm in order to obtain the context of the research study. -Exposing IK and visualisation to teachers. -Extend ideas on how IK promotes socio-cultural perspective.
2.	**Questionnaires** - Teachers independently completed survey questionnaires.	-teachers' perception, views, and experiences on the incorporation of visualisation-IK.	- To get insight perceptions and views of teachers.
3.	**Pre-intervention and post-intervention (stimulated recall) focus group interviews** - Discussion was done to find teachers' views on the knowledge learners bring at school. - Brainstorming teachers' views on the use of visualisation-IK in Mathematics teaching and learning.	-Ways teachers use to engage IK and experience to teach Mathematics concepts. - Views on enabling and constraining factors.	-To provide a picture of the teaching discourse; to find out about teachers' engagement with visualisation-IK. -To get their views on enabling and constraining factors on the use of visualisation-IK approaches.
4.	**Observation** - Teachers were observed while teaching their normal lessons. - Audio and visual recording were used in the capturing of lesson undertaken by teachers.	-IK and visualisation elements emerged from the lessons recorded.	-To understand and see teachers experiences in the use of the given approaches and bring some changes and empowering them.

3.8 DATA ANALYSIS

The data generated in this research study was analysed quantitatively and qualitatively. Descriptive statistics were used to analyse some of the data generated by the survey questionnaires. The quantitative data collected in the survey was described statistically and presented in bar graphs and pie charts. However, most of the data collected from the survey questionnaires and interviews were analysed by using qualitative methods. In this instance it is the data that was gathered from the views and experiences of teachers on use of visualisation materials and the inclusion of IK in mathematics lessons.

During the observations, I used the analytical instruments to record the frequency of the occurrence of visualisation processes and the inclusion of IK in the lessons. Firstly, I had to develop and use an analytical instrument (see Table 3.2) adapted from Bishop (1991) to analyse the inclusion of IK in the mathematics lessons recorded. Secondly, I designed an analytical instrument (see Table 3.3) on the basis of the 13 questions that Presmeg (1991) proposes to be of major importance when researching visualisation in mathematics education. This instrument was used to analyse visualisation processes happening in the classroom.

These analytical instruments were also used to analyse and interpret the video recordings. The video recordings were analysed for evidence of re-contextualising IK in conjunction with visualisation processes. The quantitative analysis was inevitably influenced by the number of data sets and people from whom data had been collected (Cohen et al., 2011, p. 461). Vygotsky's socio-cultural theory informed the analytical framework which *inter alia* involves understanding the incorporation of cultural artefacts and experiences in teaching mathematical content and processes.

Table 3.7 Analytical instrument A- indicators on the inclusion of IK in the teaching of each recorded lesson. Adapted from Bishop (1991b)

Universal activities	**Organizing concepts**	**Coding**			
	In the lessons there is evidence of:	**1**	**2**	**3**	**4**
Counting	the use of a systematic way to compare and order mathematical concepts such as tallying, ordering and counting in the traditional way of the learners' home context;				
Locating	contextualising the taught mathematical concepts in the local environment;				
Measuring	quantification (such as ordering, comparing, counting or measuring) with regard to local and traditional methods;				
Designing	integrating local and traditional forms of design and spatial understanding. This may include traditional ways of symbolism and coding;				
Playing	making use of (or referring to) traditional games and activities children would engage in at home or in their free time;				
Explaining	contextualising or explaining mathematical concepts in relation to traditional religious practices, rituals and animations;				
Connecting	reflecting on local, traditional, indigenous artefacts and/or cultural practices;				

Table 3.8 Analytical instrument B- indicators on visualisation processes that each participant used in his/her lessons. Adapted from, Presmeg (1991)

In the lesson there is evidence of the following visualisation processes:	**Coding**			
	1	**2**	**3**	**4**
the teacher promotes the use of visual artefacts in his/her lesson;				
there exist classroom culture where the use of visuals is encouraged or motivated;				
the teacher uses different types of visualisation in mathematical concepts;				
the teacher uses gestures in conjunction with visualization artefacts in his/her lesson;				
the teacher uses metaphors in conjunction with visualization artefacts in his/her lesson;				
the teacher helps learners to make connections between visual and symbolic inscriptions of the same mathematical concepts;				
the teacher helps learners to make connections between visual imagery and mathematical processes;				
the teacher uses visualisation to promote mathematical abstraction and generalization;				
the teacher uses imagery visualisation to promote a positive disposition and enjoyment of learning and doing mathematics;				

Table 3.9 The coding consists of a likert scale and was used for both IK inclusion and visualisation processes evidence categories.

Codes	**Categories**	**Descriptions** (visualization-IK)
1	Strong evidence	Abundant use of IK and/or visual representations. (more than 3 incidences)
2	Medium evidence	Some IK and/or visual representations used. (3 incidences)
3	Weak evidence	A few IK and/or visual representations used. (1-2 incidences)
4	No evidence	No IK and/or visual representations used.

3.9 VALIDITY

To increase the research trustworthiness, the researcher may use triangulation (Bertram & Christiansen, 2015, p.188). In an effort to address the issues of validity and reliability, I used a variety of data generation methods to triangulate the data. The data was interpreted based on underpinning theory and analytical frameworks following the case study protocol and not my own personal views and opinions. I gave each teacher an opportunity to go through the relevant lesson observation and interview audio-video recordings with me to ascertain whether they felt I had captured things accurately, and whether there was anything in the transcripts which might cause discomfort. This member checking, or "respondent validation" (Cohen et al, 2011, p. 136) allowed me to assess intentionality and correct factual errors. It also helped me to offer respondents the opportunity to add further information or to put information on record; to provide summaries and to check the adequacy of the analysis.

3.10 ETHICS

O'Leary (2004) stresses that "the research should be conducted in a manner that balances the biases and subjectivities of the researcher, in order to protect the dignity and welfare of the researched" (p. 43). As a researcher one is accountable in acting ethically. Ethics is an important consideration in this study. The ethical considerations are explained below.

3.10.1 Respect and dignity

In order to maintain respect, dignity and mutual trust between participants and myself, I worked sensitively and respectfully with all teachers to ensure that there was no breach of confidentiality pertaining to the identities of individual teachers. I reassured them that they had the right to withdraw from the research at any time. Further, I also assured all the teachers that all identifying data will be kept under lock and key, and shared only with my supervisor, unless I had their expressed permission to do otherwise.

3.10.2 Transparency and honesty

First of all, I got the permission from the Director of Education to conduct the survey in Oshana Region, Namibia (Appendix 1, p.111). I also obtained permission (Bertram & Christiansen, 2015, p.66) from the three school principals and four mathematics teachers who took part in the research (Appendix 2, p. 112). To sustain transparency and honesty, the teachers were informed of the purpose of the study and the benefits they would get from the study. I further explain that the participants will gain more knowledge on how to incorporate IK into visualisation in their mathematics lesson.

3.10.3 Accountability and responsibility

In this study, I acknowledged the role that was played by all participants in choosing to share their knowledge, not just with me, but with the Namibian education community. Therefore, it was ethically appropriate and consistent with the research purposes, to acknowledge the contribution of the participants. The power relationship issues between participants and me, which might have influenced the outcome of the research, were considered so as to avoid leading participants into giving responses that they were not entirely comfortable with. To overcome power-related bias or issues, I firstly established a positive rapport between the participants and myself.

3.10.4 Integrity and academic professionalism

Throughout my research, I upheld the professional and academic standards and integrity required by Rhodes University by adhering to the laid-down rules and standards of the institution. My position as a teacher did not have any influence on the study, as I am in the same professional position (teacher) as the participants. I made sure that the research findings and all the data were presented authentically without any distortion or manipulation to suit my assumptions and opinions. Even though one of my four participants was a close colleague at my own school, I ensured that this did not influence biasness. I encouraged all the participants to provide me with authentic reflections of their experiences during an interaction.

3.11 LIMITATIONS AND CHALLENGES

The retrieval of the survey questionnaires from mathematics teachers of Oshana region was a challenge. At first only 20% of the survey questionnaires were returned to me. Thus, I had to send reminders with further copies of the survey questionnaires. Some of the teachers complained that the questions were too long and required descriptive answers. Some teachers further claimed that they could not understand the concept of indigenous knowledge. I assumed that this was the reason why some survey questionnaires that I got back from teachers were only partly completed and in some cases, the answers were not elaborated upon as required. In addition, some of the teachers kept postponing the due date (retrieval date) and I was only able to receive the survey questionnaires at the end of June 2017. One teacher subsequently withdrew from the study; thus, the number of main participants was reduced from five to four. These were the challenges, especially with time allocated to the process of data collection.

3.12 CONCLUSION

In this chapter, I described the methodological framework I used to gather data for my research. I also looked at the interpretive paradigm which informed my research. I discussed the mixed methods approach used in this study. Furthermore, this chapter outlined in more detail the sampling strategies I used to choose the participants for the interviews. The issue of trustworthiness was ensured by using triangulation, validity and trustworthiness. Lastly, I looked at the ethical considerations that I had to follow throughout my research. In the next chapter, I present, analyse and discuss the data generated from the gathering techniques.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.1 INTRODUCTION

The data presented in this chapter was generated through document analysis, survey questionnaires, interviews and the classroom observation. Different data gathering techniques were used to gather data so that they could complement one another as well as for triangulation purposes. In order to answer the research questions, I analysed the data collected in a variety of ways. In the case of document analysis, the Namibian National Curriculum for Basic Education (NNCBE, 2010), and the extracts from the document (mathematics syllabi grades 1-12) on visualisation, indigenous knowledge and socio-cultural perspective of teaching mathematics were analysed. Furthermore, during interviews with the teachers, every statement made regarding mathematics teaching and learning or problem-solving in conjunction with any visualisation-IK approach was identified and recorded. During the classroom observations, themes were inferred from comments, instructions, questions, classroom environment and behaviours observed.

4.2 DOCUMENT ANALYSIS

In this study, two documents were analysed, namely: the general curriculum document for the Namibian National Curriculum for Basic Education (NNCBE, 2010) and an extract document of the mathematics syllabus for grades 1-12. These documents revealed the policies in line with the use of visualisation processes, indigenous knowledge and socio-cultural theory. This data informed my understanding of teachers' perceptions, views and experiences in visualisation-IK approaches in mathematics classroom practices.

4.2.1 Curriculum document NNCBE

Visualisation

The NNCBE (2010) states that mathematical skills, knowledge, concepts and processes enable the learners to investigate, model, and interpret numerical and spatial relationships and patterns that exist in the world. This gives us the idea that the policy encourages the use of visualisation materials in the teaching of mathematics.

Indigenous Knowledge

In line with components of indigenous knowledge, the NNCBE (2010) outlines that, if learners are taught in a way which builds on what they already know and have experience in, and relate new knowledge to the reality around them, they will learn that learning in school can be meaningful. It further indicates that teachers should help learners realize what they might already know, or what ideas or questions they might have in a learning concept. The NNCBE (2010) further emphasised existing knowledge by asserting that understanding will then be added to and will modify previous experience. It further states the new understanding will lead to further activities and explorations of reality knowledge creation. This is in support of the inclusion of IK.

Socio-cultural theory

The NNCBE (2010) indicates that we are situated in a natural and cultural context with which we interact, which affects us and which we draw upon to construct understanding. This means that functioning well in a knowledge-based society can be summed up as the ability to respect, relate well to, and work well with others in multi-cultural settings and communities. Thus, the curriculum gives direction to the teachers on how to deliver their mathematics lessons with the inclusion of a visualisation-IK approach on the basis of a multiculturalism perspective.

4.2.2 Mathematics syllabus

Visualisation

In the Mathematics syllabus (2010) it is stated that mathematics uses its own specialised language that involves notations and symbols for describing numeric, geometric and graphic relations. Mathematical concepts build on one another throughout all the phases, thereby creating a coherent structure.

Indigenous Knowledge

On page 1 of the Mathematics syllabus (2010), it is indicated that the starting point for teaching and learning is what the learner brings to school, which is a wealth of knowledge and social experience gained continually from the family, the community, and through interactions with the environment. The kind of knowledge learners bring to school is in most cases IK.

Socio-cultural

According to the Mathematics syllabus (2010, p. 2), “mathematics is a purposeful activity in the context of social, political, technological and economic goals and constraints”. In addition, it is a discipline that is not value-free or culturally neutral. It further stresses that knowledge is part of culture and we need this knowledge and these skills in order to solve many everyday tasks, and to take care of personal interests and duties. It contributes to the development of logical and scientific thinking and provides pleasure and satisfaction when learners solve problems and enjoy number games. Thus, its knowledge is part of every-day culture and we need this knowledge and these skills in order to solve everyday tasks.

4.3 THE SURVEY

To answer my first research question, survey questionnaires were distributed to 60 mathematics teachers throughout the Oshana region. The survey questionnaire was divided into three sections; a) visualisation in mathematics teaching, b) IK in mathematics teaching and c) visualisation-IK approach in mathematics teaching. The survey questionnaire was designed to generate quantitative and qualitative data. As part of the ethical agreements all respondents were identified by a given code. Teacher participants in the returned data set were referred to as T1 to T25.
Below is the analysis of the survey:

4.3.1 Visualisation in Mathematics teaching

The responses from the teachers’ survey questionnaires are presented below.

1. ***Do you use visualisation materials/objects in your teaching? Please elaborate.***

   21 teachers responded *yes*, 2 teachers responded *no,* and 2 teachers responded *sometimes* with different reasons.

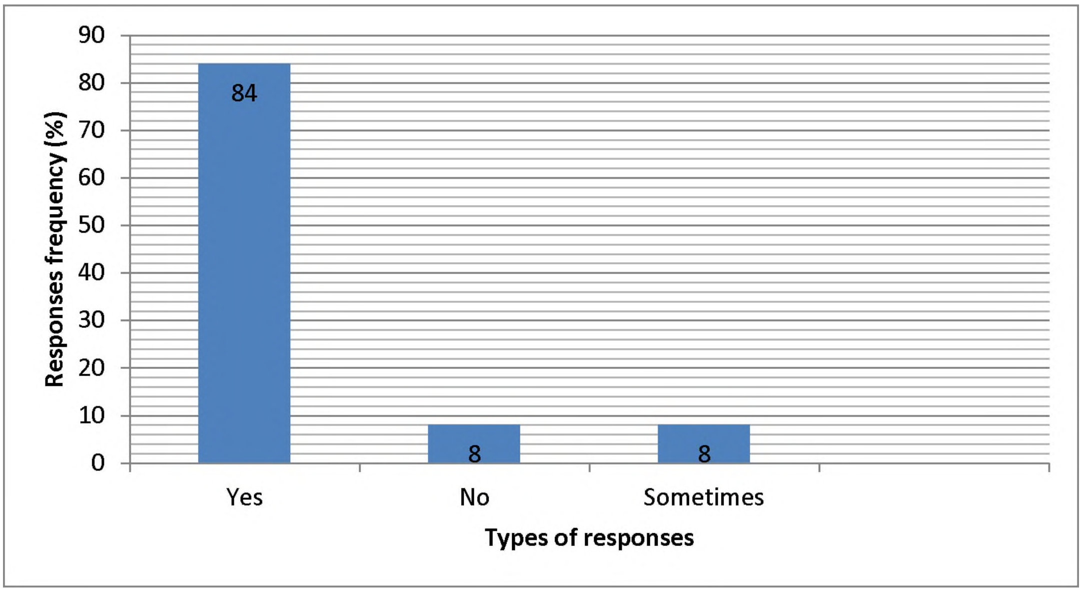

Figure 4.1 Responses of the teachers in percentages

From the graph above, we can see that most teachers responded that they use visualisation materials and few teachers indicated that they do not use visualisation materials. This indicates that most of the teachers might be familiar with what the curriculum expects them to cover, because they are aware of the importance of visualisation materials or objects. Only a few use it sometimes or never.

Those who responded *yes* to this question wrote:

Yes

- *This helps learners to understand better, especially when it comes to the practical activities.*
- *I use an over-head projector in order to show visual pictures and graphs to learners.*
- *Because some concepts are too difficult for the learners, using pictures or diagrams for example, will help learners to get the meaning.*
- *When learners are observing visual materials, they understand better and therefore think better to solve the problems.*
- *It enables leaners to solve mathematics problems easily.*
- *I use visualisation materials especially when introducing topics like mensuration, so that learners can get the relevance of shapes.*
- *I use concrete materials for learners to feel the reality.*
- *Because learners learn better by seeing and observing.*

Those who responded *no* to this question wrote:

No

- *I do not use visualisation materials because I do not really understand what is meant by visualisation.*
- *I only teach what is specifically prescribed in the syllabus.*

Those who responded *sometimes* to this question wrote:

Sometimes

- *When needed, I hardly find the need of visualisation materials in most of the topics that I teach.*
- *Occasionally, these materials need much time for preparation and are time-consuming in the lesson.*

2. ***What kinds of visualisation materials/object do you use?***

- About 90% of the teachers indicated that they use pictures, diagrams, manipulative objects, posters, local advertisements, models, projectors, measuring instruments and printed materials.

3. ***How do you use these materials/objects in your lesson?***

Teachers gave different responses to this question, as follows:

- *I use different materials such as hand-outs with pictures for observation.*
- *I use the projector to show some objects that are hard to find in the local environment as well as to show video clips that are educative.*
- *Demonstration on the board.*
- *When teaching money and finance for instance, I encourage my learners to find local advertisements from local shops.*
- *I use those materials during introduction to stimulate their enthusiasm.*
- *I sometimes send learners to collect those materials from the community for projects and practical investigations.*

4. ***On average how often do you use these materials/objects in your teaching per week?*** Tick (√)

The tally mark of the responses

Every day	twice a week	once a week	never
HHT	HHT HHT	HHT ///	//

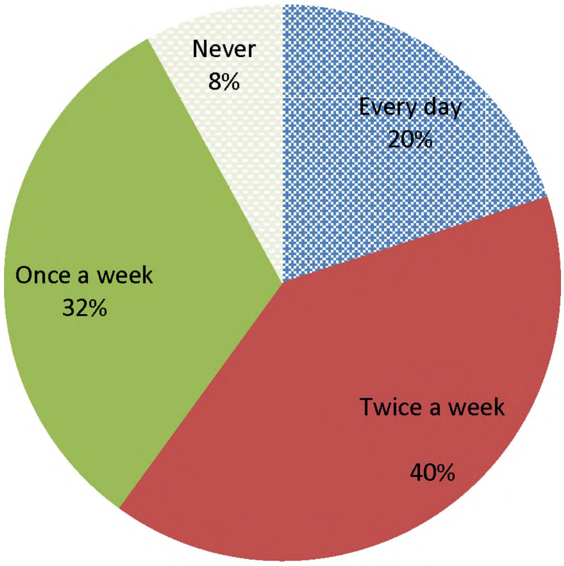

Figure 4.2 Teachers' responses to question 4, the use of visualisation materials in their lessons in a week.

From Figure 4.2 above, we can see that most teachers responded that they use visualisation materials and few teachers indicated that they do not use visualisation materials in a week. In other words, more than 90% of the teachers use visualisation approaches at some point during a week of teaching. As only less than 10% responded that they never used visualisation materials, this suggests that there are few teachers who do not consider visualisation materials in their teaching.

5. ***In your view, how can a visualisation approach to teaching support the teaching of Mathematics?*** Teachers' responses are as follow:
   - *It helps in the way that it is a cognitive modality.*
   - *It stimulates the interest of learners as they can clearly see the images and pictures.*
   - *Visual aids greatly help learners grasp concepts with a great understanding.*
   - *It helps learners to reason and engage in a high order of thinking towards mathematics problems.*
   - *It bridges the gap between what a learner knows and what is expected to be known.*
   - *It enhances critical and logical thinking in learners.*
   - *It helps learners to connect classroom mathematics with the daily practical mathematics.*

On this question, teachers have indicated that they have critical awareness, perceptions and experience in the effective use of visualisation materials in the teaching of mathematics.

6. ***Why do you think the use of visual objects such as manipulative objects are important in the teaching of Mathematics?***

   Responses:

   - *It promotes cognitive thinking.*
   - *It promotes physical mobility of the learners.*
   - *Learners interact with objects to solve the problem.*
   - *It enhances the learning progress, thus making teaching much easier.*
   - *It helps learners to understand better and make their own judgement.*

The teachers believe, for various reasons, that engaging visual objects that are manipulative is good practice. They feel that it helps learners to understand, and it helps in the explanation of concepts and methods. In their views, manipulative visual objects promote cognitive thinking, which means learners can easily remember the concepts they are learning when concrete materials are used, and it helps to accommodate all learners with different learning abilities.

7. ***Do you ever relate the visualisation objects or artefacts that you use in your teaching to the local environment? Please elaborate.***

   About 95% of the responses to this question were *yes* with almost the same reasons:

Yes

- *When dealing with geometry I relate geometric shapes to the immediate shapes that are locally found in the community.*
- *Most objects on display are known to learners but could probably not be available at hand.*
- *For example, when teaching volume of a cylinder and cuboid, I refer my learners to fish cans or boxes of shoes.*
- *When I teach lines and angles, I always relate to the lines.*

No

- *I just started teaching, not yet.*

- *Sometimes local environment references discriminate against learners from different backgrounds or those who are not from that local environment.*

8. ***Can the use of visual objects be helpful in problem solving? Explain***

All respondents to this question replied positively by writing:

Yes

- *It helps learners to develop mental imagery and make their own interconnections.*
- *They can be helpful in explaining steps involved in problem-solving.*
- *For example, using boxes to explain different shapes or Pythagoras theorem makes it easier for learners to understand, enabling them to recall easily.*
- *Learners can make the image of an object to relate to and solve the problem.*
- *When learners look at objects, touch and feel them, they learn better than just hearing.*

9. Do you think that your learners visualise mathematical concepts in their minds? Please elaborate.

This is how the majority of the respondents answered:

Yes

- *But learners visualise and perceive things differently; some may get a clear message from visuals, while some may find it difficult to get the message.*
- *Because they always solve mathematics problems in a short time.*
- *But not all, some learners lack logical thinking when it comes to mathematics visual representations.*

Not always

Few respondents wrote:

- *Sometimes learners fail to make simple conclusions on objects.*

10. ***List the weaknesses in using visualisation in your teaching***. (see Table 4.1)

11. ***List the strengths in using visualisation in your teaching.*** (see Table 4.1)

Table 4.2 for questions 10 and 11 shows the strengths and weaknesses in using visualisation in the teaching of Mathematics.

