AN ANALYSIS OF THE ROLES AND FUNCTIONS OF TEACHERS' GESTURES AS VISUALISATION TOOLS IN THE TEACHING OF MATHEMATICS AT THE JUNIOR PRIMARY PHASE (GRADES 0 –3)

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ABSTRACT

There is ample evidence in the literature that gestures are important hand and bodily actions that play vital roles during interactions between learners and teachers in the mathematics classroom. These gestures enable both the teacher and the learner to visualise mathematical concepts and ideas. The aim of this Namibian interpretive case study, located in enactivist theory, was to analyse the types of gestures that three selected teachers at the junior primary phase (Grades 0–3) used in their teaching of mathematics. The study also interrogated the roles that these gestures played in the teaching process of the three teachers. As I intended to analyse the types of gestures the selected teachers used and understand their views and perceptions of the roles and functions their gestures played as visualisation tools in the teaching of mathematics, I observed ten lessons of each teacher and video recorded them. I then interviewed them (one-on-one stimulus-recall interviews) and interpreted the gestures they used and utterances they made about using these gestures. The types of gestures that the participating teachers used are classified according to McNeill's (1992) framework, namely pointing (deictic) gestures, iconic (illustrators) gestures, metaphoric gestures, beat (motor) gestures and symbolic (emblems) gestures.

The study found that the participating teachers incorporated a variety of gestures into their lessons and used them strategically. According to the teachers, gestures made the lessons interesting and encouraged active participation of the learners in the lessons. The teachers also revealed that gestures assist in explaining mathematical concepts and thus affected the learners' understanding positively. This study strongly suggests that the usefulness and efficacy of employing gestures as visualisation tools in mathematics education should be strategically harnessed.

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DEDICATION

I would like to dedicate my work to my lovely, caring, supportive and inspiring parents, Erwin Natangwe Namakalu and Scholastika Ndapandula Nguluwe,

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DECLARATION OF ORIGINALITY

I, Dietlinde Nelao Namakalu, student number **17N8214**, declare that this thesis entitled "*An analysis of the roles and functions of teachers' gestures as visualisation tools in the teaching of mathematics at the junior primary phase (Grades 0 –3)*", is my own work and it has not been submitted for a degree or examination at any other university. Where I have drawn on ideas from other sources, I have fully acknowledged and referenced these in accordance with Rhodes University, Education Department reference guide.

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Dietlinde N Namakalu 30 November 2018

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CHAPER ONE

INTRODUCTION

This chapter presents the context and background of the study on gestures as visualisation tools in the teaching of mathematics. It also briefly outlines the research goals and questions of the study, the theoretical framework underpinning this study, the research methodology employed and the significance of the study. The chapter ends with a short outline of the structure of the thesis.

1.1 CONTEXT AND BACKGROUND OF THE STUDY

When people speak, they often perform a variety of movements such as nodding their heads, changing their postures, moving their arms and hands, making facial expressions, moving their eyes and many more, resulting in both visual and auditory streams of information (Holle & Gunter, 2007). These hand and body movements are commonly called gestures. McNeill (1992) asserts that gestures often support the form, shape or action that happens with concurrently occurring speech. In addition, gestures can restate information expressed in speech, clarify doubts, and even add information not found anywhere in the words they accompany (Goldin-Meadow, 2003). Thus, gestures are an important component of human face-to-face communication.

One communicative situation, in which gestures play a major role, is the interaction between learners and teachers (Ping & Goldin-Meadow, 2008). In their study, Alibali, Nathan, Wolfgram, Church, Jacobs, Johnson and Knuth (2014) observe that mathematics teachers use a range of modalities such as gestures, manipulative, drawings and many more to represent and communicate mathematical ideas during instruction. Ping and Goldin-Meadow (2008) suggest that "gestures' success in facilitating learning may stem not from its ability to link words to the visible world, but from its ability to convey additional information that frames the information conveyed in those words"(p.3).

In my readings, not much research has been conducted on the roles of gestures in the teaching and learning process of mathematics in Namibia. As can be expected, more substantial research has been done for example on the role of language and the role of code

switching in the teaching of mathematics (Chikiwa & Schafer, 2016; Shilamba, 2012). I argue in this research study that as gesturing is an integral component to communication, it is also integral to the teaching process. Through my own use of gestures and having observed other colleagues making use of gestures inspired me to undertake a study that interrogates the use of these gestures more closely. As gesturing can be used to reinforce a visual image or even support a process of visualisation, (see definition in Chapter two) my particular focus is on how these hand and body movements are used as visualisation tools to support Grades 0-3 learners to visualise mathematical ideas and concepts (concrete and abstract).

1.2 RESEARCH GOALS AND QUESTIONS

The aim of this case study was to

(a) Analyse the types of gestures that three selected teachers at the junior primary phase (Grades 0-3) used in their teaching of mathematics

(b) Understand their views and perceptions of the roles and functions these gestures play as visualisation tools. The research questions that the study sought to answer were:

1. What are the types of gestures that selected junior primary teachers use in the teaching of mathematics?

2. What are the selected teachers' views and perceptions of the roles and functions these gestures play as visualisation tools in the teaching of mathematics?

1.3 THEORETICAL FRAMEWORK

This study was informed by an enactivist perspective. Begg (2013) defined enactivism as "a way of understanding how all organisms including human beings, organise themselves, and interact with their environments" (p.81). According to the enactivist perspective, in a teaching setting, a teacher is an integral part of any of the learner's environments (Khan, Francis and Davis, 2015). What the teacher does is thus also an integral element of the co-evolving of the individual (in this case the learner) and the environment (in this case the teacher). Proulx (2009) articulated that learning takes place from the learners' own structure

as it interacts with its environment. Thus, learning is dependent on, but not determined by, the environment. Proulx (2009) states that the environment in which learners are placed is of fundamental importance to trigger learning. The teacher acts as a trigger for learners and has to be active in the teaching and learning process, where his or her actions are seen as triggers for the students' learning (*ibid.*). This resonates well with my study as the gestures that I am focusing on are the actions that Proulx is referring to.

In this study, the learners observed the teachers' gestures and made meaning with and of them. The co-evolvement of the learners with their environment (and vice versa) happened through the medium of gestures. It is my assertion that this co-evolvement is an important element in the learning process.

1.4 RESEARCH METHODOLGY

This study was situated in an interpretive paradigm. According to Maree (2007, p.60), an interpretive paradigm researcher aims to "offer a perspective of a situation and to analyse the situation under study to provide insight into the way in which a particular group of people make sense of their situation or the phenomena they encounter", in this case a group of junior primary school teachers. In addition, Cohen, Manion and Morrison (2013) highlight that interpretive research is characterised by individuals, to understand their interpretations of the world around them. In order to maintain the phenomenon under investigation, one has to make an effort to get inside the person and to understand him/her from within (*ibid.*). Moreover, Bertram and Christiansen (2014) state that interpretive researchers do not predict what people will do, but rather describe and understand how people make meaning of their particular actions.

In this study, as I intended to understand the selected teachers' views and perceptions of the roles and functions their gestures play as visualisation tools in the teaching of mathematics, I did not set out to predict what they did, but I observed them in action and in the moment. I then interviewed them and interpreted the gestures they used and utterances they made about using these gestures. Together with them, I attempted to understand the types of their gestures and how they made meaning of their own use of their gestures in their classrooms.

This research took the form of a case study. Bertram and Christiansen (2014) defined a case study as a "systematic and in-depth study of one particular case in its context, where the case may be a person (such as a teacher, a learner, a principal or a parent), a group of people (such as a family or a class of learners), a school, a community, or an organisation" (p.42).

For my study, the case was three selected junior primary phase (Grades 0 –3) mathematics teachers. The unit of analysis of my case study was firstly the types of the observed teachers' **gestures** and secondly their views and perceptions of the **roles and functions** these gestures play as visualisation tools in the teaching of mathematics. A case study methodology aligns very well with my study because it involves observing and interviewing a particular case (a group of three teachers) in a particular context.

This study used a mixed methods approach. According to Ivankova, Creswell and Stick (2006), a mixed methods approach is a procedure for collecting, analysing, and 'mixing' or integrating both quantitative and qualitative data within a single study for the purpose of gaining a better understanding of the research problem (p.3).

In the context of this study, I analysed all the recorded lessons quantitatively on my own, using my analytical tool illustrated in Chapter three (Table 3.1). I used descriptive statistics such as a bar graph and a pie chart to analyse the occurrences of the five categories of gestures that the participating teachers used in the thirty lessons that I video-recorded. Maree (2007) describes a quantitative research approach as a process of collecting and analysing numerical data in a systematic and objective way.

A qualitative research approach on the other hand, attempts to collect rich descriptive data of a particular phenomenon with the intention of developing an understanding of what is being observed or studied (Maree, 2007). The choice of this approach is well aligned with the purpose of this study, which is to analyse both the types of gestures that selected mathematics teachers used and their views and perceptions of their gestures as visualisation tools in the teaching of mathematics. Through observations and interactions (stimulus-recall interviews) with them, I understood their use of gestures better.

1.5 SIGNIFICANCE OF THE STUDY

This study is anticipated to enrich the participants' understanding and knowledge on the roles and functions of their gestures in the teaching of mathematics. This would not only benefit the Namibian children of the participating teachers but would also assist in spreading the results of this research a little wider. The study is anticipated to contribute towards understanding the links between visualisation and gestures. It is further hoped that the findings of this study will create critical awareness in mathematics teachers, senior education officers, directors of education, policy makers, curriculum designers and researchers that teaching involves not only the spoken words and sentences and the writings on a chalkboard, but also includes body movements and gestures.