The responses are in the table below:

Strengths	Weaknesses
• *Accelerates better understanding.* • *It attracts learners' attention.* • *Real life is brought to the classroom.* • *Improves creativity in learners.* • *More learner-centred* • *Easy teaching* • *Active participation* • *Encourages discussion in the classroom (learner-centred approach).* • *Allows learners to make comparisons between real world and classroom Mathematics.*	• *Lack of resources.* • *Learners may focus more on playing than on learning.* • *Time consuming.* • *Most learners are in hostels and find it difficult to collect materials for projects.*

From the table above, teachers gave more points to strengths than to weaknesses. This suggests that teachers are aware and familiar with the positive effects of using visualisation materials, even though they have also identified some limiting factors such as lack of resources and time.

4.3.2 Indigenous knowledge in mathematics teaching

1. Do you use IK in your teaching? Please elaborate.

Those who responded yes to this question wrote:

Yes

- *I always relate the lesson to the world around us.*
- *My learners use songs to relate Mathematics to the environment.*
- *When suitable, I give examples related to local environment.*
- *I use traditional games such as 'Owela' for counting and addition processes, done by our grandfathers when counting their cattle and goats.*
- *When teaching cylinders, circle, area and volume, I relate to the construction of traditional huts.*
- *By using teaching and learning aids from the environment such as seeds, leaves or butterflies for lines of symmetry.*

No

- *I do not use IK at all in my teaching.*
- *Not really, not well known to me apart from 'Owela' and a simple traditional way of measuring time.*
- *It is not well prescribed in the syllabus.*
- *I am not a native speaker of the local language, it might bring bias.*

Sometimes

- *Not always, only when it is necessary, some topics do not require IK.*
- *I incorporate IK in my teaching only when possible, depending on the concept and the basic competencies that I am dealing with at that time.*

2. Some say that IK should be the point of departure for teaching any knowledge. Do you agree with this statement? Please elaborate.

Most respondents agreed, and their responses were as follows:

- *Yes, it contributes to the understanding of Western knowledge.*
- *Yes, it builds a strong foundation in the learners' minds. If you know something in your culture or language, it is easy to transform it to another context.*
- *I do, but I find it difficult to connect IK to mathematics lessons.*

Only a few disagreed and said:

- *No, it depends on the locality where you are teaching. If you find yourself in a foreign area where you do not know about local knowledge at that place it will be difficult.*

3. How often do you use IK in your teaching? Tick (√)

The tally marks of the responses:

Every day	twice a week	once a week	never
𝍸 ///	𝍸 ///	𝍸 //	//

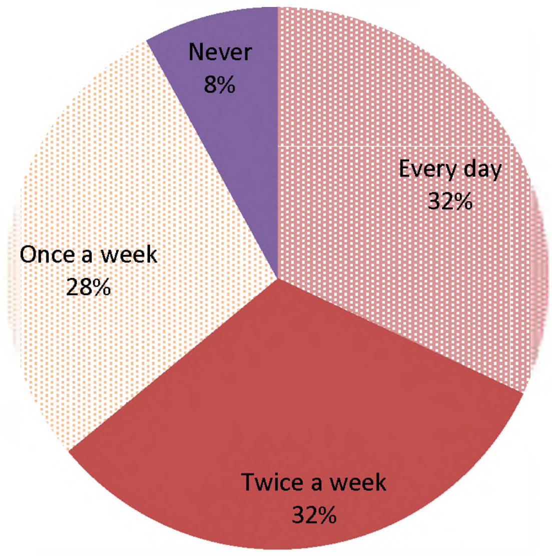

Figure 4.3 Teachers' responses to question 3 on the use of IK in their lessons in a week.

From Figure 4.3 above, we can see that most teachers responded that they use IK and few teachers indicated that they do not use IK in their teaching per week. This means that about 92% of the teachers include IK in their teaching, while 8% never include IK in their teaching, which in this study, represented only 2 teachers.

4. ***When do you use IK in your teaching? (e.g. when introducing a lesson, when doing practical activities, group work etc.). Respondents answered:***
    - *Throughout the lesson if learners do not clearly understand a certain concept I use IK through code-switching).*
    - *To make connections with learners' existing knowledge and experiences.*
    - *During introduction and during practical activities.*
    - *When introducing a new topic, for us to make the connection between what learners already know and the new topic.*
    - *I have not yet tried using IK.*
    - *To explain concepts.*
    - *To clarify statements or questions.*
    - *To emphasise or conclude the points.*

5. ***Why do you think the incorporation of cultural knowledge is important in mathematics classroom?*** Responses:

- *It makes learning easier and enables learners to understand that Mathematics is around them.*
- *It increases creative thinking and reasoning in one's own context.*
- *It strengthens the link between mathematics and culture.*
- *It is important because there are cultural activities that are related to mathematics.*
- *For learners to use their cultural knowledge to solve mathematical problems.*

6. ***Do you think it is important for teachers to understand the cultural and historical background of the learners? Please elaborate.***

Yes

- *Because the context is always connected to the society.*
- *It helps the teacher to plan a lesson depending on the learners' IK.*
- *For the teacher to use knowledge and examples that learners know from their local environment.*
- *It helps the teacher to identify the learning needs of the learners.*

No

- *Sometimes teachers label learners due to their cultural and historical background.*
- *Time-consuming.*

7. ***In your opinion, in what way can IK be helpful in the construction of new knowledge?***
   - *It is an adaptable, dynamic system based on skills, abilities and problem-solving techniques that is likely to change over time depending on environmental condition.*
   - *Can be immensely valuable in creating a more responsible education system for all learners.*
   - *Learners make sense of the Mathematical world as they experience it.*
   - *Learners can make connections between what they find in the classroom and what they experience in the environment.*
   - *Provides the link between IK and new knowledge.*
   - ***How can the inclusion of IK in the teaching of mathematics promote multiculturalism?***
   - *Both teachers and learners will learn different traditional mathematics knowledge found in different cultures.*

- *Learners tend to understand and appreciate others' cultural background to accept one another.*
- *Helps learners to use their prior everyday knowledge in the classroom.*

9. List the weaknesses in using IK in your teaching. (See Table 4.2)

10. List the strengths in using IK in your teaching. (See Table 4.2)

Table 4.3 for questions 9 and 10 shows the strengths and weaknesses in using IK in the teaching of mathematics.

The responses are in the table below:

Strengths	**Weaknesses**
• *It integrates all Mathematical aspects acquired from the society.* • *Learners feel recognised when their culture models used in the learning processes.* • *It helps in the sustainability of IK.* • *Fast learning.* • *Easy teaching* • *Touchable and observable teaching aids enhance cognitive thinking.*	• *It requires teachers to develop their IK better in order to be able to assist learners.* • *Learners may not improve in English as a medium of instruction because IK uses more terminology in vernacular languages.* • *It might be difficult to find out how the two (IK and new knowledge) are related.* • *Most national examination papers are always set to represent western knowledge and this will disadvantage learners that rely on IK.* • *It benefits only learners with rich cultural knowledge.* • *Some learners may stereotype others' IK.*

From Table 4.2 teachers gave the same numbers of points to strengths and weaknesses. This shows that teachers are considering IK in their teaching, but they are still experiencing some difficulties that may hinder the effective inclusion of IK in the teaching of mathematics in the region.

4.3.3 Visualisation-IK approach in Mathematics teaching

The survey stated "the use of visualisation in teaching can be useful to re-contextualize IK into mathematics knowledge. This is sometimes called a visualisation-IK approach to teaching."

1. ***Do you agree with the statement above? Please explain.***

Responses:

- *Yes, because learners visualise better on what they already know and see at home.*
- *Learners can come up with their own terminologies and concepts.*
- *It helps learners to re-contextualise IK into Mathematics knowledge.*
- *It promotes learners' further understanding of the complex concept.*

2. ***How can a visualisation-IK approach promote meaningful understanding in the teaching of Mathematics?***

Responses:

- *Learners with less numeracy skills tend to work easier through visualisation.*
- *By allowing learners to use all their common senses to approach new concepts.*
- *It encourages manipulation by means of observing real objects and relating to the learning area.*

3. ***List the weaknesses in using a visualisation-IK approach in your teaching***. (see responses in Table 4.3)
4. ***List the strengths in using a visualisation-IK approach in your teaching***. (see responses in Table 4.3)

Table 4.4 for questions 3 and 4 shows the strengths and weaknesses in using a visualisation-IK approach in the teaching of Mathematics.

The responses are in the table below:

Strengths	**Weaknesses**
• *At the same time it promotes concepts understanding and multiculturalism.* • *Learners understand better what they see than what they hear.* • *Learners can get the message from objects or artefacts rather than from talking.*	• *It requires training e.g. if you want to use computer in mathematical visualisation one needs to go for training first.* • *Most national examination papers are always set to represent western knowledge and this will disadvantage learners who rely on IK.*

Drawing from Table 4.3 above, teachers positively recommended a visualisation-IK approach. However, the points that were listed on weaknesses are based more on the curriculum set up, teacher training and examination design. This gives us an indication that an inclusion of visualisation and IK needs an emphasis at all levels of the education system.

4.4 OBSERVATIONS

After carrying out the survey, four teachers were selected from the group surveyed. A workshop on the use of visualisation-IK approaches was carried out with the four teachers. Three of those four teachers teach Mathematics at Upper Primary Phase (grades 4, 5, 6 & 7) at different schools, while one teacher teaches at secondary level (grades 8-12) at a different school. Teachers were observed in different grades teaching different topics. However, most of the teachers at Upper Primary were busy with measurements in their termly scheme of work. All the lessons were video-recorded with the focus on the teacher only. Table 3.7 (page 44) of the analytical instrument was used to assess the inclusion of IK in the lesson; the activities were: counting, locating, measuring, designing, playing, explaining and connecting. Table 3.8 (page 45) was used to assess the visualisation processes happening in the classroom; the indications were: visual artefacts, classroom culture, external visualisation, gesture, metaphors, symbolic inscription, visual imagery, abstraction and positive disposition.

Appropriate coding was used as follows:

Teacher I Video transcript (TIV)
Teacher II Video transcript (TIIV)
Teacher III Video transcript (TIIIV)
Teacher IV Video transcript (TIVV)
Learners from grade 4 (L4)
Learners from grade 5 (L5)
Learners from grade 7 (L7)
Learners from grade 10 (L10)
Learners from grade 11 (L11)

4.4.1 Teacher I (TIV)

4.4.1.1 Lesson 1

Brief description of the lesson

The observation was carried out at X primary school, in grade 4A, with TIV, on data handling: collecting and representing data. The lesson lasted 30 minutes. The learning objectives of this lesson were for the learners to collect discrete data from local sources e.g. shoe sizes, ages, types of animals etc. Another objective was to organise data in tally forms and tables, as well as to represent data on pictograms and vertical bar graphs, and to interpret and analyse data from pictograms and vertical bar graphs.

Indigenous knowledge

After welcoming the learners to the mathematics class, the teacher asked learners to reflect on the previous lesson before introducing the day's lesson on data handling, specifically on vertical bar graphs. After explaining the meanings of the terms *vertical* and *horizontal*, the teacher asked learners, "*if you are standing, are you horizontal or vertical?*" , whereupon learners responded *'vertical'*. Later learners were asked to raise their hands to represent languages they speak at home. Under the teacher's guidance seven local languages were represented. This was done to generate data. They also used the occurrence of favourite domestic animals of learners to collect data. Finally, the teacher asked learners to use their knowledge to answer questions such as find the least, most, or how many more.

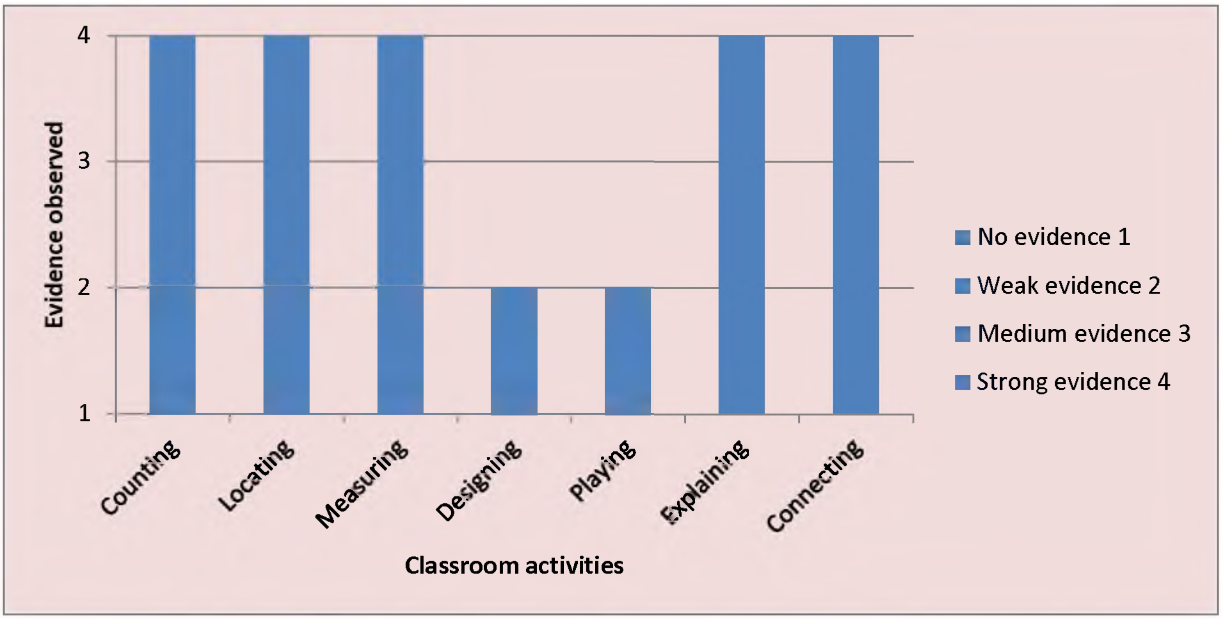

Figure 4.4 Evidence observed on the inclusion of IK in classroom activities in lesson 1

Figure 4.4 above shows that the teacher mostly used IK on activities such as counting, locating, measuring, explaining and connecting. This could be because those activities are carried out in everyday life. On explaining and connecting, the teacher used IK to clarify concepts and to make connections between what learners already know from their own context and the new content.

Visualisation processes

In this lesson the teacher drew the bar graph on the chalkboard and asked learners to interpret it so that they could answer the questions. The teacher then displayed a poster with a bar graph on the chalkboard for learners to interpret it and encouraged them to look at it carefully. In this lesson learners observed and interpreted the bar graph, chalkboard and textbook. In addition, the teacher and one learner used pencils to demonstrate one "how many more?" question. Classroom environment promotes visualisation.

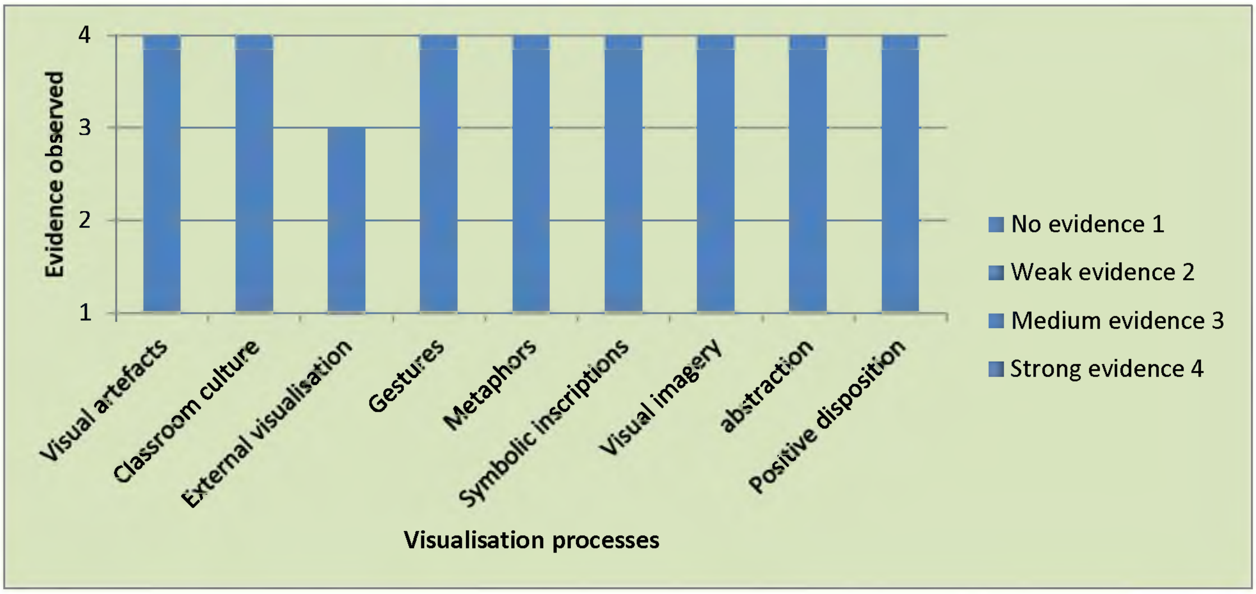

Figure 4.5 Evidence observed on visualisation processes in classroom activities in lesson 1

Figure 4.5 above shows that the teacher engaged all visualisation processes in the lesson. This indicates that the teacher considered visualisation processes to take place in the teaching to mediate learning.

4.4.1.2 Lesson 2

Brief description of the lesson

The observation was carried out at X Primary School, in grade 4C, with TIV, on 'Unit of time'; the lesson lasted for 40 minutes. At the end of the lesson learners were expected to read and record analogue clock time to the nearest 5 minutes, e.g. "25 minutes past 3"; was recorded as 3.25. They read and recorded digital 12-hour clock time, e.g. 3:25; was read as "25 minutes past 3". Further, learners read time from analogue and digital clocks by indicating the minutes left to the next hour e.g. 6:40 which was read as twenty minutes to seven. They were expected to read and interpret simple timetables and calendars, use vocabulary associated with time correctly such as: past, present, future, earlier, later, now, then, a long time, a short time. They also recognised and used units of time and their abbreviations as seconds (s), minutes (min) and hours (hr.).

Indigenous knowledge

The teacher greeted the learners and welcomed them to the lesson. She told the learners that they were going to learn about units of time. The lesson was introduced by asking learners why time is important in our lives. Learners gave different answers such as; *"to tell us to go to school, to inform us whether it is late or early"* (L4). The teacher asked again: what reminds us about time? Leaners responses were: clock, alarm clock, news on television. "*Apart from clocks and watches, what else can remind us about time at home"?* (TIV) One learner stated that a cock can also remind us about time during the night. The teacher thanked the learner for a good example and rectified that not only does a cock remind people about time during the night, but it crows at every exact clock time. The sun also tells us about the time. The teacher presented addition details on the example given: "*Looking at the sun, it tells a person about the time, when the sun is above your head it is probably noon."* The teacher gave another example: *when we were young, we used stick shadows to measure the time when playing.*

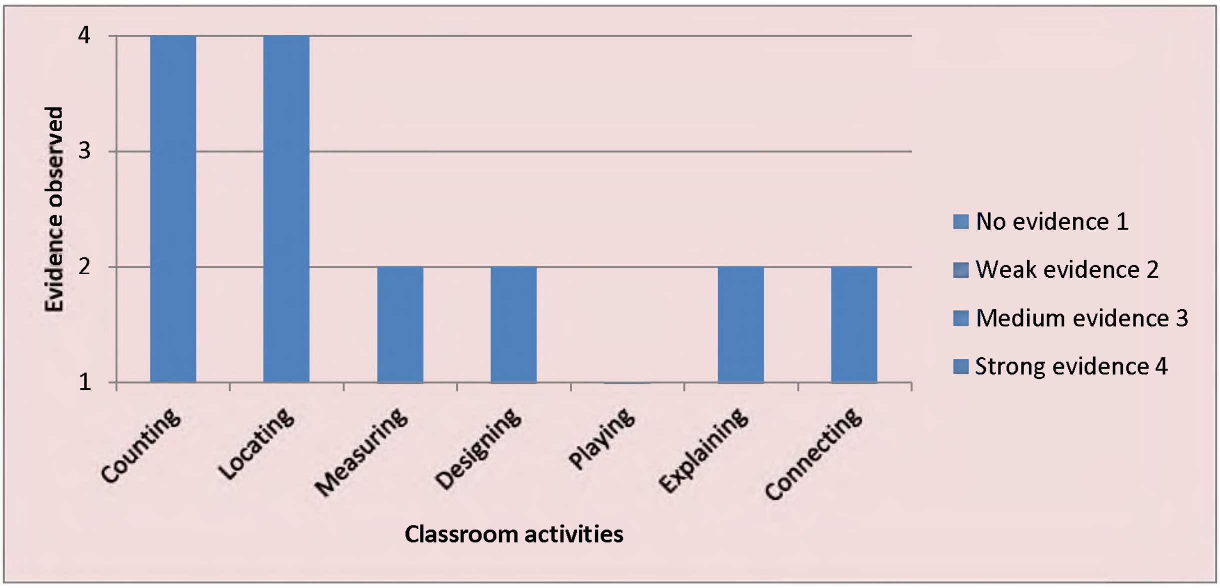

Figure 4.6 Evidence observed on the inclusion of IK in classroom activities in lesson 2

Figure 4.6 above shows that the teacher mostly used IK on counting and locating. This could be because the topic *time* has more to do with numbers. On measuring, designing, explaining and connecting, the teacher used only a few IK examples to clarify concepts and to make connections between what learners already know from their own context and the new content.

As the topic focused on the unit of time vocabularies, I think this could be the reason why there was no IK evidence observed on *playing*.

Visualisation processes

The teacher had many visualisation materials at her disposal. The clock was placed on the wall for learners to read the time. The teacher prepared the time written on the poster to show learners a digital clock. A clock cut out of a poster was also used to demonstrate that 1 hour is equal to 60 minutes. There were also hands of the clock made out of hard poster board shown to learners in reference to which hand shows hours and which one shows minutes.

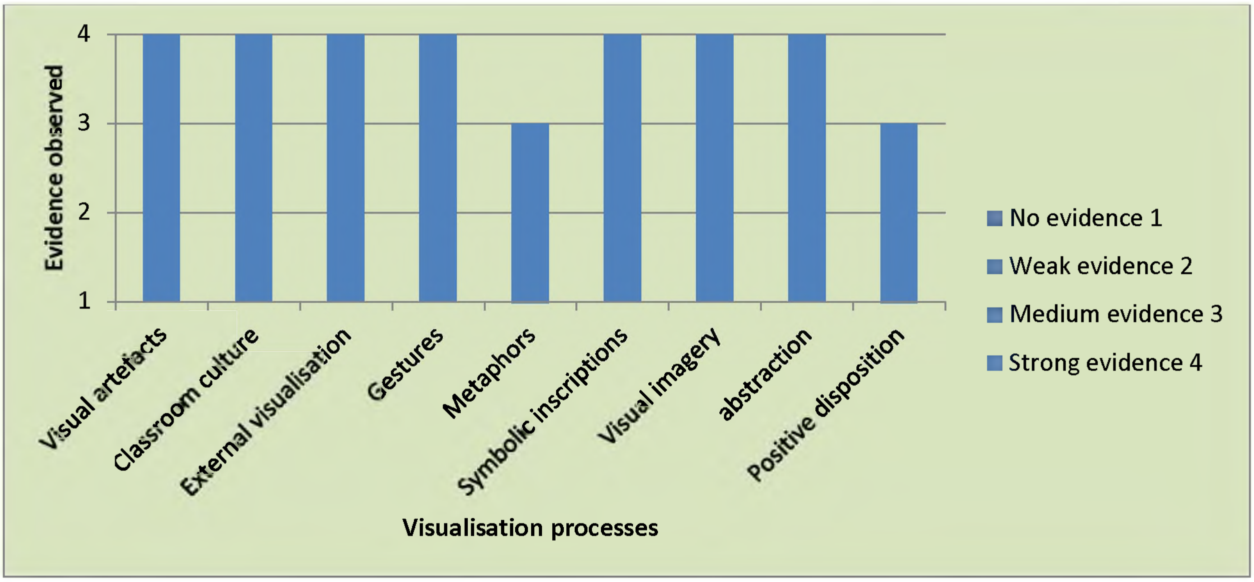

Figure 4.7 Evidence observed on visualisation processes in classroom activities in lesson 2

Figure 4.7 above shows that the teacher engaged all visualisation processes in the lesson although medium evidence was observed on the use of metaphors and imagery visualisation to promote positive disposition. This indicates that the teacher considered visualisation processes to take place in the teaching to mediate learning.

4.4.1.3 Lesson 3

Brief description of the lesson

This observation was carried out at Z Primary School, in grade 4C, with T1V on mensuration. The objectives of the lesson were to estimate and measure perimeters of two-dimensional shapes. This means learners would calculate the perimeter of squares, rectangles and triangles. They also calculated the area of a square, rectangle and triangle.

Indigenous knowledge

The teacher greeted the learners and asked them to do a bit of reflection on the previous lesson, thereafter the teacher wrote the topic on the chalkboard and requested the learners to pay more attention. The teacher introduced mensuration as the topic for the day, and defined it as the study of shapes, perimeters, area and volumes of shapes. *The perimeter is the distance around a shape* (TIV). Further, learners were asked to give examples of objects with a perimeter. They mentioned examples such as a house, a kraal, a dam and a soccer field. In addition, the teacher demonstrated how to measure the dimensions of an object in order to calculate the perimeter and asked learners to measure the dimensions of the figure in the text book to find its perimeter. It was observed that learners have knowledge on distances around shapes, because they were measuring side after side in order to add these measurements to find the perimeter.

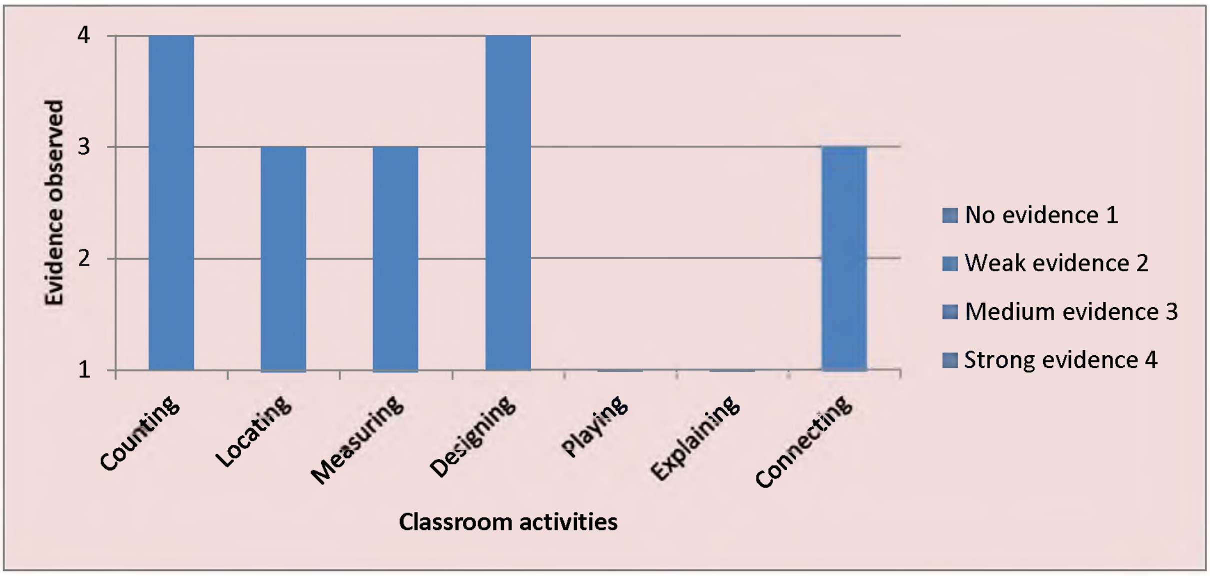

Figure 4.8 Evidence observed on the inclusion of IK in classroom activities in lesson 3

Figure 4.8 above shows that strong evidence on the inclusion of IK was recorded on activities such as counting, locating, measuring, designing and connecting. This could be because mensuration in our everyday life requires those activities. This topic was more focussed on practical investigation and this could be the reason why there was no evidence observed on playing and explaining.

Visualisation processes

The teacher distributed activity hand-outs with squares and rectangles for learners to measure and calculate the perimeter. Learners measured the shapes and calculated the perimeters.

After the teacher confirmed the answers on the perimeter, he introduced the concept of area and asked learners to define the term *area.* Learners simply defined *area* as the surface covered by a shape. On the chalkboard, the teacher showed learners how to determine the areas of regular and irregular shapes by counting square units on a grid.

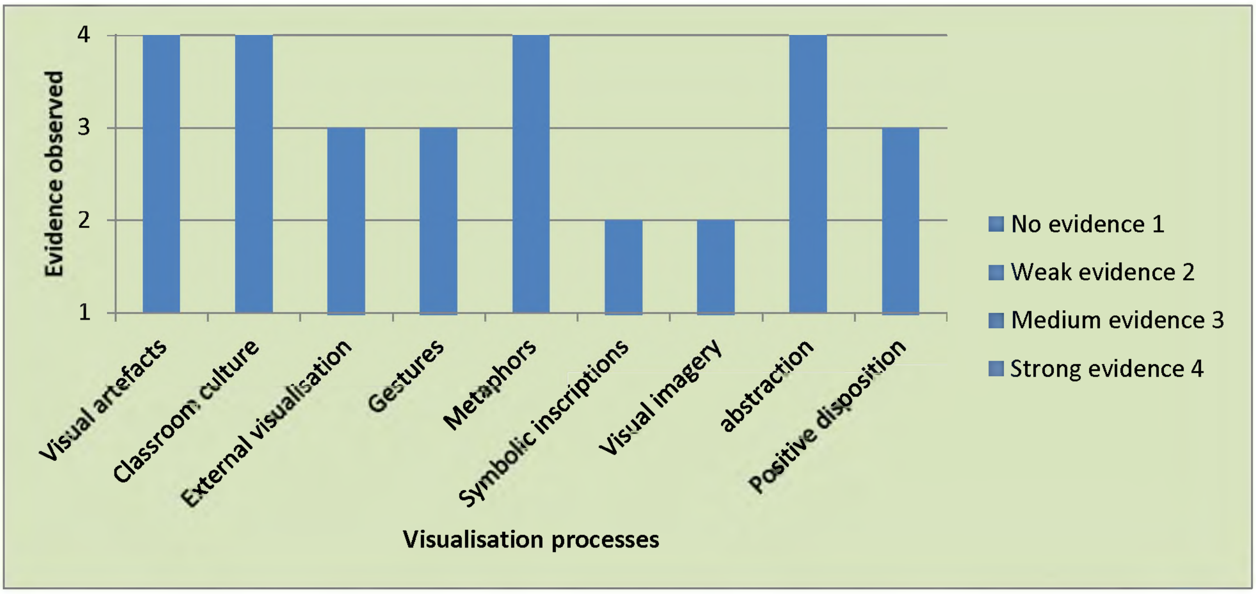

Figure 4.9 Evidence observed on visualisation processes in classroom activities in lesson 3

According to Figure 4.9 above the teacher engaged all visualisation processes in the lesson although weak evidence was observed on helping learners to make connections between visual and symbolic inscriptions. This shows that the teacher considered visualisation processes to take place in the teaching to mediate learning, however there was not much engagement on symbolic inscription and visual imagery. This could be that the other processes were more useful than these.

4.4.2 Teacher II (TIIV)

4.4.2.1 Lesson 1

Brief description of the lesson

The observation was carried out at X primary school, in grade 5A, with TIIV, on measuring and recording: length, mass and capacity. The lesson objectives were to estimate and measure familiar objects in metric units for length (km, m, cm and mm), mass (kg, g) and capacity (ℓ, mℓ); convert between at most two consecutive metric units. (e.g. m to km or mℓ to ℓ); perform the four basic operations on values that were expressed in not more than two different units. To use and interpret expressions for opposites such as tall/short, long/short, higher/lower, far/near, thick/thin, wide/narrow, times more/times less, light/heavy, lighter/heavier, more mass/less mass, empty/full, large/small, more/less.

Indigenous knowledge

The teacher started the lesson by greeting learners. He told them that they were going to learn about measuring and recording length, mass and capacity. A shoe was used and referred to as having the capacity for your foot to fit in properly. A clay pot was brought to the classroom to show learners how women used their traditional knowledge in consideration of what capacity to make the clay pot. "*You cannot just start cooking at home without considering the capacity of the pot and the volume of water you are using.*" The teacher helped the learners to draw on capacity knowledge from home. The teacher used match sticks to compare decimals in measurement

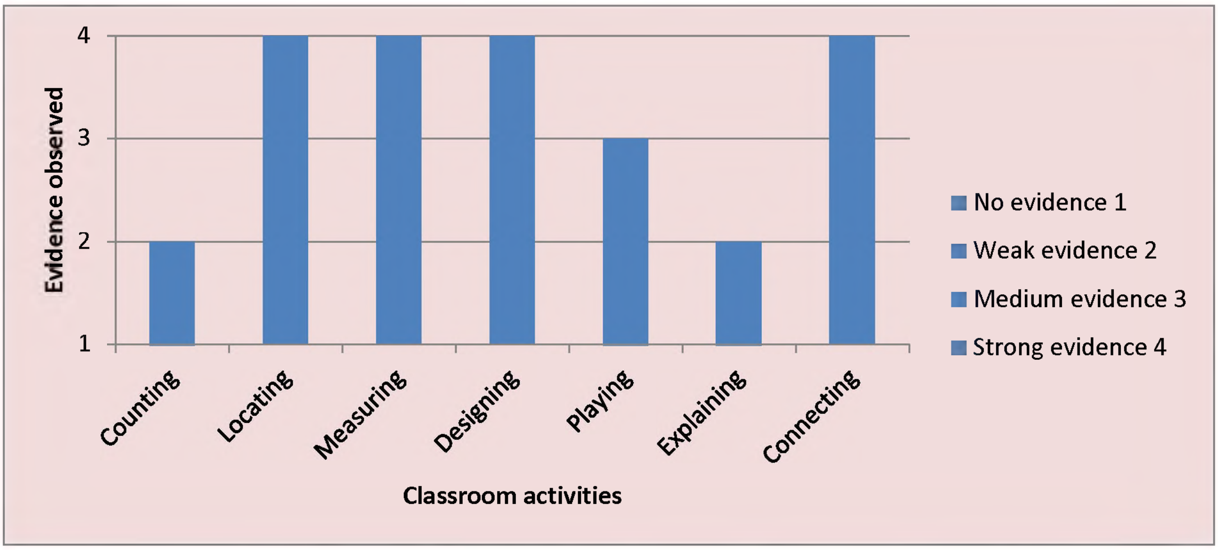

Figure 4.10 Evidence observed on the inclusion of IK in classroom activities in lesson 1

Figure 4.10 above indicates that the teacher mostly used IK on locating, measuring, designing and connecting. This could be because these activities are carried out in everyday life. On counting and explaining, the teacher used little IK as the topic focused more on practical activities of measuring.

Visualisation processes

When teaching capacity, the teacher referred the classroom building to a container, because it has capacity too. *"The bigger the capacity of the classroom, the more learners it can accommodate"*. Different sized containers were used by the teacher and learners to compare capacity from one container to the others. Learners were also asked to look at the small containers and estimate how many can fit into the bigger container. Further, they were asked to practically demonstrate how many 125ml containers would fit into a 1litre container.

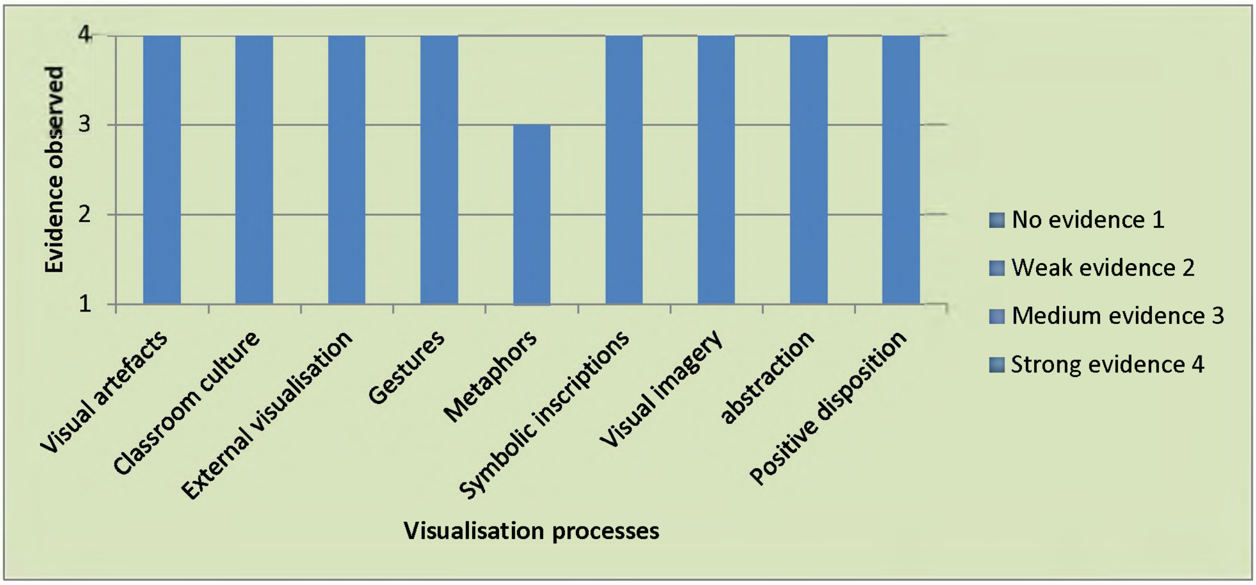

Figure 4.11 Evidence observed on visualisation processes in classroom in lesson 1

Figure 4.11 above shows that the teacher engaged all visualisation processes in the lesson. This indicates that the teacher considered visualisation processes to take place in the teaching to mediate learning.

4.4.2.2 Lesson 2

Brief description of the lesson

The observation was carried out at X primary school, in grade 7A, with TIIV, on measuring and recordings: length, mass, capacity and time. At the end of the lesson, leaners were expected to be able to convert between different metric units of length, mass and capacity in the context of a calculation or a problem. The lesson also involved solving context problems involving metric units of length, mass and capacity using whole numbers, common fractions, decimal fractions and percentages. It also involved interpreting and using tables relating to time e.g. tide charts, sunrise/sunset tables, bus, train and airline timetables, and solving word problems related to time in everyday contexts.

Indigenous knowledge

The teacher started the lesson by greeting learners and welcoming them. She told learners that the lesson would be focusing on metric units of length, mass and capacity. *What makes up your mass?* the teacher asked learners, expecting them to mention flesh, water, blood or bones. The learners responded that it is the body. *"Yes, I know it is the body, but your body consists of many things, so everything that is on your body, contributes to your mass."* (TIIV) When it comes to the length, the teacher referred to walking a distance from home to school as knowledge to measure between time and distance. Baskets *(Elilo)* and clay pots *(Okayo)* were referred to as traditional capacity measuring utensils.

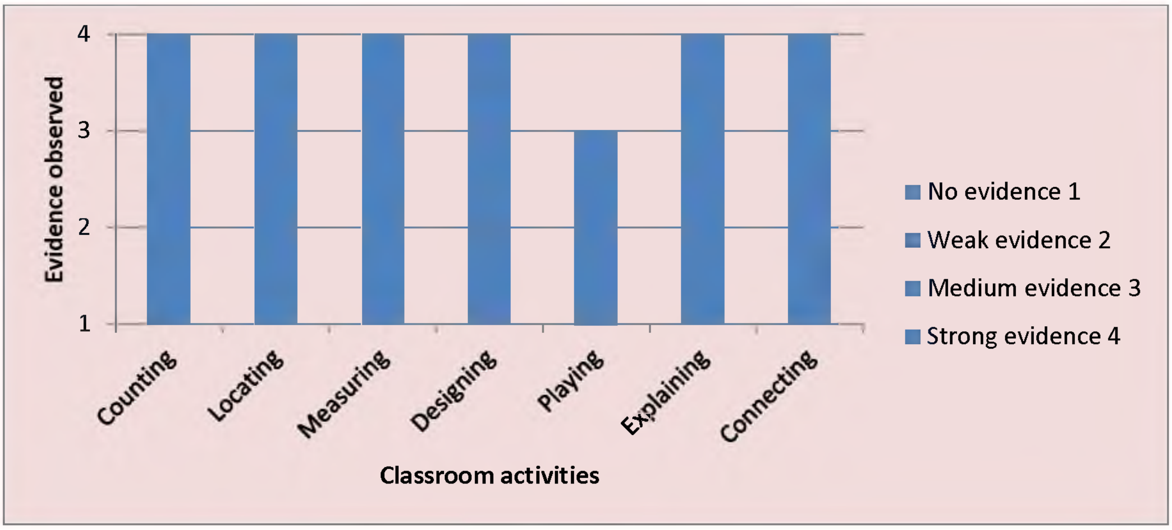

Figure 4.12 Evidence observed on the inclusion of IK in classroom activities in lesson 2

Figure 4.12 above indicates that there was evidence of IK inclusion in all activities carried out in the classroom. This shows that the teacher used IK in the lesson as a mediating tool.

Visualisation processes

In this lesson, different juice containers were brought to the classroom and used to compare capacity. A 1metre ruler was displayed on the chalkboard to show that 1m =100cm. Learners in groups were asked to use 30cm rulers to measure and confirm that 1m = 100cm. A poster with metric units of length, mass and capacity was displayed on the chalkboard and the teacher explained how to convert units.

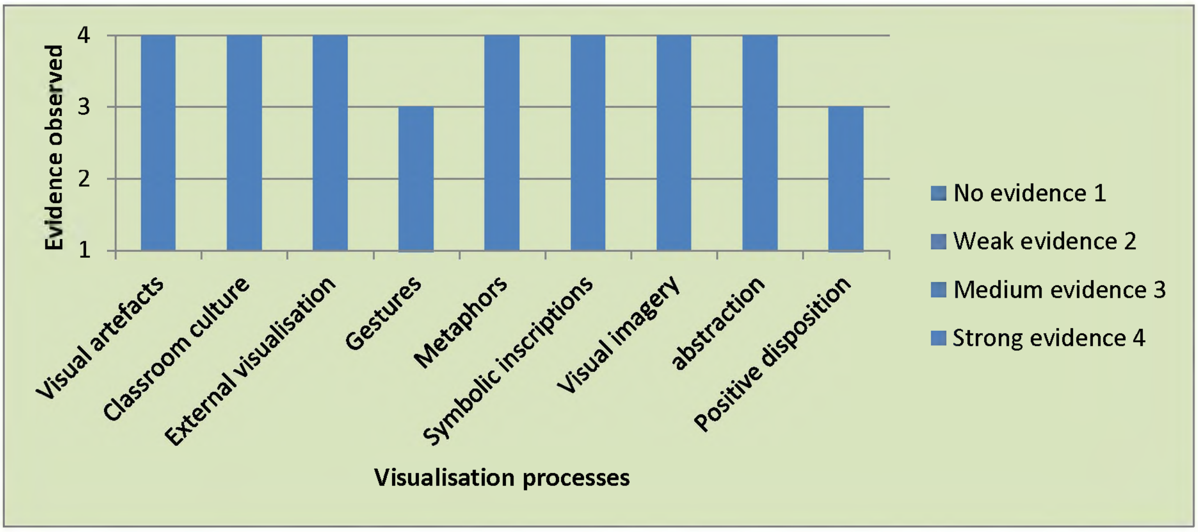

Figure 4.13 Evidence observed on visualisation processes in classroom activities in lesson 2

Figure 4.13 above shows that the teacher engaged all visualisation processes in the lesson. This indicates that the teacher considered visualisation processes to take place in the teaching to mediate learning.

4.4.2.3 Lesson 3

Brief description of the lesson

The objectives of this lesson were for learners to calculate the perimeter of regular and irregular 2-D shapes. They were also expected to calculate the lengths of the sides of a rectangle and square when sufficient information was given. The lesson involved the use of the formulae to calculate the areas of squares and rectangles and composite shapes that can be divided into rectangles and squares.

Indigenous knowledge

The teacher greeted the learners and welcomed them to the lesson. He told the learners that the topic for the day was mensuration, calculating the area of 2-dimensional shapes and the volume of 3-dimensional shapes. He asked the learners to define the term *area*. Leaners in this grade have knowledge of area from the previous grade and they are old enough to relate area to real life objects. *"Area is a space occupied by an object"* (L7). *"Why is area important in our daily lives?"* (TIIV).