1.6 STRUCTURE OF THE THESIS

This research study is structured as follows:

Chapter two (Literature review)

This chapter discusses the two main concepts of this study which are gestures and visualisation. Under gestures, various definitions are provided; the types of gestures discussed, the roles and functions of gestures in the teaching and learning of mathematics are elaborated on, as well as some of the difficulties experienced when using gestures. On visualisation, the following aspects are discussed: the definition of visualisation, the roles of visualisation in the teaching-learning of mathematics, difficulties around visualisation as well as gestures as visualisation tools. It also looks at the literature on enactivism which forms the theoretical framework of this study.

Chapter three (Methodology)

This chapter outlines the research methodology I used to answer my two research questions. It discusses in detail the research orientation, the research methods, research design, research techniques, the data analysis process, validity and reliability and finally, the ethical considerations for this research project.

Chapter four (Data analysis and discussions)

This chapter presents and discusses the findings of the research project drawn from thirty lesson observations and stimulus-recall interviews. I firstly analysed each teacher's lesson and extracted all the gestures that the teacher used in the ten lessons. I then analysed each teacher's interview and concluded with a summary of the five types of gestures used by the three teachers. I then wrote a summary of the interviews on the teachers' views and perceptions of the roles and functions these gestures played as visualisation tools in their teaching of mathematics. The themes used to categorise and discuss data came from the analytical tool adapted from McNeill's (1992) and some emerged from the interviews.

Chapter five (Conclusion and recommendations)

This chapter concludes the study by presenting the summary of findings, significance of the study and limitations of the study. It also makes some recommendations for further research. Finally, it ends with my personal reflections on my research journey.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discusses literature relating to gestures, visualisation and enactivist theory.

It examines aspects of gestures under the following discussion points:

- Definitions of gestures
- Types of gestures
- The roles and functions of gestures
- Difficulties with gestures

It further examines features of visualisation under the following discussion points:

- Definitions of visualisation
- The roles of visualisation in the teaching and learning of mathematics
- Difficulties with visualisation
- Gestures as visualisation tools

Lastly, it provides an overview of the theoretical framework (enactivism) underpinning this study under the following discussion points:

- Definitions of enactivism
- Embodied cognition
- Gestures as embodied action
- Co-emergence
- Gestures as co-emergent process

2.2 GESTURES

2.2.1 Definitions of gestures

People often move their hands and body when engaged in active cognitive activities, such as speaking or solving problems. These movements are commonly called gestures (Alibali, 2005). Mustafa, Nusantara, Subanji and Irawati (2016) state that gesturing can be delivered

in the form of hand gestures, bodily movements, face expressions, eye gaze, touch or artefacts. Goldin-Meadow (2004) defined gestures as "hand movements that accompany and are directly tied to speech" (p.314). She further stated that gestures can point out referents of speech or exploit imagery to elaborate the content of speech. Kendon (1996) on the other hand, defined gestures as any variety of movements including those of the hands and arms, adjustment of posture, the touching of oneself (e.g. stroking one's hair), various (nervous) tics, and other fiddling movements that people use when talking. Gestures can also be defined as spontaneous movements, usually of the hands and arms that people use when they speak (Mc Neill, 1992).

2.2.2 Types of gestures

A number of authors (Efron, 1972; Kendon, 1997; & McNeill, 1992) outline different types of gestures that are used in various everyday conversational situations. However, this study is not dealing with typical everyday communication gestures, but focuses in particular on the teaching gestures that selected teachers use in their teaching and learning processes. So, this study is classroom bounded. Since the teaching gestures that are observed are directed at learners, they should be clear and unambiguous for the learners to understand and interpret. Gestures are different in nature and have diverse characteristics. The following gestures are discussed below: pointing (deictic) gestures, iconic (illustrators) gestures, metaphoric gestures, beat (motor) gestures, and symbolic (emblems) gestures (Efron, 1972; Kendon, 1997; McNeill, 1992).

1. Pointing (deictic) gestures

These are pointing movements, typically formed with an extended index finger but sometimes also with other fingers or the entire hand (McNeill, 1992). They function in a way that is similar to demonstrative pronouns like this and that (Krauss, Robert, Chen & Gotfexnum, 2000). They are often used along with speech to indicate persons, objects, directions, inscriptions or locations in the physical environment via pointing (Alibali & Nathan, 2012; Alibali, Nathan, Wolfgram, Church, Jacobs, Martinez & Knuth, 2014).

Speakers often use pointing gestures to index existing objects or inscriptions that are present in the socially shared environment (Alibali et al. 2014), (e.g. Pointing to a physical cuboid

in the classroom when referring to that cuboid). However, speakers sometimes use pointing gestures to index non-present objects, locations or inscriptions (*ibid.*), (e.g. pointing to an equation on the board to refer to a similar equation that was discussed earlier in the lesson). Alibali and Nathan (2012) affirmed that pointing gestures physically link speech and associate mental processes to the physical environment. Without the environment that gives it meaning, pointing would often be meaningless and un-interpretable.

Goodwin (1986) states that pointing gestures can serve at least two other functions: The first function is determining the significance of a gesture that accompanies the talk. The speaker uses gesture as the main target of the talk (e.g. "What is this?") or secondary to the talk. The second function makes gesture salient. In other words, the speaker could show the gesture before verbalizing or referencing an object. The gesture becomes a preview to the talk (e.g. pointing while saying, "I left it on the table."). He further indicates that regardless of how a speaker uses a deictic gesture, it serves three main purposes. Firstly, this gesture enables the speaker to transition from a verbal to a visual mode. Secondly, this gesture is not only restricted to specific events but also develops, changes, and disappears as talk changes. Thirdly, the listener is attuned to the gesture so that the talk is understandable. In my own teaching, this type of gesture is indispensable for me, as I rely on pointing to strengthen or support what I am referring to.

2. Iconic (illustrators) gestures

These are gestures that imagistically represent object attributes, actions and spatial relationships (McNeill, 1992). They are used to show semantic content directly via the shape or motion trajectory of the hand(s) (e.g. tracing a rectangle in the air to mean a rectangle). They bear a close formal relationship to the semantic content of speech, illustrating what is being said. McNeill (1992) observes that iconic gestures are closely related to speech, describing what is spoken, through hand gesture. A teacher can describe a physical object using a hand to show how big or small the object is. Iconic gestures are useful because they add details to the mental image that the speaker is trying to convey and they imagistically represent object attributes, actions and spatial relationships.

3. Metaphoric gestures

These are gestures that are used to shape, reinforce, affirm and explain ideas or actions, either with specific shapes such as finger pinches and physical shaping, or more general waving of hands that symbolise the complexity of what is explained (McNeill, 1992). Metaphoric gestures present images of abstract concepts in a concrete form via metaphors (*ibid.*). A teacher may produce a sequence of cutting motions when talking about fractions as parts of a pie. This is metaphoric because it is impossible to physically remove an idea from one's head and literally present it to others, but the gesture in this case conveys that meaning nonetheless.

4. Beat (motor) gestures

These are simple, repetitive hand movements that keep the rhythm of speech (Kendon, 1997). These gestures are not thought to convey any semantic content, but they do connect portions of discourse over large spans (*ibid.*). They are typically small, low energy, rapid flicks of the fingers or hand; they lack a special gesture space and are performed wherever the hands happen to find themselves, including rest positions (the neck to the cheek, lap, etc.) (McNeill, 1992). They can be as short as a beat or as long as needed to make a particular point. A teacher can use beat gestures to make emphasis on certain points or grab learners' attention.

Beat gestures are often produced when speakers are searching for words and they need to buy time to find these words. They have been found to occur often as iconic gestures during successful resolution of a tip-of-the-tongue situation (Beattie & Coughlan, 1999). Beat gestures might enable speakers to find words more quickly simply because they are motor actions, not because they are gestures, per se (*ibid*.).

5. Symbolic (emblems) gestures

These are gestures that are used to substitute or support speech. They have meaning independent from speech and can occur on their own without speech. For some people, verbally communicating thoughts or ideas using speech only can be difficult and as a result, they use emblems to support or substitute talk (Castellon & Enyedy, 2006). At times,

gestures could also simply be a visual substitute for speech. Thus, gestures can enable the listener to understand the speakers when talk is absent or limited. According to McNeill (1992), emblems, such as the 'thumbs up' or 'peace sign', are hand configurations that have a culturally specific meaning, and unlike co-speech gestures, they convey information independently of speech. In fact, emblems often stand alone from speech. For example, most learners know that if a teacher holds a finger tightly to his/her lips that means 'be quiet' and the thumbs-up sign means 'okay'.

Alibali and Nathan (2012) stated that "(a) **pointing gestures** manifest grounding in the physical or imagined environment, (b) **iconic gestures** (representational) manifest mental simulations of action and perception, and (c) **metaphoric** gestures reveal conceptual metaphors that are grounded in the body and human experience. In my observation all of these types of gestures routinely occur in communicating about mathematical ideas, for example in instruction and explanation. Gestures thus provide a unique and informative source of evidence regarding the nature of mathematical teaching.

The above types of gestures form the basis of my analytical framework discussed in the methodology chapter.