The learners responded that, "*area shows you the size of a space or object.*" The teacher further asked learners to refer to the community to give examples of where people really consider area in their daily activities. *"When constructing the traditional homesteads, people have to consider the area of the house" (*LG7). The teacher asked a follow-up question: *"Why is it important for one to consider the area before constructing a structure?* (TIIV). *"To know whether something is bigger or smaller"* (LG7). To check the IK of learners, the teacher asked the learners to give more local examples. Learners gave examples such as: *"when constructing oshipale, you have to consider the area in order for you to know how much mahangu can be accommodated."* Learners also stated that it is important for one to know the area before construction to know how much materials are needed for construction. The teacher stated that the area is also important for our parents to determine the size of the field to be cultivated so that it is big enough to feed the family.

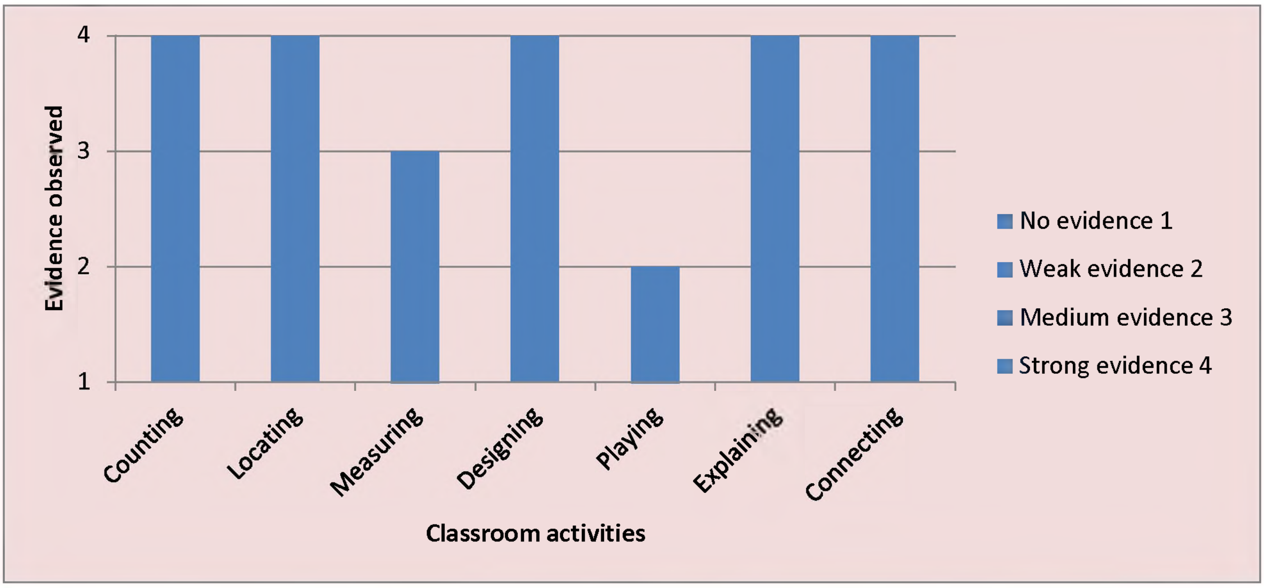

Figure 4.14 Evidence observed on the inclusion of IK in classroom activities in lesson 3

Figure 4.14 indicates that the teacher used IK on all activities carried out in the classroom despite the fact that little evidence was observed on playing. This means that the teacher has an understanding of the importance of IK in this lesson.

Visualisation processes

After demonstrating how to calculate the area, the teacher provided learners with a measuring tape for them to measure the dimensions of the classroom and find its area. To introduce the concept of volume, the teacher brought containers to the classroom to demonstrate. The teacher further explained by showing learners 3-dimensional shapes such as: cubes, cuboids and cylinders as they have different formulae to calculate their volumes. While demonstrating how the area of the base of an object influences the volume, the teachers drew a square, rectangle and circle as the bases of the 3-D shapes concerned. He asked the learners to find the volume of a cube, a cuboid and a cylinder.

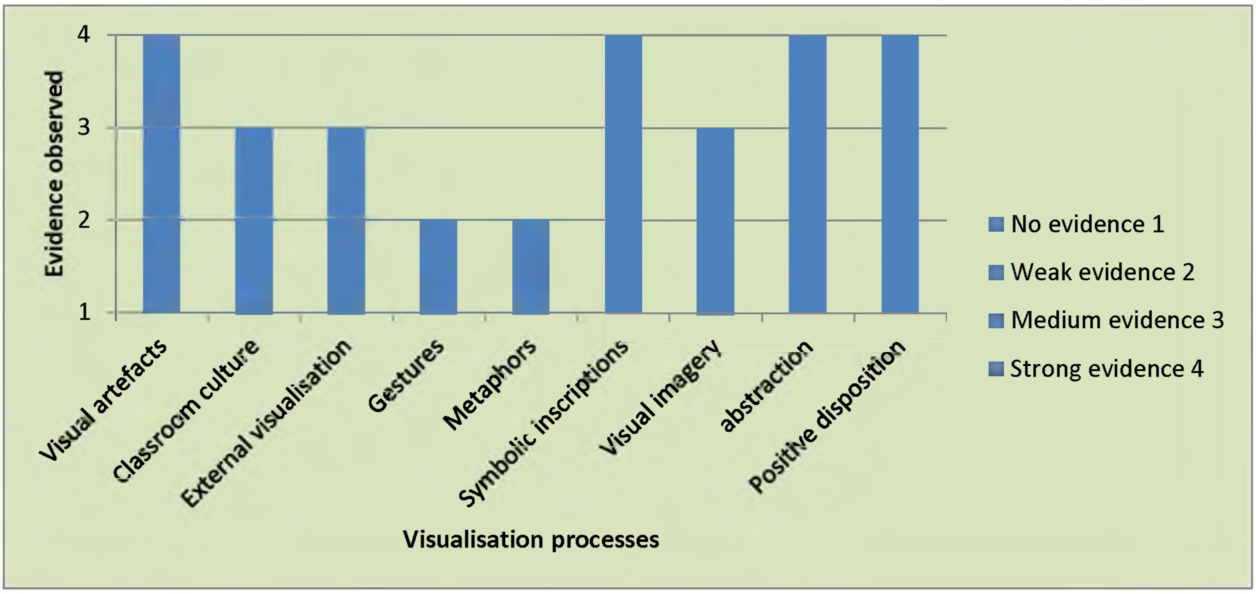

Figure 4.15 Evidence observed on visualisation processes in classroom activities in lesson 3

According to Figure 4.15 above the teacher engaged all visualisation processes in the lesson although weak evidence was observed in the use of gestures and metaphors in conjunction with visualisation artefacts. This shows that the teacher considered visualisation processes to take place in the teaching to mediate learning, however he could not engage much on the two processes. This could be that the other processes were more useful than these.

4.4.3 Teacher III (TIIIV)

4.4.3.1 Lesson 1

Brief description of the lesson

The observation was carried out at Y Senior Secondary School in grade 11A with TIIIV, on linear equations. The objectives of the lesson were to understand how to transform linear equations to find their solution and to realise the importance of algebraic equations in real-life problems. Learners would be able to solve linear equations with brackets, and word problems by translating them into linear equations. Learners' understanding of variables became their starting point to participate in this lesson. The insights about equations from previous grades were observed. However, there was still no guarantee that they could formulate an equation from real-life scenarios.

Indigenous knowledge

The teacher started the lesson by greeting the learners and welcoming them to the lesson. He told them that the lesson would be focusing on linear equations. The number of family members going to Etosha National Park was used as an example to construct the linear equation and solve it. *A man and a woman took their two children on a school tour to Etosha National Park. They met their friend who took his five children on the same tour. While talking, they discovered that they had paid the same amount of money for the ticket* (TIIIV). The teacher used C to represent the cost of the ticket for a child. He constructed the equation $2 + 2C = 1 + 5C$ and solved it. The teacher gave another example. *If Elago sold 6 cattle at N$ 2500 each and 10 goats at N$ x, he received N$23000 in total. What was the price of each goat?* (TIIIV) Learners responded using knowledge they had acquired from the local context.

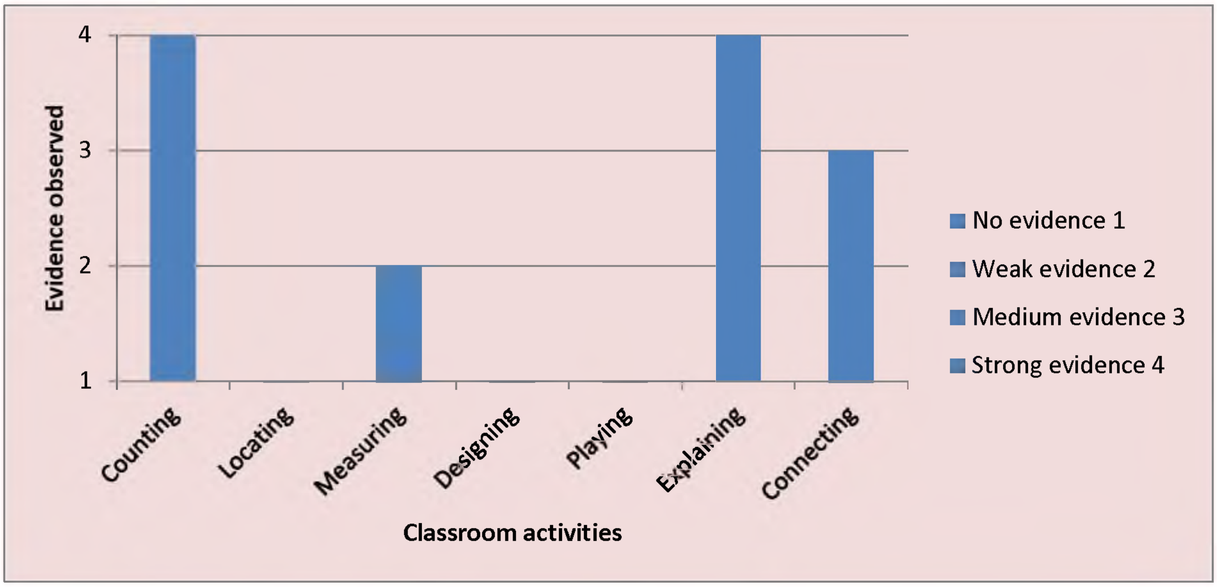

Figure 4.16 Evidence observed on the inclusion of IK in classroom activities in lesson 1

Figure 4.16 above indicates that the teacher used IK in four activities only and no evidence was observed in the other three activities. This could be because in most cases algebra focuses more on algorithmic procedures than on daily activity scenarios. This means in algebra the teacher might find it difficult to incorporate IK in locating, designing and playing to relate it to everyday activities.

Visualisation processes

The number of family members was used as an example to construct the linear equation and solve it. The rectangle was drawn on the chalkboard to construct simultaneous equations. Two-dimensional figures were used to construct two questions that were solved simultaneously. *"Have you ever seen a man with -23 cattle?"* (TIIIV) The teacher clarified that if you are calculating simultaneous equation about real things and you get a negative (-) answer, then go through your calculation again because you might be wrong. In this lesson there was little evidence of IK and visualisation processes.

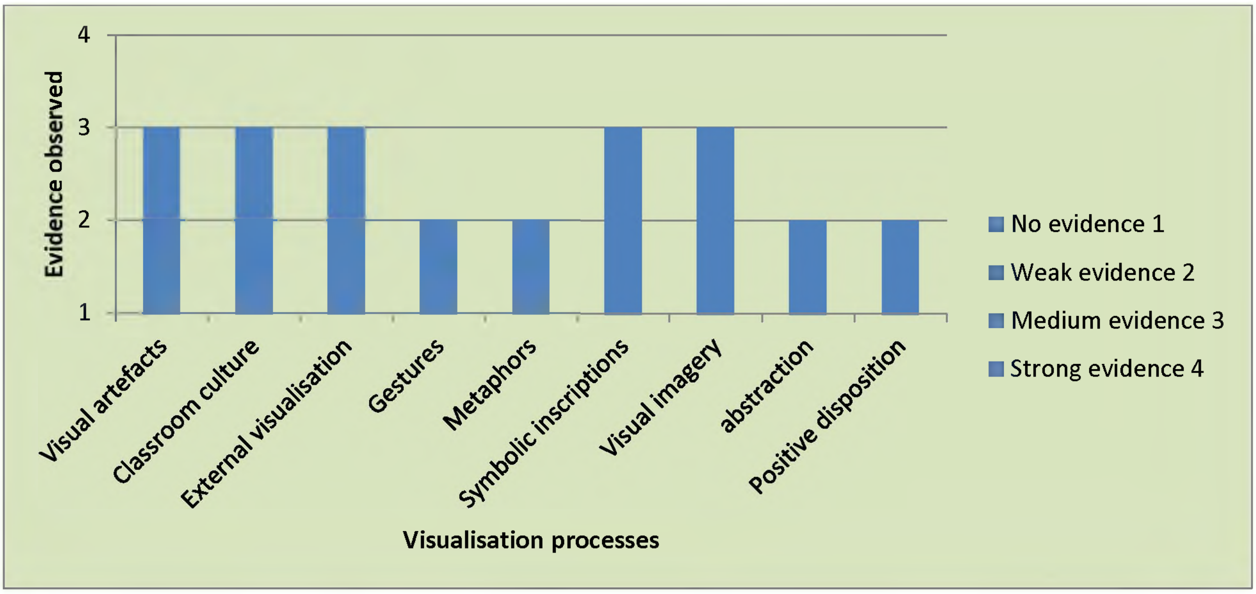

Figure 4.17 Evidence observed on visualisation processes in classroom activities in lesson 1

Figure 4.17 above shows that the teacher engaged all visualisation processes in the lesson, but that there was no rich evidence observed in any of the processes. Weak evidence was observed in the use of gestures, helping learners to make connections between visual and symbolic inscriptions. This shows that the teacher considered visualisation processes to take place in the teaching to mediate learning; however, he could not engage much visualisation material. This could be that the teacher did not prepare visualisation material, or the topic did not require much visualisation material.

4.4.3.2 Lesson 2

Brief description of the lesson

The observation was carried out at Y Senior Secondary School in grade 9B with TIIIV, on mensuration. The objectives of the lesson were to calculate the volumes and surface areas of cuboids and cylinders using appropriate formulae. The lesson involved the calculation of unknown dimensions of cuboids and cylinders, if the volume or surface area and sufficient other information was given, and apply the concepts of volume and surface area of cuboids and cylinders. Learners were also expected to construct different 3-D shapes and calculate TSA and volume.

Indigenous knowledge

The teacher began the lesson by welcoming learners to the mathematics class. He told learners that the lesson would be about mensuration. Learners in Grade 9 had already been introduced to mensuration from Grade 8, but they had not learnt how to calculate the total surface area of a closed or open cylinder. To test their existing knowledge, the teacher asked them if they could still remember how to calculate the area of a circle. Further, the teacher explained that a circle can occupy a bigger space; this is why traditional houses and huts are constructed in circular shapes. He also stated that many containers are made in circular shapes so that they can hold more content.

In addition, the teacher elaborated with an example that men in the community use 'mahangu' stalks as a diameter to draw up the circumference of the hut on the ground before the construction. The teacher further explained that the Oshiwambo hut is a 3-dimensional combined shape of a cone and cylinder. "*The hut is firstly constructed by drawing the locus points (circle) on the ground, that are equidistant from the pillar (centre) with a nail tied on a rope. The rope is a radius that determines the circumferences of both the hut and the wall*", clarified TIIIV. He continued explaining, *"the pillar that is used at the beginning, determines the height of the hut and it is precisely the height of the cone, in the new Mathematics context, that determines the volume and area of the cone."* With this example the teacher explained clearly how to make meaningful connections and understand the role of radius and diameter in calculation of the circumference and area of a circle, and the volume of a cylinder. *"omudhingililo gwondunda ogwo ocircumference."* (TIIIV) The teacher used the vernacular to explain the concept of the circumference of the circle and made learners use their IK from the construction of a traditional hut.

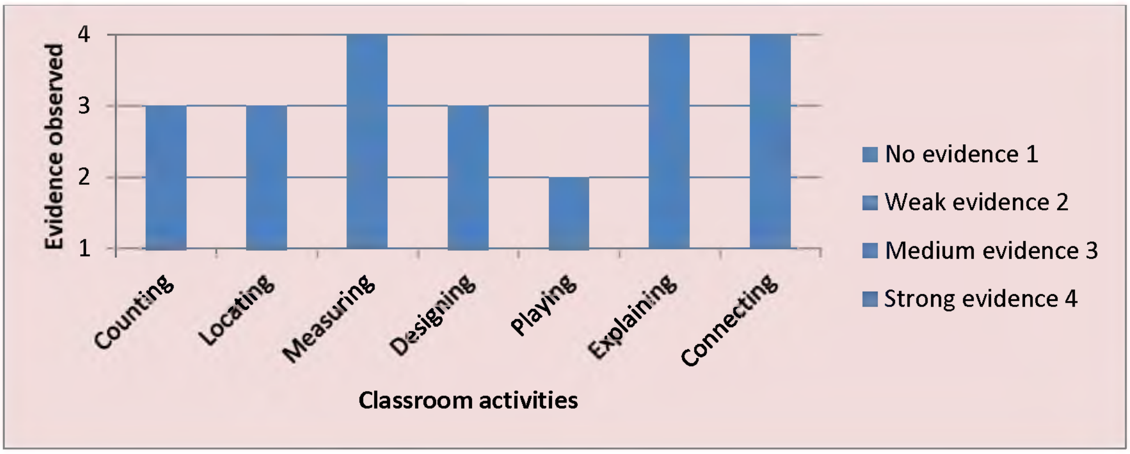

Figure 4.18 Evidence observed on the inclusion of IK in classroom activities in lesson 2

Figure 4.18 above indicates that the teacher used IK on all activities carried out in the classroom despite the fact that little evidence was observed on playing. This means that the teacher has an understanding of the importance of IK in this lesson.

Visualisation processes

The teacher drew a hut on the chalkboard as he explained the diameter, circumference and area of a circle. He then demonstrated to learners how to find the area of the hut floor and the surface area of the wall. He further displayed a poster with 2- and 3-dimensional shapes for learners to calculate the perimeter, area and volume. He instructed the learners on how to carry out this activity.

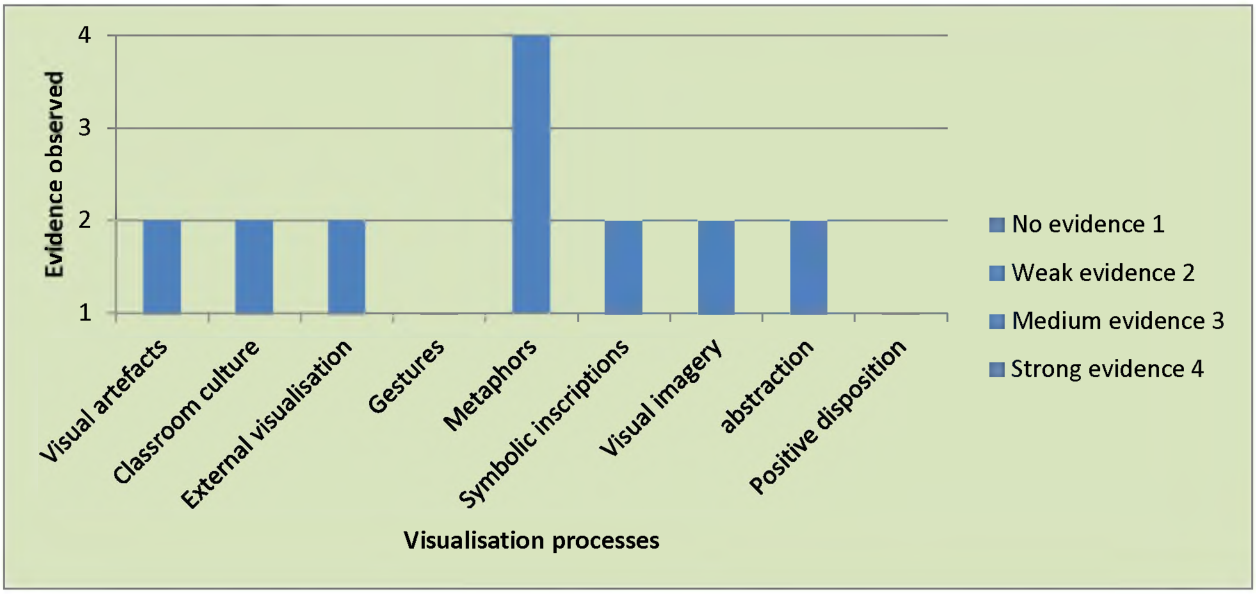

Figure 4.19 Evidence observed on visualisation processes in classroom activities in lesson 2

Figure 4.19 above shows that the teacher engaged visualisation processes in the lesson, but with weak evidence observed on all processes, except metaphors, and no evidence on the use of gestures. This shows that the teacher considered visualisation processes to take place in the teaching to mediate learning; however, he did not engage much with visualisation material. This could be that the teacher did not prepare visualisation material, or the topic did not require much visualisation material.

4.4.3.3 Lesson 3

Brief description of the lesson

The observation was carried out at Y Senior Secondary School in grade 10 with teacher III, on trigonometry bearings. The learning objective of this lesson was to solve problems in right-angled triangles, including applications of the Theorem of Pythagoras and bearings. The lesson also involved solving problems in two dimensions using angles of elevation and depression, and reading bearings of 90^0, 180^0 and 270^0

Indigenous knowledge

The teacher referred to Bushmen as they use estimated degrees to find where an animal is.