2.3 ROLES AND FUNCTIONS OF GESTURES

Gestures have different roles depending on the context, the listener(s) and the communicator(s) who use them (Castellon & Enyedy, 2006).

2.3.1 Gestures as communicative tools

Gesturing occurs across all cultures, ages, backgrounds and tasks (Goldin-Meadow, 1999; Kelly, Manning & Rodak, 2008). Iverson & Goldin-Meadow (1998) made an interesting observation that even congenitally blind individuals who have never seen anyone gesturing, move their hands when they speak even if they know that they are speaking to another blind person. It is almost impossible for people to talk naturally without gesturing (Goldin-Meadow, 2005). In fact, the gestures we produce as we talk (communicate) are firmly tangled with our speech in timing, meaning and function, and to ignore gestures is to ignore

part of the conversation (Kendon, 1994). Gestures can restate information expressed in speech, clarify doubts, and even add information not found anywhere in the words they accompany (Goldin-Meadow, 2003). This suggests that gestures are an important part of the whole speaking and talking process. Alibali (2005) affirmed that people often gesture when they describe their mental images and they tend to gesture more when talking about spatial topics than when talking about abstract or verbal ones (*ibid.*). Thus, gestures are commonly used to express spatial information, and using gestures to communicate an idea can at times be closely connected to visualising this idea.

Tellier (2005) articulated that gestures and speech often work together, and one relies on the other to have and create meaning; in short, they are complementary. Since gesturing occurs most often in communicative contexts, we might guess that gesture's main purpose is to aid communication (Novack & Goldin-Meadow, 2015). De Ruiter (2007) stated that gestures are not direct representations of unformulated thought, but they are carefully planned visual messages designed to be understood in combination with the accompanying speech. He further stressed that for gestures to be recognizable as gestures, and to be understandable by the recipient(s), they have to be designed to accomplish that.

Listeners can use gestures to indicate their assessment or comprehension of a speaker's talk by making inferences about an activity (Castellon & Enyedy, 2006). A body movement gesture such as nodding the head, a facial expression of approval, acceptance, understanding or negation is an indication of assessing the talk in progress (*ibid.*). During a conversation, when a listener frowns, nods, or holds up a hand, the speaker will interpret the gesture and possibly adjust how he/she communicates to the listener (DeFornel, 1992; Goodwin & Goodwin, 1992). DeFornel (1992) articulates that a listener may also elicit talk and gesture simultaneously or after a speaker has produced a gesture; this is referred to as a return gesture. He defines a return gesture as a visible and reflexive movement that replies to the speaker's ongoing talk. It is produced with talk and with an action performed in a sequential context. A return gesture acknowledges the verbal expression, interprets the iconic contribution and displays the listener as an active participant who analyses and participates in the talk (*ibid.*).

Even though McNeill (1992) indicated that gestures and speech form an integrated system, there are rare circumstances when gestures can be produced completely on their own (without speech) and as a result they look quite different when they share the burden of communication with speech, compared to when they assume the full burden of

communication on their own (Goldin-Meadow, 2005). Goldin-Meadow (2005) further indicated that when gestures are produced on their own, they undertake the full burden of communication and take on a language-like form. In contrast, when gestures are produced along with speech, they share the burden of communication with speech and take on a comprehensive imagistic form, often conveying information not found anywhere in speech. Thus, gestures change form as they change both their context and functions. Gestures therefore, permit speakers to deliver their thoughts that may not easily fit into the categorical system that their conventional language offers (McNeill, 1992; Goldin-Meadow, 1999). Gestures therefore offer us a window into the mind that is distinct from the window that speech offers; and as a result, it is only by looking at both gestures and speech that we can understand how people learn, remember, and solve problems (Goldin-Meadow, 2005).

Research from linguistics, psychology to neuroscience, supports the theoretical claim that gestures have a special connection to the words they accompany (Kelly, Manning & Rodak, 2008). "Gestures can be seen as an important bridge between imagery and speech; and a link bringing together action, imagery, memory, speech and mathematical problem solving" (Edwards 2005, p.135). Understanding this integrated relationship provides useful insights into how children and adults comprehend language, how they allocate resources while speaking, and how they think during problem solving (*ibid.*). This knowledge may help both the teachers and clinicians to better identify and treat children with developmental disorders and to successfully communicate with struggling learners (Kelly, Manning & Rodak, 2008).

Gestures and speech are not only resourceful tools to communicate with the listener(s) but are also purposeful methods that facilitate learning in educational settings (Castellon & Enyedy, 2006). Hence my special interest in looking at the use of gestures in a teaching context. Gestures combined with speech and graphical resources are communicative tools that are readily available to all teachers and learners and can be used to support meaningful conversations (Castellon & Enyedy, 2006).