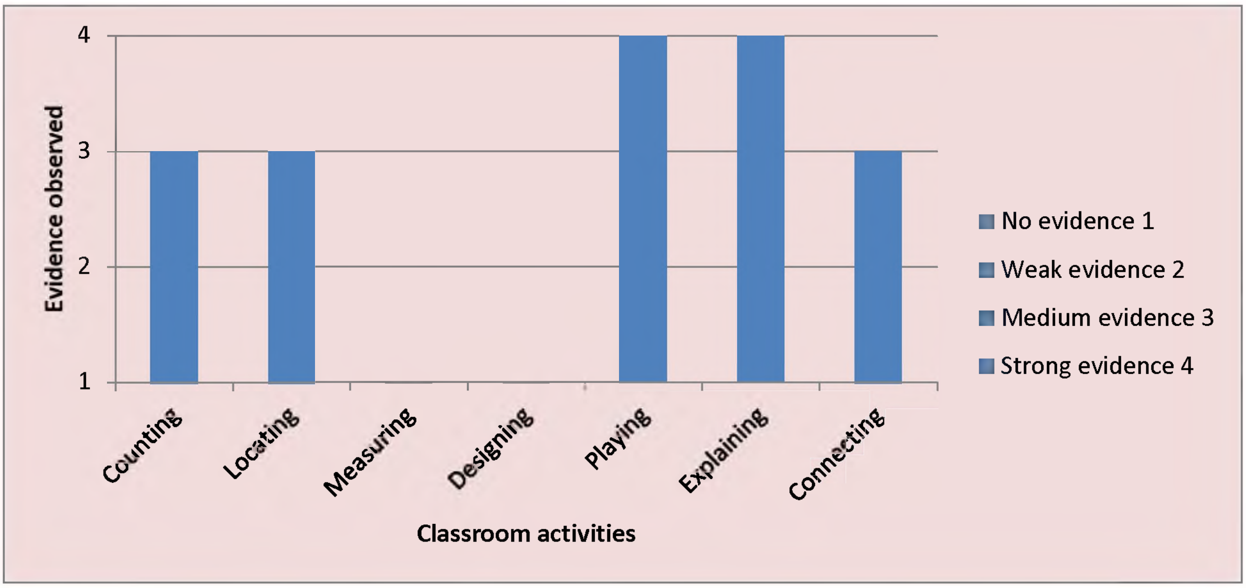

Figure 4.20 Evidence observed on the inclusion of IK in classroom activities in lesson 3

Figure 4.20 above shows that the teacher used IK on five activities only and no evidence was observed on the other two activities, measuring and designing. This could be because in most cases the topic *trigonometry* (bearings) focuses more on the theoretical procedures than on daily activities scenarios. This means that trigonometry the teacher might find it difficult to use IK on measuring and designing.

Visualisation processes

The teacher used a big protractor to show learners how to use and read the protractor. He drew the bearing on the chalkboard and asked learners to find the bearing from one point to another. He then asked learners to imagine how one would direct someone in the sea where there are no trees or other physical objects, the conclusion being that people use degrees for direction. Later learners were given the activity with a picture to find the bearing of a man from a tree; the teacher used a picture for learners to visualise.

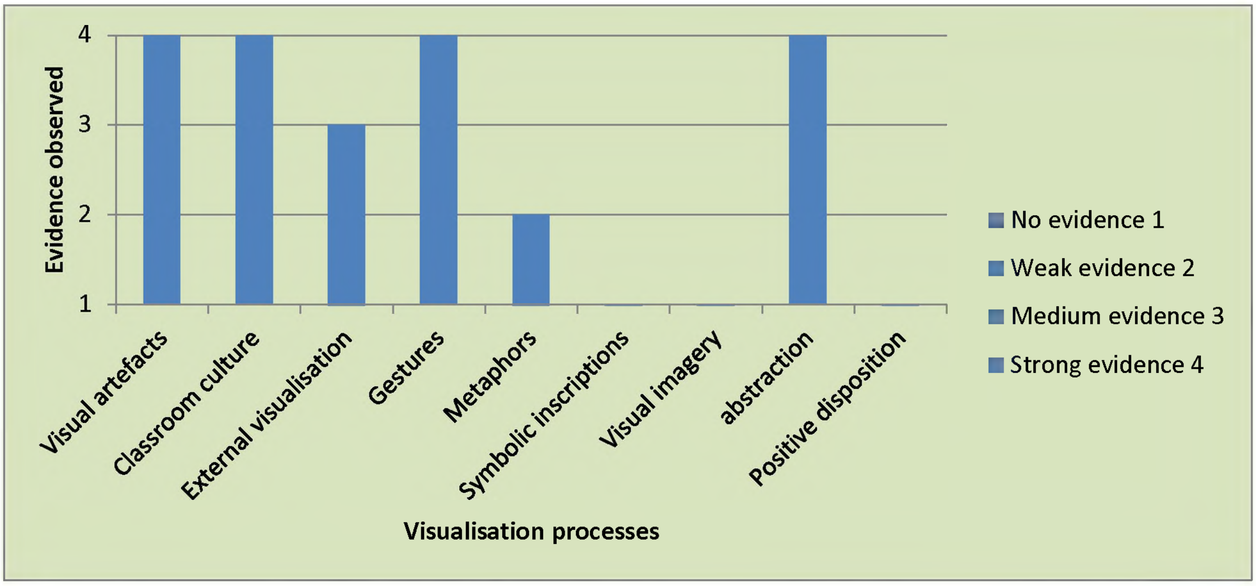

Figure 4.21 Evidence observed on visualisation processes in classroom activities in lesson 3

Figure 4.21 above indicates the teacher engaged visualisation processes in the lesson although no evidence was observed on helping learners to make connections between visual and symbolic inscriptions. This shows that the teacher considered visualisation processes to take place in the teaching to mediate learning. However, he could not engage symbolic inscriptions or visual imagery. This could be that other processes were more useful than these.

4.4.4 Teacher IV (TIVV)

4.4.4.1 Lesson 1

Brief description of the lesson

The observation was carried out at Z Primary School in grade 4A with TIVV, on measurements of time. At the end of the lesson learners were expected to read and record analogue clock time to the nearest 5 minutes, e.g. "25 minutes past 3"; recorded as 3:25, and to ead and record digital 12-hour clock time, e.g. 3:25; read as "25 minutes past 3". Leaners were expected to read time from analogue and digital clocks by indicating the minutes left to the next hour e.g. 6:40 which was read as twenty minutes to seven. They were also expected to read and interpret simple timetables and calendars, correctly use vocabulary associated with time, such as past, present, future, earlier, later, now, then, a long time, a short time. The objectives of the lesson were also to recognise and use the units of time and their abbreviations as seconds (s), minutes (min) and hours (hr.).

Indigenous knowledge

The teacher started the lesson by greeting learners. After welcoming learners to the Mathematics lesson, the teacher asked learners to do a bit of reflection on the previous lesson before introducing the day's lesson which was time. Learners did the reflection on the previous lesson though they could not pronounce the word *vocabulary* as they tried to respond that *"we learned about vocabularies associated with time."* (L4) *Darkness is used to determine the estimated time especially before sunrise or after sunset, whether it is evening or afternoon* (TIVV). "*What time do we eat breakfast, lunch and supper?"* (TIVV) Learners responded: *we eat breakfast in the morning, lunch in the afternoon and supper in the evening*. The teacher also used the cock example; "*cocks are literally used as clock reminders as they crow at every o'clock time. As there were no watches and clocks to tell the time, our parents used shadows to determine the time to do their activities such as taking animals to the kraals, fetching water or firewood, or going to work in the field*", explained TIVV.

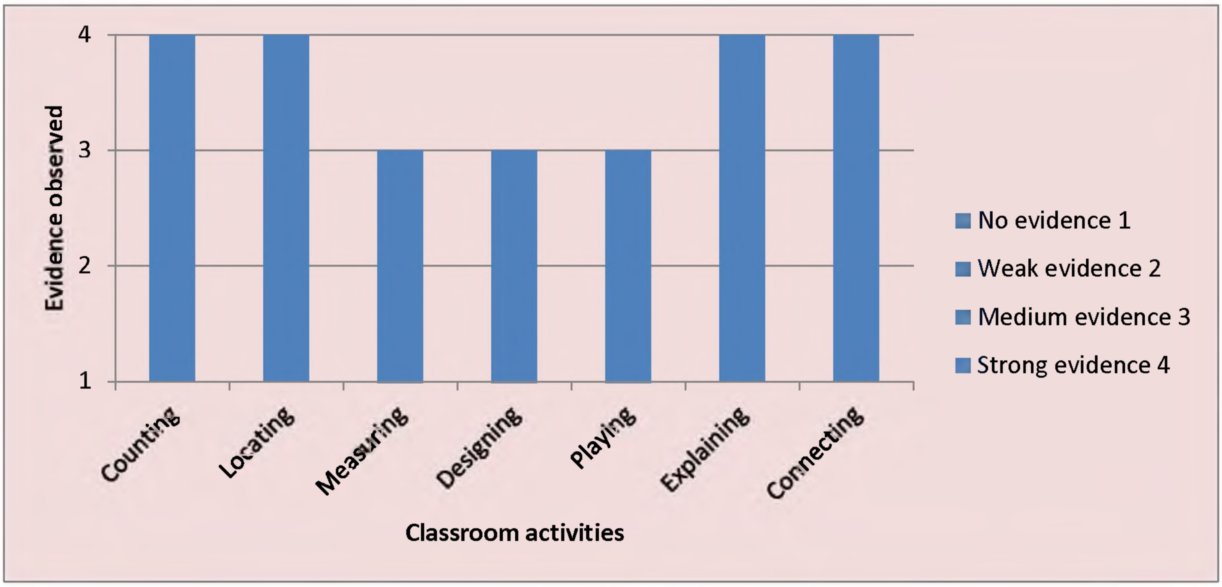

Figure 4.22 Evidence observed on the inclusion of IK in classroom activities in lesson 1

Figure 4.22 indicates that the teacher used IK on all activities carried out in the classroom despite the fact that little evidence was observed on playing. Measuring, designing and playing all show medium evidence. This means that the teacher in this lesson has an understanding of the importance of IK.

Visualisation processes

In this lesson a digital projector was used to show different pictures and videos to illustrate time. Learners were given pictures with time vocabularies to construct sentences. The teacher displayed a picture of Dr Sam Nujoma on the projector and instructed learners in their groups to pick a word from the list and formulate a sentence. The vocabularies were; midday, midnight, earlier, later, then, past, present, future, now, a short time, a long time, afternoon, morning and evening. Most of the learners wrote in their responses: Dr Sam Nujoma had been a president of Namibia for a long time. After the teacher confirmed the answers, he showed a short video-clip of a Jamaican sprinter Usain Bolt running, and asked learners to pick an appropriate word to construct a meaningful sentence about Bolt. Most learners could not get it right. Some learners said *the boy is running fast now*, some said *the man is running earlier*. The teacher gave the feedback that the appropriate one is: the man finished running in a short time.

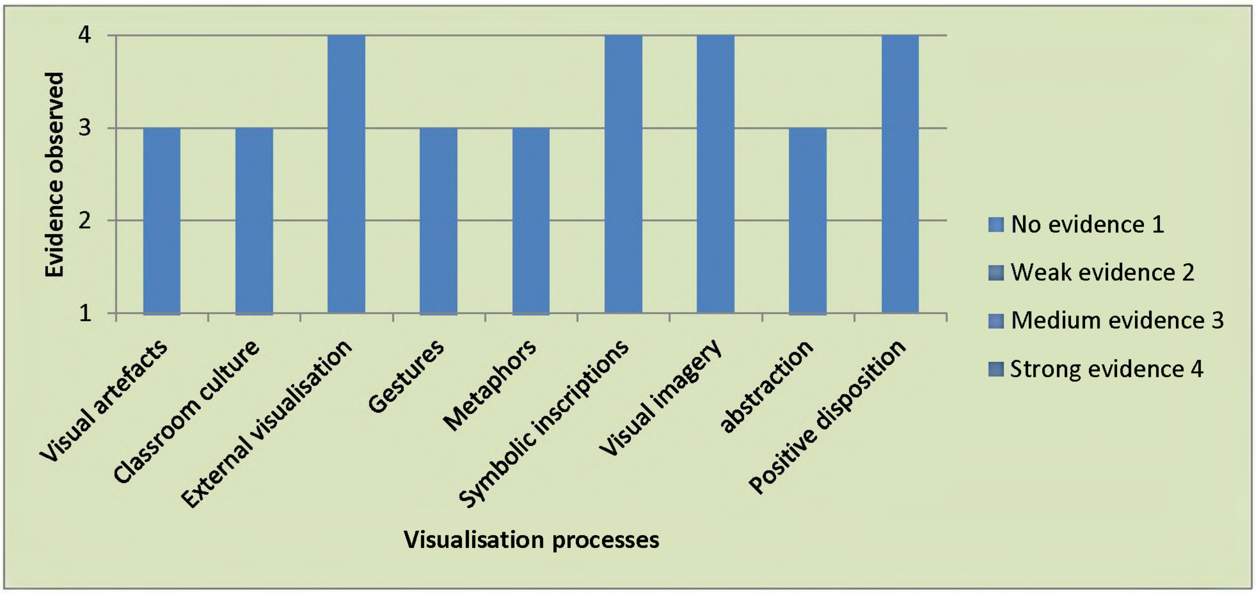

Figure 4.23 Evidence observed on visualisation processes in classroom activities in lesson 1

Figure 4.23 shows that the teacher engaged all visualisation processes in the lesson. This indicates that the teacher considered visualisation processes to take place in the teaching to mediate learning.

4.4.4.2 Lesson 2

Brief description of the lesson

This observation was carried out at Z Primary School in grade 4C with teacher IV, on mensuration. The objectives of the lesson were to estimate and measure perimeters of two-dimensional shapes. This means learners would calculate the perimeter of squares, rectangles and triangles. The lesson would also touch on estimation of the volume of regular everyday containers by packing them with blocks.

Indigenous knowledge

After exchanging greetings with learners, the teacher asked the learners to use their existing knowledge to explain why different fields in their villages take different times to finish cultivating. The bigger the field the longer it takes to cultivate. The field or compound with long perimeters requires a lot of work to fence as well.

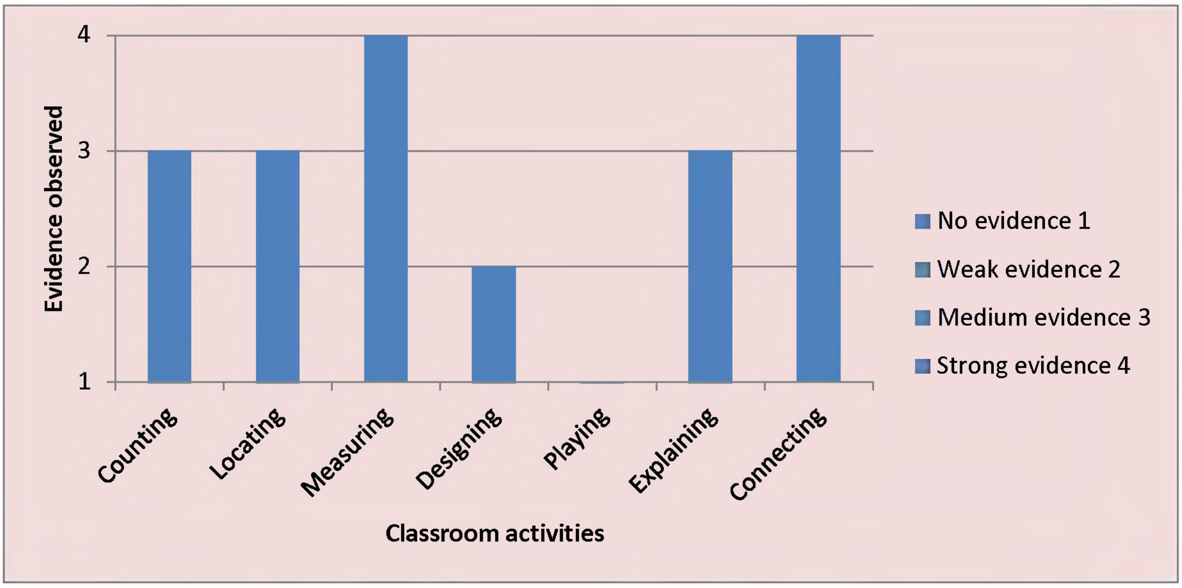

Figure 4.24 Evidence observed on the inclusion of IK in classroom activities in lesson 2

From Figure 4.24 we can see that the teacher used IK on all activities carried out in the classroom except playing. This means that the teacher has an understanding on the importance of IK in this lesson, but that the traditional games could not make a connection to the concept.

Visualisation processes

The teacher asked all learners to measure the perimeter of the book and a desk. Learners used their rulers to measure the perimeter and calculate the areas of the two objects. Two-dimensional shapes (rectangle and square) were drawn on the chalkboard for learners to calculate the perimeter and area. Learners measured the dimensions of a juice box to find the perimeter and areas of the faces as well as the volume of the container.

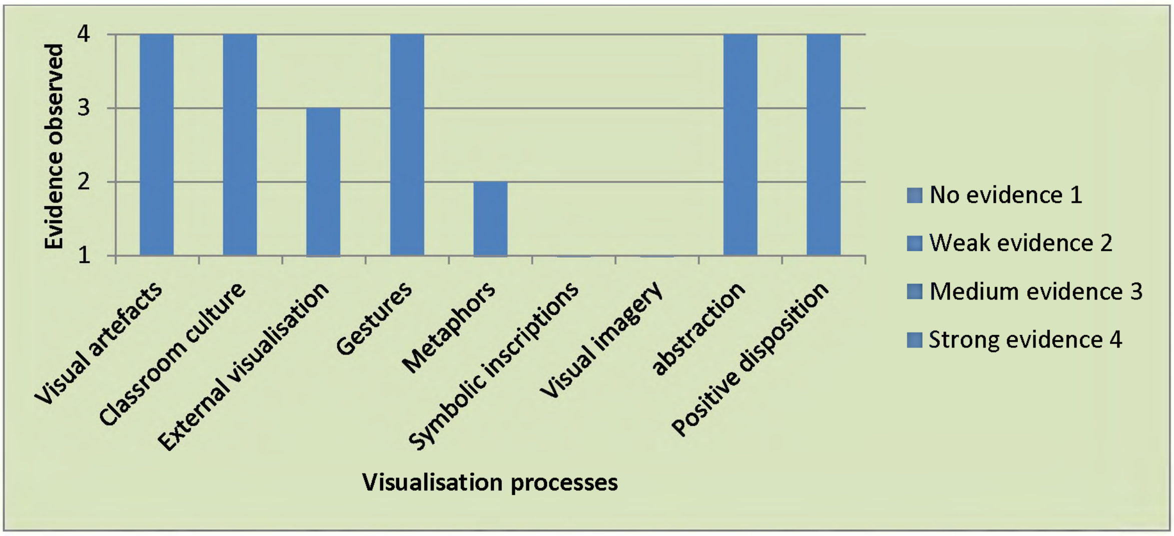

Figure 4.25 Evidence observed on visualisation processes in classroom activities in lesson 2

Figure 4.25 indicates that the teacher engaged visualisation processes in the lesson although no evidence was observed on helping learners to make connections between visual and symbolic inscriptions. This shows that the teacher considered visualisation processes to take place in the teaching to mediate learning. However, he could not engage visualisation on symbolic inscription and visual imagery. This could be that the other processes were more useful than these.

4.4.4.3 Lesson 3

Brief description of the lesson

The objectives of the lesson were to develop the skills to use approximation and rounding numbers, to facilitate estimation of answers to calculations. It also involved estimating (without counting), and then counting, the number of objects up to 50 in different arrangements of objects and round numbers up to 10 000 to the nearest power of 10 (ten, hundred or thousand). Learners were expected to apply approximation in real-life situations by reducing the complexity of large numbers of objects.

Indigenous knowledge

After exchanging greetings with the learners, the teacher introduced the topics *rounding* and *estimation*. He asked learners to define the terms "rounding" and "estimation". *It is to give the closest number to a certain number* (L7). Can you give examples of rounding and estimation that can be done in our community? (TIVV). Learners mentioned that at local open markets when people are cutting meat they estimate the size of a portion for a certain amount of money.

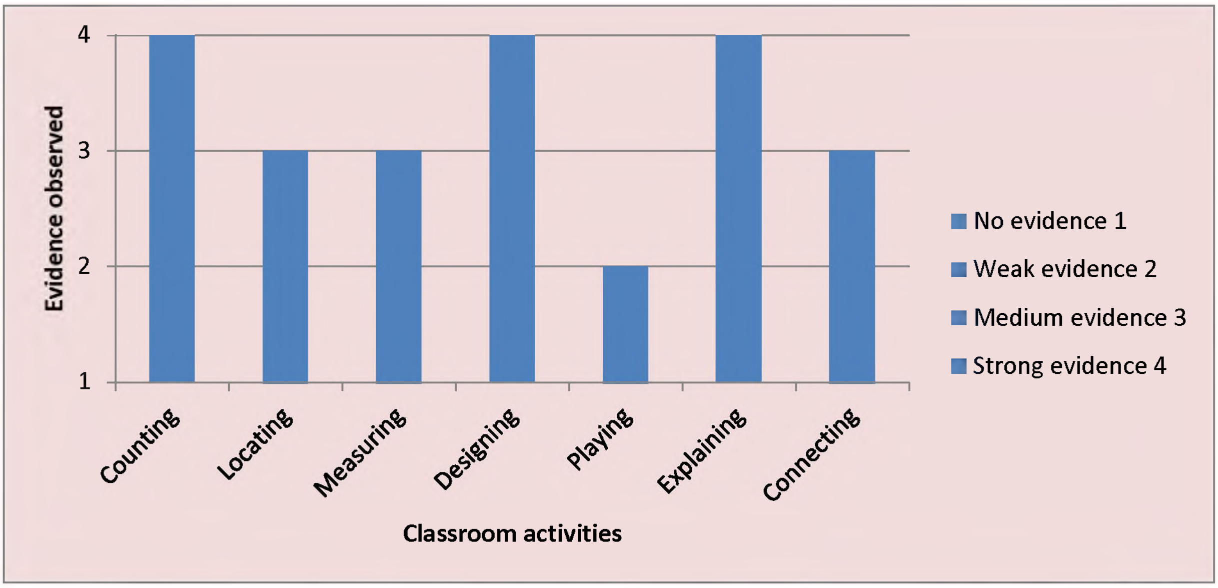

Figure 4.26 Evidence observed on the inclusion of IK in classroom activities in lesson 3

Figure 4.26 indicates that the teacher used IK on all activities carried out in the classroom despite the fact that little evidence was observed on playing. This means that the teacher has an understanding of the importance of IK in this lesson.

Visualisation processes

The teacher displayed a poster with examples on how to round decimals fractions to the nearest 10 for the class to see, and demonstrated with an explanation on how to do it. He later handed out copies with an activity for learners to practise rounding, and gave instructions.