For the scope of my study, I only focused on the **teachers'** gestures and how they specifically communicate mathematical ideas.

2.3.2 Gestures as mathematical tools

According Arzarello, Paola, Robutti and Sabena (2009), the teaching-learning process of mathematics can be seen to consist of a variety of actions and productions activated by both the teacher and learners using different resources such as words (orally or in written form); extra-linguistic modes of expression (**gestures** or glances); different types of inscriptions (drawings, sketches, graphs etc.) and various instruments (from the pencil to the most sophisticated information and communication technology devices). They further suggested that these resources may serve as communicating or thinking tools and the actions and productions they support are important for grasping mathematical ideas. Thus, they help to bridge the gap between the worldly experience and more formal mathematics (Arzarello, Paola, Robutti, & Sabena, 2009). Doherty-Sneddon, Bruce, Bonner, Longbotham and Doyle (2002) also suggest that visual communication signals (such as eye gaze, gesture and facial expression) are important sources of information that play facilitatory roles in human communication such as teaching.

Flevares and Perry (2001) remind us that all scholars of mathematics from learners to professors of mathematics depend to a smaller or larger extent on symbols to represent abstract quantities and operations when communicating about mathematical ideas. They further added that non-spoken media, such fingers (gestures), graphs, written symbols, and counting blocks can be essential to give mathematical concepts visible embodiments.

However, the focus of this study is specifically limited to gestures.

According to the Namibian Ministry of Education Junior Primary phase English second language and mathematics syllabus (MoE, 2015); mathematics is particularly relevant and meaningful for the learners if it is related to their lives. For example, learners need to appreciate that two and three-dimensional shapes or figures can be found in the immediate environment. Although mathematics is a universal language, it is only by local contextualisation and application that younger learners will understand and appreciate different uses of mathematics. Where textbooks can only generalise, or provide a micro-example, it is the teachers' responsibility to use and bring along local examples such as concrete materials found in the environment e.g. stones, sticks, bottle tops, etc. to the classroom. Flevares and Perry (2001) state that learners must attend to the visual as well as vocal means of expressing information to gain access to all of the information presented in

mathematics lessons. In the context of this study, I believe that concrete objects (visual aids) link mathematics content to local concrete materials in the learners' environments, allowing mathematics to be displayed in interesting and understandable ways and thus hopefully ensuring a smooth transition from the concrete to the abstract way of thinking. Thus, they play a central role in understanding and reasoning. Alibali et al. (2013) assert that "by presenting an abstract action via a familiar action, the teacher's gesture might help the learner grasps the instructional material, thereby promoting common ground" (p.438).

I believe that gestures and visualisation work hand in hand because when the communicator **gesture**s, the recipient **visualises**. In the context of this study, when a teacher gestures, the learner produces (visualises) an image in his/her mind and uses that image to interrogate and solve the problem at hand.

2.3.3 Gestures as teaching tools

One communicative situation, in which gestures play a major role, is the interaction between learners and teachers (Ping & Goldin-Meadow, 2008). Learners' gestures can communicate to the teacher about what they know and how they view problems, and in turn, teachers use gesture when providing instructions to the learners of all ages and grades (Church & Goldin-Meadow, 1986; Perry, Church & Goldin-Meadow, 1988; Goldin-Meadow, Alibali & Church, 1993; Alibali & Goldin-Meadow, 1993). Gestures serve to be important components of a semiotic means of objectification, used to communicate directly with others, or to highlight aspects of certain artefacts and symbolic representations of mathematical concepts (Arzarello & Edwards, 2005). In the context of this study, the communication that is being referred to is between a teacher and a learner.

Hostetter, Bieda, Alibali, Nathan and Knuth (2006) articulate that in a mathematics classroom, gestures are regarded as one of the important tools that teachers often use to help their learners see connections between ideas and events in the lessons, and ground their understanding of abstract ideas in the physical world. Alibali, Nathan, Wolfgram, Church, Jacobs, Martinez and Knuth (2014) observe that teachers gesture at a higher rate when communicating new links to the learners than when communicating links that are revised. They further state that teachers often make use of depictive and pointing gestures along with other visual and verbal representations as an integral part of their efforts to communicate during mathematics instruction.

Goldin-Meadow (2004) observes that when learners explain their answers to a problem, they convey their thoughts in both speech and gestures. She further observes that when teachers teach, they gesture, and those gestures often reveal information that cannot be found in their speech. Thus, teachers' gestures are what the learners rely on to understand what they say (Tellier, 2005). This indicates that the teachers' gestures need to convey enough clear meaning to be understood alone (without verbal language), and should assist the learner to infer the meaning of the words that they are associated with (*ibid.).*

Corts and Pollio (1999) assert that the use of gestures not only assists learners, but also teachers to express themselves better without having to rely on speech alone. Some teachers use gestures to support their talk in conveying information of a specific academic discipline, especially when referring to difficult, general, or abstract academic topics (*ibid.*).

In their study that looked at how teachers use gestures and other forms of non-verbal representations such as manipulative, pictures, or writing in mathematics instruction, Perry, Church and Goldin-Meadow (1988) observed that a huge amount of information is communicated in a non-spoken manner. Teachers were found to use some kind of non-spoken representations every ten to twelve seconds, and approximately fifty per cent of those are gestures that convey mathematical concepts. A very similar study on non-verbal representations was carried out by Flevares and Perry (2001). They studied first-grade mathematics teachers' classroom instruction on place value and found that the participating teachers used approximately five to seven non-verbal representations; i.e. pictures, symbols, concrete objects, and gestures per minute of instruction. In agreement, Tellier (2005) affirmed that teaching gestures are in fact produced more consciously than usual communicative gestures and they are specifically addressed to the learners.

Hostetter, Bieda, Alibali, Nathan and Knut (2006) and Alibali and Nathan (2012) indicate that teachers can alter their gestures if they receive specific instructions about the importance of gesture in their instruction. In their study, they asked teachers to give a mathematics lesson twice. After the first lesson, teachers were given a brief tutorial about how to link ideas using gestures. They were then asked to give the lesson a second time, incorporating as many gestures as possible into their lessons. They noted that teachers produced more gestures in the second lesson (after the brief instruction about gestures) than in the first lesson (without any specific instructions about gestures).

Ping and Goldin-Meadow (2008) argue that a gesture is usually 'in the air', creating its own space and not necessarily tied to the immediate real-world space. These gestures can be just as effective as teaching tools, as those that are tied or associated with concrete objects. Ping and Goldin-Meadow (2008) note that many learners pay attention to the information conveyed in gestures and learn from them. I therefore argue that it is very important for teachers to incorporate as many gestures as they can into their lessons provided that they are meaningful and augment the teaching process.

Cook, Duffy and Fenn (2013) observe that teachers' gestures may engage learners' attention in a distracting environment. Personally, I make use of extensive gesturing when I teach and find gestures very much part of my communication repertoire with my learners. I find that the use of speech together with gestures does not only facilitate communication, but also assists in clarifying, explaining, highlighting and emphasising mathematical concepts to my learners. Gestures also help me to get the attention of my learners and enable me to supplement my personal communication by gesturing that I am pleased with their work or disapprove of their behaviour.

I argue in this research study that as gesturing is an integral component to communication, it is also integral to the teaching learning process. I further argue that it is very important for all teachers to understand that gestures can be used as resourceful tools to convey their thought sand reasoning of a concept, and foster the learners' comprehension and learning.

2.3.4 Gestures as learning tools

Goldin-Meadow and Wagner (2005) indicate that adults often mimic non-verbal behaviours that their conversational partners produce and even infants imitate non-verbal behaviours demonstrated by speakers. It would therefore not be surprising if school-aged children were to imitate the gestures that their teachers produce (Goldin-Meadow & Wagner, 2005). They further state that gesture could play a role in learning too, not indirectly through others, but directly, by affecting learners themselves.

Kelly, Mann and Rodak (2008) affirm that gestures can also influence how information is exchanged between teachers and learners during the teaching-learning process. Goldin-

Meadow and Sandhofer (1999) observe that in a normal adult–child interaction, adults often incorporate children's deictic and iconic gestures into what they think children have verbally explained in their speech. They relate this to the teaching-learning process and find it to have obvious educational implications. They further give an example of a mathematics classroom where a learner verbally described the different heights of two objects but gesturally represented the different widths. A teacher may therefore make an assessment of that learner's knowledge that incorporates height and width.

Novack and Goldin-Meadow (2015) indicate that including gestures in instruction supports learning, not only by focusing learners' attention on objects, but also by conveying ideas through their representational form. Furthermore, they reveal that children learn more from a mathematics lesson in which a teacher simultaneously presents two correct strategies, one in speech and the other one in gestures (speech+gesture), compared to a lesson in which the teacher presents the same two strategies entirely in speech and which has to be presented sequentially (speech+ speech).

The research of Alibali and Nathan (2007) reveals that iconic and metaphoric gestures help learners to learn, especially when teachers teach new materials introducing ideas, or respond to learners' questions. In agreement, Alibali, Nathan, Wolfgram, Church, Jacobs, Martinez and Knuth (2014) put forth that lessons with gestures can be more beneficial for learners' learning than matched lessons without gestures. In most cases, learners show deeper learning (i.e. better uptake of instructional information, new forms of reasoning, generalization to new problem types, and retention of knowledge) from lessons with gestures (*ibid.*). Some learners use gestures and speech to express themselves in articulating their understandings of a concept (Church & Goldin-Meadow, 1986); while for some learners, gestures are indications of "readiness to learn" (Church & Goldin-Meadow, 1986; Goldin Meadow, 1999; McNeill, 2000).