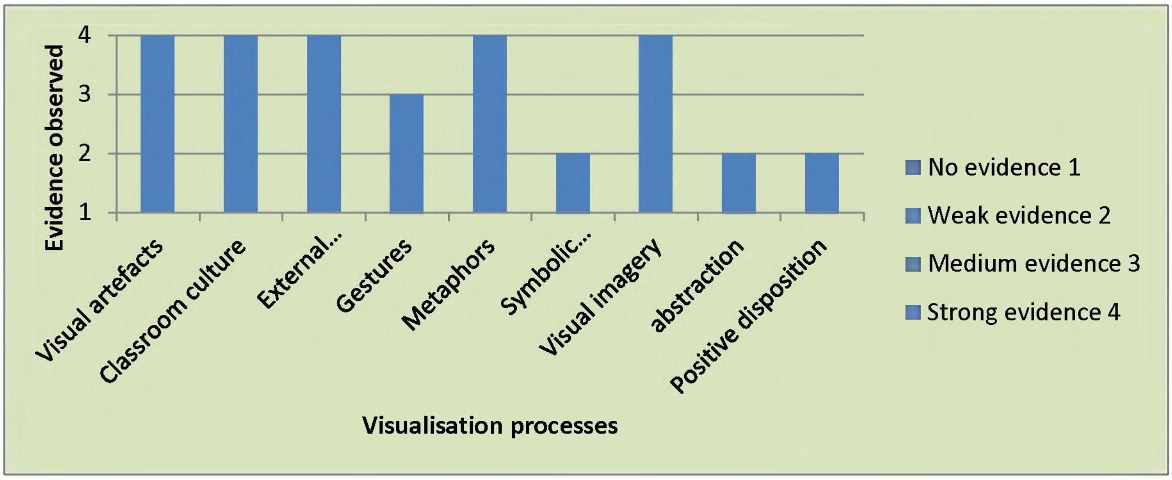

Figure 4.27 Evidence observed on visualisation processes in classroom activities in lesson 3

Figure 4.27 above shows that the teacher engaged all visualisation processes in the lesson although weak evidence was observed on the use of symbolic inscriptions, abstraction and imagery visualisation to promote positive disposition. This indicates that the teacher considered visualisation processes to take place in the teaching to mediate learning. However, he did not engage with much visualisation material on symbolic inscriptions, abstraction and positive disposition. This could be that the other processes were more useful than these.

A brief summary of the observations

Table 3.7 of the analytical instrument was used to look at the incorporation of IK on seven activities. I looked at how the IK was incorporated into counting, locating, measuring, designing, playing, explaining and connecting in the lessons. To check on the extent to which this happened, four categories were used. Strong evidence, for abundant use of IK; medium evidence, for some use of IK; weak evidence, for little IK used, and no evidence, for no IK used. The same categories were used in Table 3.8 to look at the use of visualisation or visual representations.

From the classroom observation, the study found that teachers used visualisation-IK approaches for different purposes, in different activities. It was observed that teachers used visualisation-IK approaches for the purpose of explaining concepts or explaining procedures with the intention of making it clearer to the learners. The teachers also used visualisation-IK approaches while giving instructions or trying to make connections between certain mathematical procedures. They also used the approach to clarify statements or questions to make them clear for learners to understand. Such a statement could be an answer to a particular problem, an instruction, or a statement given in a problem that required solving. From the graphs on the inclusion of IK on classroom activities, it is strongly evident that the teachers used IK in counting, measuring, explaining and connecting. From the graphs on visualisation processes, evidence was observed on all processes; the teachers engaged with visualisation processes in their lessons.

In some instances, teachers used visualisation-IK approaches to show that a certain point is very significant (easy to understand), by using a certain simple example in the learners' social context before or after making that point. All this was done to draw learners' attention to that specific point. It was also identified that using the learners' IK helped the teacher to make connections between what learners already know from their own context and the new content.

This was clearly done in order to make a link between what is known and unknown, or for learners to progress in learning from the familiar to the unfamiliar.

Further, a visualisation-IK approach was used for affective purposes and appreciation; this simply means that teachers used the approach to make the learners feel liked and appreciated. The teacher gave one or two examples of the learners' daily activities and explained how such examples are linked to the concept being learned. This was done to make learners feel the relevance of mathematics in their daily lives.

4.4.5 Similarities that emerged in the lessons

During the intervention, it was observed that all teachers showed evidence of an understanding of using visualisation in their lessons. This was evident because they had visual objects in their classrooms. These included pictures, charts, containers and local artefacts which portrayed mathematical concepts. This study found that pictures played a major role in driving the teaching processes and all teachers connected the examples to the learners existing knowledge throughout their teaching. The grades 4-7 teachers had managed to bring the artefacts from the local environment to the classroom. All teachers demonstrated their experiences on how to use visual representations to stimulate learners' enthusiasm. It was further observed that all teachers had been supportive towards visual thinking and had made conscious attempts to facilitate the construction and use of imagery. Through this intervention, this study revealed that teachers use manipulative objects to attract learners' attention and enhance visualisation.

4.4.6 Differences that emerged in the lessons

This study revealed that at Upper Primary Phase (grades 4-7), teachers use more visual objects to facilitate their lessons than teachers at the Secondary Phase (grades 8-12). That is why learners in Upper Primary Phase were more active. The fact that Secondary Phase teachers did not use many of the visual objects made it difficult for them to connect IK to their topics. Further, it was identified most teachers teaching at grades 4-7 are native and speak the local language when using IK in their teaching.

4.4.7 Idiosyncratic aspects that emerged

Apart from the similarities and differences, I also identified some interesting aspects from individual teachers or lessons. From grade 4, it was found that group work allowed learners to discuss and visualise things independently; this enables them to use a variety of their IK effectively in an enjoyable atmosphere. Hence, it was recorded that the lessons that do not use visual materials were boring to learners, the teachers struggled to engage the learners' attention and it took time for learners to grasp the concepts. On the other hand, teachers who were non-native language speakers did not include learners' IK, thus those teachers never used or referred to the local environment artefacts.

However, I found that most of the topics in grades 10-12 did not require much use of IK, but they did require visual representations. That is why some teachers at this level tried to use IK in their lesson, but did not give a clear link between IK and new concepts.

4.5 Focus-group interviews

Two focus-group interviews were conducted in this research study. A pre-intervention focus-group interview was conducted before the classroom intervention and audio-recorded to find the views, perceptions and awareness of teachers about the use of a visualisation approach, and their views on IK in general. After the lesson observation, a post-intervention focus-group interview (the stimulated recall) was also conducted and recorded to reflect on the lessons. This was done to find out from teachers how the use of a visualisation-IK approach had an effect on the practices during the teaching processes. Data is presented as authentically as possible. I felt this to be important as it added richness and validity to the data presentation. Therefore, where possible direct quotes from participants have been used as supporting evidence, appropriate coding was used as follows:

Teacher I Audio transcript (TIA)

Teacher II Audio transcript (TIIA)

Teacher III Audio transcript (TIIIA)

Teacher IV Audio transcript (TIVA)

4.5.1 Pre-intervention focus group interview

The interview was conducted with the selected four teachers. This was done prior to, and in preparation for, the intervention programme; the main aim was to explore teachers' views about an IK-visualisation approach to teaching mathematics, and how we could incorporate these in a teaching programme. In the interview that I had with the four participating teachers, further themes emerged that were worth being analysed and discussed. Below are the responses:

- ***Can you briefly explain the importance of visualisation in the teaching of mathematics?***

TIA indicated that she normally used IK when she found or thought that her learners did not understand the content she taught. She understood that there are some mathematical concepts which learners had never came across before. Thus, the teacher thought it was necessary to use IK. Learners had to try to make these concepts simpler and less abstract. The teacher stated that "*I try to simplify those concepts and try to give IK examples in the vernacular language that will make them understand and get a clearer picture of what is going on in the lesson*". The teacher also indicated that sometimes she used IK to maintain the spirit in the classroom. *"It helps learners to understand concepts much better or easier because they can see what is happening"* (TIA).

TIIA indicated that he mostly used IK when he wanted to explain things to his learners, in order to enhance their understanding, and also to engage his learners' attention. He further stated that "*If you reference a concept to something in the local community all learners can understand at once, unlike in the new Mathematics context; this stimulates learners' engagement by seeing and touching rather than just talking"* (TIIIA).

"It sometimes involves manipulative objects that play a major role in enhancing visualisation processes for fast learning" (TIIIA).

TIVA indicated that he usually used IK in giving instructions (about the procedures of mathematics and activities), especially when he found that the learners did not understand him. He mostly found the need to incorporate IK when he had given an activity or task, and learners found it difficult, or when they got stuck. *"Learners grasp fast and realise the relevance of mathematics in their daily lives"* (TIVA).

- ***Can you briefly explain the importance of IK in the teaching of mathematics?***

"Yes, IK is not only helpful in Mathematics, but in all subjects. Learners learn better from cultural context than modern Mathematics context" (TIA). TIA acknowledged that IK promotes understanding. However, he pointed out that the advantages of this practice were

fewer than the disadvantages. "*These advantages are few. Yes, a learner will understand. Learners will understand a bit yeah. But there are many disadvantages*" (TIA).

"*It depends on the topic; some topics might not require IK. However, it is important to every teacher to connect every lesson to IK before teaching. It helps learners to acquire knowledge from parents and use it in the classroom*" (TIIA).

"*It fills the gap between what learners know and what they need to know, and to apply it in real-life. To learners, new experiences become more meaningful only if they are related to previous experience*" (TIIIA).

"*It helps learners to appreciate themselves and know who they are mathematically outside the classroom*" (TIVA).

- ***What challenges do you think teachers will encounter in regard to the use of IK?***

TIA stated that incorporation of IK can be a challenge if used too often as this knowledge in most cases is incorporated in the vernacular which is not the language of assessment. "*So, if you use too much IK in the class of course learners will be disadvantaged when it comes to examination. As teachers, we are not well oriented when it comes to IK. Much of the IK is in our culture, but our culture is disempowered by European culture. Teacher might find it difficult to help learners in a multicultural classroom as IK may differ from culture to culture*" (TIA).

"*It is time-consuming. It is difficult to accommodate the variety of IK that learners bring to school. Teachers find it difficult to include outside knowledge as this requires time to plan and implement it*" (TIIA).

On this question, TIIIA stated that IK can be a disadvantage because the learners are expected to write their examination in English and that not all mathematics concepts can be related to their IK. "*Challenges are that the examinations are in English and in most cases, they portray Western knowledge*" (TIIIA).

TIVA related to lack of IK information. "*Nowadays people are no longer exposed to traditional games and activities. On the other hand, the importance of IK is not well presented and emphasised in literature*" (TIVA).

"Sometimes some IKs may not make a closer link to the concepts or topic being learned" (TIA).

- ***Does the NNCBE emphasise the inclusion of IK in the teaching of Mathematics?***

Teachers responded as follow:

TIIIA claimed that he was very aware of what the curriculum document and Mathematics syllabus stipulate regarding the incorporation of the existing knowledge of learners. He said that he was fully aware that the curriculum supports the use of cultural knowledge, but he thought that it needed to be reviewed to emphasise the full inclusion of IK, since it helped learners to perform better, especially in mathematics examinations and tasks. *"Yes, there are parts where the curriculum emphasised the use of existing knowledge. However, it is also every teacher's responsibility to find out how to include IK in lessons"* related TIIIA.

TIVA explained with the quote from the syllabus: *"In the mathematics syllabus it is stated that mathematics is an application of everyday life, this gives the sign that it is included in the curriculum"* said the teacher**.**

One of the follow-up questions that were asked was: *'You said the curriculum states that indigenous knowledge should be included in the curriculum, is it possible to adhere to this statement and what problems may you encounter?'* TIA agreed that indigenous knowledge should be included. However, he had a problem with the local knowledge of the learner. TIVA also agreed, but foresaw problems with National examinations, because the indigenous knowledge of the majority may not be assessed or represented, for example Oshiwambo or Kavango traditional knowledge. TIIA also agreed that IK should be included in the curriculum. He compared the rural areas where people could go to the open market to buy things that are measured visually such as meat, flour or 'omahuku', but in urban areas people use scales to measure goods.

- ***How can teachers overcome such challenges?***

TIIA responded: *"Teachers must attend more workshops on IK, how IK materials are developed and effectively used."* In this regard the teacher meant that teachers might be willing to incorporate IK in their teaching, but they do not know how to do it or when it is really required to do so.

"Teachers must appreciate and welcome the IK that learners bring to the classroom" (TIIIA).

"Teachers must use a learner-centred approach to allow learners to present their IK" (TIVA). However, the teacher stated that many learners are completely unaware of the culture and views of others.

For this question, most of the responses of the teachers could be grouped into three main themes. The first theme, namely lack of training, included responses such as no training, lack of background knowledge and no knowledge. The second theme, namely the lack of resources, included responses such as lack of resources and no time to plan a lesson that included indigenous knowledge. The third theme, namely learners, included responses such as learners having no background knowledge and that learners were unaware of other cultures.

- ***State the examples of indigenous knowledge, experience and artefacts you brought and used in the teaching.***

Traditional games such as 'Owela', 'Ondoota' and 'Euma'; those that involve counting (TIA).

Hopscotch is another counting traditional game, stated TIIA.

The construction of traditional huts, houses, clay pots and baskets are examples that I use in my teaching, added TIIIA.

- ***Do you think such knowledge, experiences and artefacts work in conjunction with visualisation?***

"Yes, learners can use their IK as a reference to embark on new knowledge" (TIA).

"If you ask about something that is at home, learners will try to visualise and make a connection", said TIIA.

"Learners can refer to shapes they see on baskets and other local artefacts" (TIVA).

- ***Do you think your own IK and experiences can help learners to use theirs to visualise concepts and re-contextualise for conceptual understanding?***

The responses were:

"It can, you can give one IK example, but learners will come up with amazingly many IK examples", said TIA.

"It depends on where you come from and your ages. If you are too young, you might not be well exposed to much of the IK" (TIIA).

"However, we need more experts to give us more workshops and expose us to much of the relevant IK, so that teachers will see the significant link between IK and classroom Mathematics concepts" (TIIIA).

"It also needs motivation; teachers need to be motivated by experts on the use and importance of visualisation and IK in the teaching of mathematics" (TIVA).

4.5.2 Post-intervention focus-group interview (Stimulated recall)

In order to answer question 3 of the research questions (which was "As a result of an intervention programme, how is IK used in conjunction with visualisation processes to promote conceptual understanding?"), a stimulated recall interview was conducted with all the teachers. The interview was conducted immediately after all classroom observations were done. The interview included nine questions, for example: How was the lesson? Was this a typical lesson? How do you feel the lesson went? What would you like to improve in the lesson and why? What is your process for preparing a lesson? Below is the summary of the first four questions of the stimulus interview.

The first and second questions were, in some respects, interrelated. In response to the first question for all lessons observed, the teachers said that the lessons were normal, for one class the learners were more cooperative and for the remaining classes the learners were quieter. The second question often was answered as a continuation of the first. The teachers stated that the lessons went well though only one of the teachers further explained why the lesson went well. She stated that the lesson went well because learning objectives were met and visualisation-IK was useful in guiding the learning processes. One teacher explained that the lesson was normal even though he had thought that the researcher in the classroom would change how the learners responded.

The third question asked was, 'What went well in the lesson?' The teacher talked about the learners participating well in the lesson. Two of the comments were more about how the learners worked quietly and presented as much local examples as possible. The fourth question dealt with how the teacher would like to improve the lesson. There were no similarities in the comments but the responses revealed something about what the teachers considered in their lessons. In one class, the teacher would have liked to use more concrete tools and ideas. In another class the concern was the amount of time spent on measuring capacity or volume from different containers that was not well managed as learners took long to complete the activity. Studying more visual materials in more depth was the concern of one class.

One teacher expressed the concern that it would have been good if more real-life examples had been used for the lesson instead. The final concern that was given was that the learners were too loud, "a very active discussing group" of learners.

Furthermore, lesson preparation was the subject of the fifth question. More specific sub-questions would perhaps have helped in obtaining more information about the lesson planning process. Three of the four teachers made reference to the use of local artefacts and traditional games in preparing their lessons. Teacher I mentioned that he spent hours thinking about the materials and deciding on what main points he wanted the learners to learn using the visual local objects. He further said he also spent time on each lesson sorting out what additional visual materials to incorporate to re-contextualise IK. Teacher II would plan to review and incorporate previously learned knowledge, including knowledge from previous grades and IK that learners acquired from home, so that he could build on that knowledge with the new material. Teacher III had lesson plans, some written down on paper and some just post-it notes, pasted in the teacher's manual

For questions 5-8 of the interview the direct quotes of responses are as follows:

- ***Did you find it worthwhile to use a visualisation-IK approach in your teaching?***

TIA: *It helped me to start my lesson with the clear message on the relevance of the topic.*

TIIA: *Learners got interested into the lesson as from the beginning till the end.*

TIIIA: *Learners brought in more relevant examples.*

TIVA: *It helped me see the area of improvement on my next lesson.*

- ***How helpful was it to the understanding of concepts when you engage different forms of IK that learners present in the lesson?***

TIA: *Learners easily helped one another by explaining in vernaculars with relevant local examples for further understanding.*

TIIA: *Learners made meaningful connection between what they know and new concepts.*

TIIIA: *Learners can carry out activities at home and get assistance from anybody else using IK.*

TIVA: *Learners can apply mathematics knowledge in everyday situations.*

- ***What were the strengths in the lesson as far as a visualisation-IK approach is concerned?***

TIA: *Learners were able to carry out the groupwork on their own.*

TIIA: *Learners participated actively.*

TIIIA: *Knowledge presented to learners appears not to be too abstract.*

TIVA: *Abundant examples emerged during the lesson.*

- ***What challenges did you find in the lesson as far as a visualisation-IK approach is concerned?***

TIA: *The size of the class is too big and it is difficult for one to consider all the IK examples that learners wish to give.*

TIIA: *It is difficult to reject irrelevant IK examples, it discourages learners.*

TIIIA: *Non-native learners may feel excluded.*

TIVA: *Time-consuming.*

Below is the summary of the responses to question 9 of the stimulated recall interview (could you please highlight the enabling and constraining factors on the use of a visualisation-IK approach in the teaching of mathematics?), in an attempt to answer question four of the research questions (what are participating teachers' experiences of the enabling and constraining factors in using a visualisation-IK approach to teaching mathematics?):

According to their views and experiences of the enabling factors in the use of a visualisation-IK approach, they stated that most schools are in the rural areas and most people in those areas survive on IK. This allows the majority of the learners to use their IK and visualise the artefacts they are familiar with. Further, teachers stated that since most of the learners at most schools speak almost the same local or native language, this helped teachers to use a visualisation-IK approach effectively through one common language. They also touched on the role of the teacher as it had an influence on the effectiveness of the use of a visualisation-IK approach. They indicated that most teachers that graduated from the University of Namibia have studied ethno-mathematics and this enabled them to facilitate visualisation processes towards IK.

Furthermore, the majority of the teachers are native speakers of the local language spoken in the areas they teach. This allowed them to easily facilitate the incorporation of IK into visualisation processes. The teachers stated that this will meet the demands of the curriculum, which emphasise the use of models, spatial relationships and the use of existing knowledge as a starting point. In addition, the teachers highlighted that learners in grades 8-12 have experienced adult-related traditional home activities and they have gained IK which they could use in mathematics classrooms. They could easily relate mathematics in the classroom to mathematics outside the classroom.

However, teachers stated that there are constraining factors that are affecting the use of a visualisation-IK approach. They stressed that there is a high reluctance amongst teachers; teachers did not want to recognise the important role of a visualisation-IK approach in their teaching of mathematics. They added that the use of IK may cause stereotyping and inequity in the teaching as there may be different tribes and races in the classroom. They further explained that IK may bring contradictions to the classroom due to the different languages and cultural background of learners.

Moreover, teachers stated that the Namibian education system is based on politics. This means that our lawmakers do not have any knowledge of educational- or curriculum-related issues. They could not revise the curriculum to the extent that it addressed what it takes to improve conceptual understanding in the teaching of mathematics. They could improve the curriculum by strongly emphasising the use of visual objects and the use of IK. On the other hand, teachers highlighted that some IK is based on myths and beliefs. This may cause confusion, and misconceptions may be carried forward. Modernisation of mathematics has also overpowered traditional mathematics knowledge. Leaners are not eager to learn in an ancient way; they feel comfortable in the modern way of learning mathematics through fast technology. This modern way of learning mathematics has spoiled them as it mostly focuses on procedures rather than meaning-making.

4.6 CONCLUSION

In this chapter, I presented and analysed the data collected using different techniques. The documents analysed brought some suggestions on how to engage visualisation processes, how to incorporate IK and how to align the curriculum to the socio-cultural perspective of teaching mathematics. The findings revealed that the use of a visualisation-IK approach is common in the Oshana region of Namibia and these findings answered my first research question. From the intervention conducted, the findings showed that through a visualisation-IK approach, teachers easily facilitated the teaching process and the concepts did not seem to be too abstract to learners. From the in-depth recall interview, this study presented the insights of the teachers on the enabling and constraining factors. This answered the fourth research question of the study. The next chapter concludes the study and makes some recommendations for possible areas of further research

CHAPTER FIVE

SUMMARY OF FINDINGS AND CONCLUSION

5.1 INTRODUCTION

In the previous chapter, the findings of the study were presented and discussed in detail and related to the literature reviewed. In this chapter I conclude this study by providing a summary of the findings and making some recommendations. I also provide a brief discussion on the limitations and constraints I encountered in this study. The chapter ends with some personal reflections and proposed avenues for further research.

5.2 SUMMARY OF EMERGING THEMES AND FINDINGS

This study sought to explore teachers' views, perceptions and experiences on the use of visualisation and IK. It sought to investigate how teachers engage a visualisation-IK approach as a mediating tool to make connections and enhance conceptual understanding. A survey and interviews were used to look at teachers' experiences about the factors that enable or constrain the use of a visualisation-IK approach in the teaching of mathematics. The discussion below answered my four research questions.

5.2.1 Teachers' views and experiences on IK (research question one)

The study found that teachers are aware and positive about the inclusion of IK in the teaching of mathematics as it helps the learners' comprehension of the concepts. The results further indicated that teachers mostly incorporate IK when teaching topics that involve measurements and shapes. It was interesting to note that teachers regarded IK as a stepping stone for learners to approach new concepts. The study reveals that the teachers in this study embraced the inclusion of IK, stating that it stimulates learners' understanding and interest in lessons. Some participants indicated that the curriculum or syllabus influenced their views as it encourages the use of IK in the teaching of mathematics. Further, the study found that the Namibian National Curriculum for Basic Education recommends that teachers incorporate the existing knowledge of learners into their lessons and learners' needs within their environment and community (NNCBE, 2010).

5.2.2 Teachers' views and experiences on visualisation (research questions one and three)

From the teachers' responses to the survey, the study found that about 90% of the teachers use visualisation materials and few teachers indicated that they do not use visualisation materials. This indicates that most of the teachers are familiar with what the curriculum expects them to cover, because they are aware of the importance of visualisation materials or objects. Through observation, the study found that teachers engaged visualisation processes in their classroom through the inclusion of: visual artefacts, classroom culture, external visualisation, gestures, metaphors, symbolic inscriptions, visual imagery, abstraction and positive disposition. The study further revealed that teachers mostly engaged these processes to explain concepts and procedures, to clarify statements and to emphasize points. Further, the study revealed that most visual materials were used in measurement-related topics or concepts.

5.2.3 Visualisation-IK teaching approach (research questions two and three)

The study found that teachers had an understanding of the use of a visualisation-IK approach. They stated that learners visualise better about what they already know and see at home. They further stated that through this approach, learners can come up with their own terminologies and concepts when exploring familiar artefacts. From the survey and interviews, teachers indicated that a visualisation-IK approach helps learners to re-contextualise IK into mathematics knowledge. Through observation, the study revealed that the use of visualisation in teaching of mathematics was effectively used to re-contextualize IK into mathematics knowledge. There is evidence from the lesson observation that teachers were able to represent mathematics ideas through different visual materials and IK artefacts.

5.2.4 Visualisation-IK as a mediating tool to enhance conceptual understanding (research question two)

Throughout the lesson presentations, teachers used a visualisation-IK approach to build bridges between what is already known by learners and the new concept to be learned. Teachers used a visualisation-IK approach to connect the mathematical concepts across mathematical domains. The findings of this study showed that through visual materials and IK artefacts brought to the classroom, teachers were able to carefully explain the connections between real objects and classroom concepts, especially on measurements. It was evident that learners could repeat processes without the guidance of the teachers, which shows that conceptual understanding was enhanced.

5.2.5 Teachers' experience on enabling and constraining factors (research question four)

The findings revealed that teachers in this study were able to name the factors that enabled them to include local knowledge in mathematics, such as availability of local materials, and starting from the known to the unknown was highlighted. Thus, accommodating the culture of the learners' immediate environment plays a significant role in learning and determines how concepts are learnt. The participating teachers also pointed out that IK has disadvantages when incorporated into mathematics classrooms. For example, they mentioned that the terminology of the local language cannot encompass all the concepts in mathematics. The teachers' highlighted aspects such as, IK is not documented, which means that there is a lack of curricula materials which show how IK can be reconciled with classroom mathematics. In other words, current mathematics textbooks have very few examples, illustrations and demonstrations linked to teachers' or learners' IK. They further mention factors such as a lack of concepts in our local language, time-consuming, no proof, lack of teachers' empowerment, and that some IKs are mythical and seasonal.

Additionally, it was stated that the unwilling participation of the community, and that some teachers lack IK, have limited planning time, and lack experience in subject content, are some of the reasons why they do not use IK in mathematics lessons. Some of the teachers who teach at schools in nearby towns have different cultural backgrounds from the learners', thus they find it difficult to incorporate IK. Language issues also emerged as a problem in this study. IK is embedded in cultural practices in which language plays a major role.

5.3 SIGNIFICANCE OF THE STUDY

Two important aspects were highlighted in this study which led to its significance. Firstly, this study opens up the issue of IK that has been ignored and rarely included in mathematics teaching or in the curriculum in Namibia. Secondly, this study allowed the participants to critically reflect on their own practice with regard to the use of a visualisation-IK approach as a pedagogical tool to mediate learning. This study is set to inform various education stakeholders in the Namibian education system at different levels. It is hoped that the findings of this research project will be useful and informative for teachers, teacher-trainers, curriculum designers, researchers/scholars and textbook authors. It is also hoped that policy makers will gain insightful information about the importance of recommending a visualisation-IK teaching approach in the curriculum in a more explicit manner.

5.4 RECOMMENDATIONS

From the insights gained from this study, I recommend the following to policy makers, curriculum designers, textbook authors, teachers and teacher training institutions:

- The Ministry of Education (MoE) should facilitate continuous professional development programmes through designing quality workshops whereby all mathematics teachers can be trained on how to incorporate IK in their lessons;
- Policy-makers should affirm and persuade curriculum designers to incorporate the use of visualisation-IK approaches in all phases of schooling;
- The MoE should develop workshops that encourage teachers to recognise the value of visualisation, IK and their integration into the teaching of mathematics. This will enable them to develop teaching support materials which take the incorporation of visualisation and IK into consideration;
- Continuous professional development programmes should motivate and encourage teachers to critically review their practices of using visualisation-IK approaches in an attempt to improve their teaching;
- IK needs to be documented. Textbook authors and curriculum designers should emphasise the use of IK in their publications. The use of IK should be more explicitly articulated in the curriculum to facilitate the creation of teaching and learning materials;
- Teachers should share best practices and observe each other's lessons when incorporating IK in their mathematics lessons;
- Mathematics teachers should create opportunities for leaners to demonstrate their solutions visually;
- Mathematics lessons should be allocated adequate time on timetables to allow teachers to use visualisation-IK approaches to represent mathematics concepts effectively. This will enhance conceptual understanding in the teaching of mathematics;

- Teacher-training institutions should train student teachers on how to incorporate visualisation and IK in the teaching of mathematics; and
- It is further recommended that parents should support their children's learning by providing them with IK and other traditional knowledge which they can use at school as starting points to make connections.

5.5 LIMITATIONS

The findings of this study about the teachers' views, perceptions and experiences were limited to only 25 teachers who returned the survey questionnaires and four teachers who took part in the study as main participants. As only 25 survey questionnaires were returned, this affected how representative the findings are of all the teachers in the Oshana region. But the data from the survey questionnaires were complemented and triangulated with interview data. The other limitation was time constraints. Some of the teachers kept postponing the due date (retrieval date) and I was only able to receive the survey questionnaires at the end of June 2017. One teacher withdrew from the study, thus the number of main participants was reduced from five to four. The findings of the study cannot be used to generalise for the whole region or country. However, despite these limitations, useful insights on the use of a visualisation-IK approach in the teaching of mathematics have been provided by this study.

5.6 SUGGESTIONS FOR FURTHER RESEARCH

This research serves as a starting point for future research on the inclusion of a visualisation-IK approach in mathematics teaching. Further suggestions for research include:

- Further studies could be done on the same topic, but expanded to include learners, curriculum designers and textbook authors;
- Studies on the inclusion of visualisation-IK approaches in mathematics teaching where more teachers from different regions of Namibia would be involved;
- A study on the learners' views and experiences on the inclusion of IK in mathematics lessons;
- The impact of IK in the mathematics curriculum on the performance of learners in Namibia;

- A study on the commonality or similarity of indigenous mathematics knowledge applicable in all regions of Namibia;
- A study on the roles of parents or community members on the inclusion of IK in classroom mathematics; and
- A study on how to overcome constraining factors to the inclusion of IK in the teaching of mathematics.

5.7 PERSONAL REFLECTION

The journey along the path of IK did not just start in 2017, but was aroused in 2016 when our Science Education lecturer introduced indigenous knowledge to us in the Science elective classes of BEd Honours. It was my pleasure to explore the knowledge that is embedded in my own culture. My interest in IK has been growing and I am happy to be one of the IK researchers in Namibian, especially in the mathematics context. Being born and raised in a rural area enabled me to handle different cultural issues during this study. This study taught me a lot and helped me to develop personally, academically and professionally. It is through this study that I have learned how to deal with disappointments like participants not meeting my expectations in terms of time or meeting deadlines. I gained a lot of insight into my field of interest, firstly through studying the literature and secondly through the research process.

Further, in this study I received a lot of correction comments especially on grammatical errors from my supervisor that could have demoralised me. However, this motivated me, as my study is one of a kind in Namibia. This was a great learning experience for me, particularly engaging in a critical research of combining visualisation and IK at the same time. This study has placed me on a different professional level. I look at issues and situations far more critically. This not only applies to the area of mathematics in the classroom, but also in other aspects of professional responsibilities. I wish to publish some articles on IK so that I can share my knowledge with other scholars and educational stakeholders in Namibia.

5.8 CONCLUSION

In this chapter I summarised the findings, discussed the limitations, made some recommendations and provided ideas for further research. I also reflected on my own experience of the research project.

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APPENDICES

Appendix 1

Approval letter from the Director of Education

REPUBLIC OF NAMIBIA

OSHANA REGIONAL COUNCIL
DIRECTORATE OF EDUCATION, ARTS AND CULTURE
Aspiring to excellence in Education for All

Tel: 065 229800
Fax: 065 229833
Enquiries: Gerhard S. Ndafenongo
E-mail: ndafenongogs@gmail.com
Ref no: 11/1/1

906 Sam Nuyoma Road
Private Bag 5518
Oshakati, Namibia

MR GAUS TSHITHIGONA
RHODES UNIVERSITY
GRAHAMSTOWN 6139
SOUTH AFRICA

Dear Mr G. Tshithigona

RE: PERMISSION TO CONDUCT RESEARCH WITH ALL MATHEMATICS TEACHERS IN OSHANA REGION

1. I acknowledge receipt of your letter 01st June 2017 and therefore it bears reference;

2. Kindly be informed that permission is hereby granted to conduct the study entitled: **An exploration of a visualization approach to re-contextualise indigenous knowledge in the teaching of Mathematics in Namibia**. You are hereby requested to present this letter of approval to the principals to ensure that the research is authorised, authentic and procedures are adhered to.

3. This permission is subject to the following strict conditions; (i) There should be minimal or no interruption on normal teaching and learning, during a class or scheduled afternoon session, (ii) Ethical issues of confidentiality and anonymity should be respected and retained throughout this activity i.e. voluntary participation, and consent from participants, and (iii) the permission is valid for the entire academic year 2017.

4. Both parties should understand that this permission could be revoked without explanation at any time.

5. Furthermore, we humbly request you to share with us your research findings with the Directorate of Education, Arts and Culture_ Oshana Region. You may contact Mr GS Ndafenongo, the Deputy Director: Programs and Quality Assurance (PQA) for the provision of summary of your research findings.

6. I wish you the best in conducting your study.

Yours Sincerely

.... 06/06/2017

HILENI M. AMUKANA
REGIONAL DIRECTOR

06 JUN 2017

All correspondence should be addressed to the Director of Education, Arts & Culture

Appendix 2

Informed consent form from the participating teachers

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

FRF CHAIR IN MATHEMATICS EDUCA
EDUCATION DEPART
Tel: +27 (0)46 603
Fax: +27 (0)46 603
Email: maths.ed@ru.

INFORMED CONSENT FORM

Research Project Title:	***An exploration of a visualisation approach to re-contextualise indigenous knowledge in the teaching of mathematics in Namibia***
Principal Investigator(s):	**Gaus Tshithigona**

Participation Information

- I understand the purpose of the research study and my involvement in it
- I understand the risks and benefits of participating in this research study
- I understand that I may withdraw from the research study at any stage without any penalty
- I understand that participation in this research study is done on a voluntary basis
- I understand that while information gained during the study may be published, I will remain anonymous and no reference will be made to me by name or student number
- I understand that video recording may be used
- I understand and agree that the interviews will be recorded electronically
- I understand that I will be given the opportunity to read and comment on the transcribed interview notes
- I confirm that I am not participating in this study for financial gain

Information Explanation

The above information was explained to me by: Gaus Tshithigona

The above information was explained to me in English and I am in command of this language:

I, [redacted] hereby voluntarily consent to participate in the above-mentioned research

Signature:	Date: / /

Investigator Declaration

I, Gaus Tshithigona declare that I have explained all the participant information to the participant and have truthfully answered all questions ask me by the participant

Signature:	Date: 04 / 07 / 2017

Appendix 3

Permission letter to the principal

PERMISSION LETTER TO HEAD OF INSTITUTION

Gaus Tshithigona
Rhodes University
Grahamstown.
6139
04th July 2017

Att: The Principal
Shinim[redacted]
Ondang[redacted]

REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT THE SCHOOL

To whom it may concern

My name is **Gaus Tshithigona**, and I am an MEd student at Rhodes University (RU) in Grahamstown, South Africa. The research I wish to conduct for my Master's full thesis requires me to observe Mathematics teaching at a lower primary, upper primary, junior secondary and senior secondary as well as to interview the participating teachers on two occasions. This research will be conducted under the supervision of Professor Marc Schäfer, The SARChI Chair of Mathematics Education at Rhodes University. The title of my research is: **An exploration of a visualisation approach to re-contextualise indigenous knowledge in the teaching of mathematics in Namibia.**

This letter serves to seek formal consent to approach [redacted] to be one of the participants for this research. Further, I would be grateful if I may access appropriate documents at their discretion. For this reason I request your permission to visit the school as from **June –July 2017** to conduct my research as outlined in my attached research proposal.

I attach a copy of my research proposal which includes copies of the consent and assent forms to be used in the research process. Once I have received ethical clearance from Rhodes University, I will provide you with the ethical clearance letter. As part of this I undertake to ensure that the name of the schools and all participants will be replaced with pseudonyms and that all the material I collect as part of the research will be accessible only to me and my supervisor.

Appendix 4

Survey questionnaire

RHODES UNIVERSITY

Where leaders

AN INVESTIGATION INTO TEACHING MATHEMATICS USING A VISUALISATION APPROACH TO RE-CONTEXTUALISE INDIGENOUS KNOWLEDGE

A survey

You are invited to participate in a research study (survey) entitled: ***An exploration of a visualisation approach to re-contextualise indigenous knowledge in the teaching of mathematics in Namibia.***

The aim of this survey is to explore how widely the use of Indigenous Knowledge in conjunction with visualisation processes is included in the teaching of mathematics in the Oshana region. Your participation is important to other teachers, teacher-trainers, curriculum designers, researchers/scholars and textbook authors.

This survey has obtained the permission from the Director of Education and the participation in this research is voluntary. The data collected from this survey will remain anonymous and confidential. Please note that you have the right to withdraw at any given time during the survey should you feel so.

As we wish to select five participants for a follow-up study we ask you to provide your name and details as indicated. Once this selection has been made your name will not be of any significance to the survey. Please remember there are no right or wrong answers to this survey. We wish to elicit you perceptions and opinion, so please respond to every question.

NB: if you run out of space, please use the blank page overleaf

Name:………………………………………………………. **School**: …………………………………………………………….

Section A Visualisation in mathematics teaching

A visualisation approach to mathematics teaching is one where the teacher makes use of visual materials/objects to teach and unpack mathematical ideas and concepts. These materials may include posters, pictures, diagrams, manipulatives, artefacts, models etc.

Please answer the following questions:

12. Do you use visualisation materials/objects in your teaching? Please elaborate.

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13. What kinds of visualisation materials/object do you use?

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14. How do you use these materials/objects in your lesson?

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15. On average how often do you use these materials/objects in your teaching per week? Tick(√)

Every day twice a week once a week never

16. In your views, how can a visualisation approach to teaching support the teaching of mathematics?

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17. Why do you think the use of visual objects such as manipulative are important in the teaching of mathematics?

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18. Do you ever relate the visualisation objects or artefacts that you use in your teaching to the local environment? Please elaborate.

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19. Can the use of visual objects be helpful in problem solving? Explain

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20. Do you think that your learners visualise mathematical concepts in their minds? Please elaborate

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21. List the strengths in using visualisation in your teaching.

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22. List the weaknesses in using visualisation in your teaching.

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Section B Indigenous knowledge in mathematics teaching

Indigenous knowledge (IK) is the knowledge that is grounded in the local environment. This is the knowledge that is extracted from traditional artefacts, activities, games and social interaction.

Please answer the following questions:

8. Do you use IK in your teaching? Please elaborate.

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9. Some say that IK should be the point of departure for teaching any knowledge. Do you agree with this statement? Please elaborate.

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10. How often do you use IK in your teaching? Tick(√)

Every day twice a week once a week never

11. When do you use IK in you teaching? (e.g when introducing a lesson, when doing practical activities, group work etc.)

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12. Why do you think the incorporation of cultural knowledge is important in mathematics classroom?

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13. Do you think it is important for teachers to understand the cultural and historical background of the learners? Please elaborate.

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14. In your opinion, in what way can IK be helpful in the construction of new knowledge?

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15. How can the inclusion of IK in the teaching of mathematics promote multiculturalism?

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16. List the strengths in using IK in your teaching.

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17. List the weaknesses in using IK in your teaching.

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Section C Visualisation-IK approach

The use of visualisation in teaching can be useful to re-contextualize IK into mathematics knowledge. This is sometimes called a visualisation-IK approach to teaching.

5. Do you agree with the statement above? Please explain

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6. How can a visualisation-IK approach promote meaningful understanding in the teaching of mathematics?

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7. List the strengths in using a visualisation-IK approach in your teaching.

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8. List the weaknesses in using a visualisation-IK approach in your teaching.

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END OF SURVEY
THANK YOU!

Appendix 5

Interview questions

Gaus Tshithigona 15T8851

MEd 2017

Focused group interview

AN INVESTIGATION INTO TEACHING MATHEMATICS USING A VISUALISATION APPROACH TO RE-CONTEXTUALISE INDIGENOUS KNOWLEDGE

1. Can you briefly explain the importance of visualization in the teaching of mathematics.
2. Can you briefly explain the importance of IK in the teaching of mathematics?
3. What challenges do you think teachers will encounter in regard to the use of IK?
4. How can teachers overcome such challenges?
5. State the examples of indigenous knowledge, experience and artefacts you brought and used in the teaching.
6. Do you think such knowledge, experiences and artefacts work in conjunction with visualisation?
7. Do you think your own IK and experiences can help learners to use theirs to visualise concepts and re-contextualise for conceptual understanding?

Appendix 6a

Teacher 1 Lesson 1

MATHEMATICS LESSON PLAN

Grade: 4 **Date: 3-5/07/2017**

Data Handling **40min**

- **Previous Knowledge:** learners understand and know how to collect data
- **Learning Objectives:** for the learners to collect discrete data from local sources e.g. shoes sizes, ages, types of animals etc
- **Basic Competencies:** to organise data in tally forms and tables, as well as to represent data on pictograms and vertical bar graphs, and to interpret and analyse data from pictograms and vertical bar graphs.
- **Resources:** Maths Grade 4 Learner's Book and Teacher's Guide Protractor **&** Calculator

Teacher activities	Learner Activities
Introduction The teacher introduces the concept of data handling.	
Methodology -The teacher asks learners to do a reflection on the previous lesson before introducing the day's lesson on data handling, specifically on vertical bar graphs. -Explain the meanings of the terms vertical and horizontal, the teacher asks learners; "if you are standing, are you horizontal or vertical?" This can be done to generate data. -The teacher asks learners to use their knowledge to answer questions such as find the least, most or how many more.	- Learners expected to respond 'vertical'. - Learners will raise their hands to represent languages they speak at home. -Under the teacher's guidance seven local languages were represented. They also used the occurrence of favourite domestic animals of learners to collect data.
CONCLUSION (15 min): The teacher highlights on the vertical and horizontal bargraphs	Learners take notes

Assessment/Follow activities Learners solves problems involving collecting data.,	Describes and illustrates the development of data collection

Reflection:………………………………………………………………………………

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Controller's Comments: ……………………………………………………………

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Controller's name: ………………………… Rank: ………………………………….

Controller's Signature …………………………………….. Date ………………

Appendix 6b

Teacher 1 Lesson 2

MATHEMATICS LESSON PLAN

Grade: 4 **Date: 10-12/07/2017**

Unit of time **40min**

- **Previous Knowledge:** Learners already know how to read time from digital clocks.
- **Learning Objectives:** to read and record analogue clock time to the nearest 5 minutes, e.g. "25 minutes past 3"; was recorded as 3.25. Read digital 12 hour clock time, e.g. 3:25; was read as "25 minutes past 3". Further, learners read time from analogue and digital clocks by indicating the minutes left to the next hour e.g. 6:40 which was read as twenty minutes to seven.
- **Basic Competencies:** to read and interpret simple timetables and calendars, use vocabulary associated with time correctly such as; past, present, future, earlier, later, now, then, a long time, a short time. They also recognised and used units of time and their abbreviations as seconds (s), minutes (min) and hour (hr.).
- **Resources:** Maths Grade 4 Learner's Book and Teacher's Guide Protractor **&** Calculator

Teacher activities	Learner Activities
Introduction The teacher introduces the vocabularies associated with time.	Learners take notes
Methodology - The teacher greets the learners and welcomed them to the lesson. - asks learners why time is important in our lives. The teacher asks again; what reminds us about time? -The teacher rectifies that not only during the night a cock reminds people about time, but it crows at every exact clock time. - The teacher informs learners that at the sun, it tells people about the time, when the sun is above your head it is probably noon.	-Learners expected to give different answers such as; to tell us to go to school, to inform us whether it is late or early. - Leaners responses expected; clock, alarm clock, news on television. "Apart from clocks and watches, what else can remind us about time at home"? -Learners expected to mention that a cock can also remind us about time during the night.

The teacher gives another example; when we were young, we used stick shadows to measure the time when playing.	
CONCLUSION (15 min): The teacher highlights on the vocabularies associated with time.	Learners take notes
Assessment/Follow activities	Learners solves problems involving time

Reflection:……………………………………………………………………………………

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Controller's Comments: ……………………………………………………………

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Controller's name: ………………………… Rank: …………………………………..

Controller's Signature ………………………………………..

Appendix 6c

Teacher 1 Lesson 3

MATHEMATICS
LESSON PLAN

Grade: 4 **Date: 22-24/07/2017**

Mensuration **40min**

- **Previous Knowledge:** learners understand and know how use the formulae for the calculation of perimeter and area of simple shapes
- **Learning Objectives:** do calculations involving the perimeter and area of simple shapes, the surface area and volume of simple solid bodies
- **Basic Competencies:** calculate the perimeter and area of a trapezium and calculate the perimeter of a kite and a rhombus. Calculate the area of a kite, a rhombus and a square using the lengths of the diagonals.
- **Resources:** Maths Grade 4 Learner's Book and Teacher's Guide Protractor **&** Calculator

Teacher activities	Learner Activities
Introduction The teacher introduces the concept of area by summarizing the pupils 'findings and explains	Pupils make 5 or 6 groups. Teacher gives a sheet on which 4 rectangles have been printed with A, B, C, D, and smaller square cut-outs of 1cm by 1cm to each group
Methodology Teacher prepares 4 or 5 sheets and plenty of cut-outs. Instruct learners to use the formulae for perimeter and area of rectangle, square, parallelogram and triangle and volume of cuboids in problem solving situations	Solves problems involving known geometric figures and solids • Measures precisely, selects measuring instruments • Estimates and calculates with precision, selects and uses appropriate formulae and measurements • Describes and illustrates the development of measuring instruments
CONCLUSION (15 min): The teacher introduces the concept of area by summarizing the pupils' findings and explains the conclusion.	Use simple formulae for perimeter and area of trapezium, kite, and rhombus; surface area of cuboids; investigate circumference and area of a circle
Assessment/Follow activities Learners solves problems involving known	Describes and illustrates the development of measuring instruments

geometric figures and solids	

Reflection:………………………………………………………………………………………

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Controller's Comments: ………………………………………………………………

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Controller's name: …………………………   Rank: ………………………………….

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Appendix 6d

Teacher 2 Lesson 1

MATHEMATICS
LESSON PLAN

Grade: 5 **Date: 3/07/2017**

Measuring and Recording **40min**

- **Previous Knowledge:** leaners already know how to measure
- **Learning Objectives:** to estimate and measure familiar objects in metric units for length (km, m, cm and mm), mass (kg, g) and capacity (ℓ, mℓ). Convert between at most two consecutive metric units.
- **Basic Competencies:** Perform the four basic operations on values that were expressed in not more than two different units. To use and interpret expressions for opposites such as tall/short, long/short, higher/lower, far/near, thick/thin, wide/narrow, times more/times less, light/heavy, lighter/heavier, more mass/less mass, empty/full, large/small, more/less.
- **Resources:** Maths Grade 5 Learner's Book and Teacher's Guide Protractor **&** Calculator

Teacher activities	Learner Activities
Introduction The teacher starts the lesson by greeting learners and tells them that they will learn about measuring and recording length, mass and capacity.	Learners take notes
Methodology -used shoes to refer them to as having the capacity for your foot to fit in properly. - A clay pot will be brought to the classroom to show learners how women used their traditional knowledge in consideration of what capacity to make the clay pot. The teacher will help the learners to draw on the capacity knowledge from home. In comparisons to measurement with decimal numbers, the teacher uses match sticks to compare decimal in measurement.	-use different sized containers by the teacher and learners to compare capacity from one container to the other. - Learners use the small containers and estimate how many can fit into the bigger container. Practically demonstrate how many 125ml containers would fit into a 1litre container.
CONCLUSION (15 min):	Learners take notes

The teacher highlights on the what mas, length and capacity	
Assessment/Follow activities	

Reflection:…………………………………………………………………………………

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Controller's Comments: ………………………………………………………………

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Controller's name: …………………………   Rank: ………………………………….

Controller's Signature ………………………………………..   Date ………………

Appendix 6e

Teacher 2 Lesson 2

MATHEMATICS
LESSON PLAN

Grade: 5 **Date: 5/07/2017**

Measuring and Recording **40min**

- **Previous Knowledge:** leaners already know how to measure
- **Learning Objectives:** to be able to convert between different metric units of length, mass and capacity in the context of a calculation or a problem.
- **Basic Competencies:** solving context problems involving metric units of length, mass and capacity using whole numbers, common fractions, decimal fractions and percentages. It also involved interpreting and use tables relating to time e.g. tide charts, sunrise/sunset tables, bus, train and airline timetables solve word problems related to time in everyday contexts.
- **Resources:** Maths Grade 5 Learner's Book and Teacher's Guide Protractor **&** Calculator

Teacher activities	Learner Activities
Introduction Teachers tells learners that the lesson would be focusing on metric units of length, mass and capacity.	Learners take notes
Methodology - The teacher ask. What makes up your mass? - A clay pot (Okayo) will be brought to the classroom to show learners how women used their traditional knowledge in consideration of what capacity to make the clay pot. The teacher will help the learners to draw on the capacity knowledge from home. In comparisons to measurement with decimal numbers, the teacher uses match sticks to compare decimal in measurement.	-learners expecting them to mention flesh, water, blood or bones.-use different sized containers by the teacher and learners to compare capacity from one container to the other. - Learners use the small containers and estimate how many can fit into the bigger container. Practically demonstrate how many 125ml containers would fit into a 1litre container.
CONCLUSION (15 min): The teacher highlights on the what mas,	Learners take notes

length and capacity	
Assessment/Follow activities	

Reflection:………………………………………………………………………………………

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Controller's Comments: ………………………………………………………………………

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Controller's name: ……………………………   Rank: …………………………………….

Controller's Signature ………………………………………..   Date ………………

Appendix 6f

Teacher 2 Lesson 3

MATHEMATICS
LESSON PLAN

Grade: 7 **Date: 14/07/2017**

Mensuration **40min**

- **Previous Knowledge:** learners understand and know how use the formulae for the calculation of perimeter and area of simple shapes
- **Learning Objectives:** do calculations involving the perimeter and area of simple shapes, the surface area and volume of simple solid bodies
- **Basic Competencies:** calculate the perimeter and area of a trapezium and calculate the perimeter of a kite and a rhombus. Calculate the area of a kite, a rhombus and a square using the lengths of the diagonals.
- **Resources:** Maths Grade 7 Learner's Book and Teacher's Guide Protractor **&** Calculator

Teacher activities	Learner Activities
Introduction The teacher introduces the concept of area by summarizing the pupils 'findings and explains	Pupils make 5 or 6 groups. Teacher gives a sheet on which 4 rectangles have been printed with A, B, C, D, and smaller square cut-outs of 1cm by 1cm to each group
Methodology Teacher prepares 4 or 5 sheets and plenty of cut-outs. Instruct learners to use the formulae for perimeter and area of rectangle, square, parallelogram and triangle and volume of cuboids in problem solving situations	Solves problems involving known geometric figures and solids • Measures precisely, selects measuring instruments • Estimates and calculates with precision, selects and uses appropriate formulae and measurements • Describes and illustrates the development of measuring instruments
CONCLUSION (15 min): The teacher introduces the concept of area by summarizing the pupils' findings and explains the conclusion.	Use simple formulae for perimeter and area of trapezium, kite, and rhombus; surface area of cuboids; investigate circumference and area of a circle
Assessment/Follow activities Learners solves problems involving known	Describes and illustrates the development of measuring instruments

geometric figures and solids	

Reflection:…………………………………………………………………………………………

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Controller's Comments: …………………………………………………………………

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Controller's name: ………………………… **Rank: ………………………………….**

Controller's Signature ……………………………………….. **Date ………………**

Appendix 6g

Teacher 3 Lesson 1

MATHEMATICS LESSON PLAN

Grade: 11 **Date: 14-15/07/2017**

Linear equation **40min**

- **Previous Knowledge:** The insights about equations from previous grade should be observed.
- **Learning Objectives:** The objectives of the lesson were to understand how to transform linear equations to find the solution and realise the importance of algebraic equations to real life problems.
- **Basic Competencies:** Learners will be able to solve linear equations with brackets and word problems by translating them into linear equations. Learners' understanding of variables became their starting points to participate in this lesson. The insights about equations from previous grade were observed. However, there was still no guarantee if they could make an equation from real life scenarios.
- **Resources:** Maths Grade 11Learner's Book and Teacher's Guide

Teacher activities	Learner Activities
Introduction The teacher starts the lesson by greeting the learners and welcoming them to the lesson. Tells them that the lesson would be focusing on linear equations.	Learners take notes
Methodology Use the number of family members going to Etosha National Park was used as an example to construct the linear equation and solve it. A man and a woman took their two children to a school tour at Etosha National Park. They met their friend who took his five children to the same tour. While talking, they discovered that they have paid the same amount of money for the ticket The teacher uses c to represent the cost of the tickets for children. He constructed the equation $2 + 2C = 1 + 5C$ then he solved it. The teacher gives another	-Learners responded using knowledge they had acquired from the local context. -Use the rectangle drawn on the chalkboard to construct simultaneous equations. 2-dimensional figures were used to construct two questions that were solved simultaneously.

example. *If Elago sold 6 cattle at N$ 2500 each and 10 goats at N$ x then he got N$23000 in total. What was the price of each goat?*	
CONCLUSION (15 min): Highlight on the construction of equations	Learners take notes
Assessment/Follow activities	

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Appendix 6h

Teacher 3 Lesson 2

MATHEMATICS
LESSON PLAN

Grade: 9 **Date: 11-14/07/2017**

Lesson Topic: Mensuration **Duration 40min**

- **Previous Knowledge:** learners already know the types of shapes
- **Learning Objectives:** understand and use the formulae for the calculation of perimeter and area of a trapezium, kite and a rhombus
- **Basic Competencies:** Calculate the perimeter and area of a trapezium and calculate the perimeter of a kite and a rhombus. Calculate the area of a kite, a rhombus and a square using the lengths of the diagonals

Resources:

Maths For Life Grade 9 Learner's Book and Teacher's Guide Protractor

Calculator

Teacher activities	Learner Activities
Introduction Teacher introduces the lesson by telling a story relating to area (e.g.. land, plantation, etc.	Pupils make 5 or 6 groups. Teacher gives a sheet on which 4 rectangles have been printed with A, B, C, D, and smaller square cut-outs of 1cm by 1cm to each group
Methodology Teacher prepares 4 or 5 sheets and plenty of cut-outs. Instruct learners to use the formulae for perimeter and area of rectangle, square, parallelogram and triangle and volume of cuboids in problem solving situations	Solves problems involving known geometric figures and solids • Measures precisely, selects measuring instruments • Estimates and calculates with precision, selects and uses appropriate formulae and measurements • Describes and illustrates the development of measuring instruments
CONCLUSION (15 min): The teacher introduces the concept of area by summarizing the pupils' findings and explains the conclusion.	deduce the formulae for perimeter and area of trapezium, kite, and rhombus; surface area of cuboids; investigate circumference and area of a circle
Assessment/Follow activities	Describes and illustrates the development

Solves problems involving known geometric figures and solids	of measuring instruments

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Appendix 6i

Teacher 3 Lesson 3

MATHEMATICS
LESSON PLAN

Grade: 10 **Date: 14-15/07/2017**
Trigonometry bearings **40min**

- **Previous Knowledge:** learners already know simple bearings
- **Learning Objectives:** The learning objective of this lesson was to solve problems in right-angled triangles, including applications of the Theorem of Pythagoras and bearings.
- **Basic Competencies:** The lesson also involved solving problems in two dimensions using angles of elevation and depression. And read the bearing of 90^0, 180^0 and 270^0
- **Resources:** Maths Grade 10 Learner's Book and Teacher's Guide

Teacher activities	Learner Activities
Introduction The teacher starts the lesson by greeting the learners and welcoming them to the lesson. Tells them that the lesson would be focusing on bearing	Learners take notes
Methodology -The teacher refers to Bushmen as they use estimated degrees to find where an animal is. -The teacher uses a big protractor to show learners how to use and read the protractor. -Draws the bearing on the chalkboard and asked learners to find the bearing from the point to next. Asks learners to imagine how one would direct someone in the sea where there are no trees or other physical materials; so people use degrees for direction.	- Learners carry out the activity with a picture to find the bearing of a man from tree; the teacher used a picture for learners to visualise.
CONCLUSION (15 min): Highlight on the bearings	Learners take notes
Assessment/Follow activities	

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Appendix 6j

Teacher 4 Lesson 1

MATHEMATICS LESSON PLAN

Grade: 4 **Date: 10-12/07/2017**

Unit of time **40min**

- **Previous Knowledge:** Learners already know how to read time from digital clocks.
- **Learning Objectives:** to read and record analogue clock time to the nearest 5 minutes, e.g. "25 minutes past 3"; was recorded as 3.25. Read digital 12 hour clock time, e.g. 3:25; was read as "25 minutes past 3". Further, learners read time from analogue and digital clocks by indicating the minutes left to the next hour e.g. 6:40 which was read as twenty minutes to seven.
- **Basic Competencies:** to read and interpret simple timetables and calendars, use vocabulary associated with time correctly such as; past, present, future, earlier, later, now, then, a long time, a short time. They also recognised and used units of time and their abbreviations as seconds (s), minutes (min) and hour (hr.).
- **Resources:** Maths Grade 4 Learner's Book and Teacher's Guide Protractor **&** Calculator

Teacher activities	Learner Activities
Introduction The teacher introduces the vocabularies associated with time.	Learners take notes
Methodology - The teacher greets the learners and welcomed them to the lesson. - asks learners why time is important in our lives. The teacher asks again; what reminds us about time? -The teacher rectifies that not only during the night a cock reminds people about time, but it crows at every exact clock time. - The teacher informs learners that at the sun, it tells people about the time, when the sun is above your head it is probably noon. The teacher gives another example; when we were young, we used stick shadows to	-Learners expected to give different answers such as; to tell us to go to school, to inform us whether it is late or early. - Leaners responses expected; clock, alarm clock, news on television. "Apart from clocks and watches, what else can remind us about time at home"? -Learners expected to mention that a cock can also remind us about time during the night.

measure the time when playing.	
CONCLUSION (15 min): The teacher highlights on the vocabularies associated with time.	Learners take notes
Assessment/Follow activities	Learners solves problems involving time

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Appendix 6k

Teacher 4 Lesson 2

MATHEMATICS
LESSON PLAN

Grade: 4 **Date: 11/07/2017**

Lesson Topic: Mensuration **Duration 40min**

- **Previous Knowledge:** learners already know the types of shapes
- **Learning Objectives:** understand and use the formulae for the calculation of perimeter and area of a square and a rectangles.
- **Basic Competencies:** Calculate the perimeter and area of a square and calculate the perimeter of a rectangle. Calculate the area of a rectangle and a square using the lengths given.

Resources: Maths For Life Grade 4 Learner's Book and Teacher's Guide , Protractor and Calculator

Teacher activities	Learner Activities
Introduction Teacher introduces the lesson by telling a story relating to area (e.g.. land, Plantation, etc.)	Pupils make 5 or 6 groups. Teacher gives a sheet on which 4 rectangles have been printed with A, B, C, D, and smaller square cut-outs of 1cm by 1cm to each group
Methodology Teacher prepares 4 or 5sheets and plenty of cut-outs. Instruct learners to use the formulae for perimeter and area of rectangle and square. -To test their existing knowledge, the teacher asks them if they could still remember how to calculate the area of square using blocks. -the teacher explains that a circle can occupy a bigger space this is why traditional houses and huts are constructed in circular shapes. He also stated that many containers are made in circular shapes so that they can hold much content.	Solves problems involving known geometric figures and solids • Measures precisely, selects measuring instruments • Estimates and calculates with precision, selects and uses appropriate formulae and measurements • Describes and illustrates the development of measuring instruments

CONCLUSION (15 min): The teacher introduces the concept of area by summarizing the pupils' findings and explains the conclusion.	deduce the formulae for perimeter and area of square and rectangle; surface area of cuboids.
Assessment/Follow activities Solves problems involving known geometric figures and solids	Describes and illustrates the development of measuring instruments

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Appendix 6l

Teacher 4 Lesson 3

MATHEMATICS
LESSON PLAN

Grade: 4 **Date: 19/07/2017**

Approximation and rounding **40min**

- **Previous Knowledge:** The insights about estimation from previous grade should be observed.
- **Learning Objectives:** The objectives of the lesson were to develop the skills to use approximation and rounding numbers to facilitate estimation of answers to calculations. It also involved to estimate (without counting) and then count the number of objects up to 50 in different arrangements of objects and round numbers up to 10 000 to the nearest power of 10 (ten, hundred or thousand)
- **Basic Competencies:** Learners were expected to apply approximation in real life situations by reducing the complexity of large number of objects.
- **Resources:** Maths Grade 4 Learner's Book and Teacher's Guide

Teacher activities	Learner Activities
Introduction After exchanging greeting with the learners, the teacher introduces the topic *rounding* and *estimation*.	Learners take notes
Methodology He asks learners to define the terms "rounding" and "estimation". -Can you give examples of which rounding and estimation can be done in our community?	-Learners expected to state that it is to give the close number to a certain number -Learners expected to mention that at local open markets when people are cutting meat they estimate the size of a portion for a certain amount of money.
CONCLUSION (15 min): Highlits on estimation	Learners take notes
Assessment/Follow activities	

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Appendix 7

An extract from the NNCBE document

1.7 THE APPROACH TO TEACHING, LEARNING AND ASSESSMENT

Preparation for a knowledge-based society requires a learner-centred approach to teaching and learning. This means that the point of departure is always what the learners already know and can do, then acquiring new knowledge through ways of working which are relevant and meaningful for them, and learning how to apply their knowledge creatively and innovatively. Knowledge is not learnt for its own sake, but must always lead to new understanding and new skills and the creation of new knowledge. At each step of the way, learners must show how competent they are in what they understand and can do.

An integral part of this approach is the integration of ICTs as a tool to enhance teaching and learning. The curriculum and syllabuses describe the competencies which they should attain, so that teachers know exactly what to assess in order to be sure that the learners are progressing and achieving. Teaching emphasises the varied processes and learning experiences needed for the creation of knowledge, rather than relying predominantly on the transmission of knowledge by the teacher.

Basic Education also prepares for the society envisaged in Namibia Vision 2030 by being inclusive. Learners with special educational needs and other individual needs will be included in mainstream schools and their needs will be given particular attention through differentiation of methods and materials as needed. Learners who are so severely impaired that they cannot benefit from attending inclusive mainstream classes and schools, will be provided for according to their needs in special units, classes or schools until such time that they can join the mainstream. The curriculum, teaching methods and materials will be adapted to learners with special educational needs.

Learners' progress and achievements will be continually assessed. Learner achievement in selected subject areas will be monitored nationally in Grades 5 and 8 using nationally standardised assessments, and there will be national examinations at the end of Grades 10 and 12. The results of assessment and examinations in these grades provide information on how learners achieve at the end of the phase and also how the system as a whole is performing.

Appendix 8

An extract from mathematics syllabus grade 1-12

6. LOCAL CONTEXT AND CONTENT

Mathematics is a universal language. It is only by local contextualization and application that younger learners will understand and appreciate the uses of mathematics. Where textbooks can only give general examples, it is up to the teacher to use and include local examples by developing appropriate worksheets and exercises.

JSC Mathematics and Additional Mathematics NIED 2010 4

7. LINKS TO OTHER SUBJECTS AND CROSS-CURRICULAR ISSUES

The main cross-curricular themes across all subjects and all phases deal with particular challenges and risks in our Namibian society.

The main risks and challenges we have to address to ensure that our communities become better places to live work and learn have been identified as:

- the challenges and risks we face if we do not care for and manage our natural resources;
- the challenges and risks caused by HIV and AIDS;
- the challenges and risks to health caused by pollution, poor sanitation and waste;
- the challenges and risks to democracy and social stability caused by inequity and governance that ignores rights and responsibilities;
- the challenges and risks we face from globalisation.

All of our learners need to:

- understand the nature of these risks and challenges;
- know how they will impact our society and the quality of life of our people now and in the future;
- understand how these risks and challenges can be addressed at both national and global levels;
- understand how each learner can play her or his part in addressing these risks and challenges in their own school and local community.

Mathematics offers a basis and provides the tools for investigations into these issues across the curriculum, e.g. in Life Science (HIV and AIDS), Geography (population and environmental education) and History (human rights and democracy education). Careful planning is required in order to make sure that aspects of topics from different subjects are coordinated in lesson plans and the same topics are treated at the same time in different subjects. To achieve this aim, cooperation between subject teachers is necessary.

8. APPROACH TO TEACHING AND LEARNING

The approach to teaching and learning of mathematics is based on a paradigm of learner-centred education as described in Ministry policy documents, curriculum guides, and the conceptual framework. This approach ensures optimal quality of learning when the following principles are put into practice.

The aim is to develop learning with understanding, and the skills and attitudes to contribute to the development of society. The starting point for teaching and learning is the fact that the learner brings to the school a wealth of knowledge and social experience gained continually from the family, the community, and through interaction with the environment. Learning at school must involve, build on, extend and challenge the learner's prior knowledge and experience.

Learners learn best when they are actively involved in the learning process through a high degree of participation, contribution and production. At the same time, each learner is an individual with her/his own needs, pace of learning, experiences and abilities. The teacher must be able to sense the needs of

the learners, the nature of the learning to be done, and how to shape learning experiences accordingly. Teaching strategies must therefore be varied but flexible within well-structured sequences of lessons. The teacher must decide, in relation to the learning objectives and competencies to be achieved, when it is best to convey content directly; when it is best to let learners discover or explore information for themselves; when they need directed learning; when they need reinforcement or enrichment learning; when there is a particular progression of skills or information that needs to be followed; or when the learners can be allowed to find their own way through a topic or area of content.
Working in groups, in pairs, individually, or as a whole class must be organised as appropriate to the task in hand. Cooperative and collaborative learning should be encouraged wherever possible. In such cases, tasks must be designed that necessitate group work or working in pairs; otherwise the learners will not see any relevance in carrying out tasks together. As the learners develop personal, social and communication skills, they can gradually be given increasing responsibility to participate in planning and evaluating their work, under the teacher's guidance.
Learning experiences should be characterised by an atmosphere of trust, mutual support and the sharing of knowledge. Learners should have the opportunity to solve relevant problems and should be encouraged to attempt to solve these problems before seeking help. Geometrical instruments, calculators and writing materials should be available.

Mathematical problems should always be exemplified in a context that is meaningful to the learners. The relationships between concepts and topics should continuously be developed throughout the phase. The learners' prior knowledge should always be elicited before commencing with a new topic. Particular attention must be given to ensuring that all learners achieve the basic competencies.
Each learner's progress and achievement must be monitored carefully, and any learners not making progress or not achieving these competencies must receive extra support from the teacher, peers, or by receiving individualised materials, etc. Teachers should note that all learners should attain the competencies in the syllabus, but the competencies listed are not intended to limit the initiative of the teacher or the class. Teachers are encouraged to extend their learners' competencies beyond the syllabus requirements, where possible.