Research finds that when teachers gesture during a lesson, children are more likely to gesture as well, which in turn can lead them to profit more from the lesson (Goldin-Meadow 2006). By gesturing themselves, not only do teachers improve the quality of a lesson, but they also create a classroom culture that includes gesturing *(ibid.*). Goldin-Meadow (2004) states that, learners who imitate teachers' gestures during the learning process, tend to understand the lesson more, than learners who do not perform gestures.

In one of their studies, Broaders, Cook, Mitchell and Goldin-Meadow (2007) asked learners to explain their solutions to incorrectly solved mathematical problems. They then asked them to solve a new set of comparable problems and encouraged half of the learners to gesture as they explained their solutions. They found that when told to gesture, learners added new yet correct problem-solving strategies expressed only in gestures to their repertoires, while learners who were not encouraged to gesture did not add strategies to their repertoires in either gesture or speech. Telling learners to gesture thus encourages them to convey previously unexpressed, implicit ideas, which in turn, makes them receptive to instruction that leads to learning (Broaders, Cook, Mitchell & Goldin-Meadow, 2007)

In another study, Ping and Goldin-Meadow (2008) gave learners instructions with or without gestures and with or without concrete objects. They found that learners who were given instructions with speech and gestures learnt more than learners who were given instructions with speech alone, whether with or without objects present during instructions. Gestures in instructions can thus help learners to learn even when those gestures do not direct attention to visible objects, suggesting that gesture can do more for learners than simply ground arbitrary, symbolic language in the physical, observable world.

In their study, Castellon and Enyedy (2006) observed that teachers' gestures in conjunction with speech and graphic resources, helped learners grasp and discuss mathematical concepts, elicit the justification of their thinking, and advanced the mathematical lessons. They further indicate that teacher's gestures and talk assist in clarifying, explaining, highlighting and emphasising mathematical concepts to their learners, and resolve multiple meanings.

Pozzer-Ardenghi and Roth (2007) studied teacher–learner interactions during high school biology lessons and found that for many concepts, hand gestures provided additional clarifying input for learners. They further indicate that hand gestures and other visual aids might help learners who are struggling with advanced concepts that are not easily represented and taught through speech alone. Flevares and Perry (2001) observe that when teaching first-grade children about basic mathematical concepts (i.e. counting numbers of objects), teachers frequently use non-verbal behaviours such as pointing, counting on fingers or circling objects with fingers. In most cases, teachers use visual aids and gestures more frequently when learners appear confused or struggle with mathematical concepts

(Flevares & Perry, 2001). Ping and Goldin-Meadow (2008) indicate that gestures point out objects in the immediate context and thus help ground the words learners hear in the world they see. Alibali, Nathan, Fujimori, Stein, and Raudenbush (2011) observe that teachers use gestures to guide learners' attention to relevant aspects of the mathematical task at hand.

2.3.5 Gestures lighten cognitive load

In their study to determine the impact of gesturing on children's and adults' cognitive load, Goldin-Meadow et al. (2001) and Goldin-Meadow and Wagner (2005) asked children and adults to explain how they solved a given mathematics problem. Both the children and adults did their explaining under two conditions. For half of the problems, they were allowed to move their hands freely, while for the other half, they were asked to keep their hands static on the table. They found that both children and adults remembered more words when they gestured than when they did not gesture. Goldin-Meadow and Wagner (2005) observe that gesturing can actually lighten people's cognitive load, and thus telling them not to gesture was in fact asking them to do another task, which could add to the cognitive load and might affect the memory.

The use of speech and gestures not only facilitates communication but also helps some people cognitively. Castellon and Enyedy (2006) indicate that when a person is searching for a word or communicating in a different language, gestural movements and utterances provide a useful and often convenient avenue to articulate thoughts, hunches and hypotheses without relying on speech to explore an idea. Goldin-Meadow, Nusbaum, Kelly and Wagner (2001) and Cook and Goldin-Meadow (2006) also suggest that gesture production may help children and adults free up cognitive capacity when communicating about conceptual problems.

2.3.6 Gestures pave the way for language development

Gesture is not only a useful tool for school-aged learners learning about mathematics, but can also support learning in infancy (Novack & Goldin-Meadow, 2015). With regard to language production, one interesting finding is that even congenitally blind children gesture when they speak (Iverson & Goldin-Meadow, 1998). These children gesture even when speaking to other blind children (Kelly, Manning & Rodak, 2008). The fact that language

learners produce gestures without ever having seen them is one of the best evidence that speech and gestures form a tightly integrated system indeed (*ibid.*).

Goldin -Meadow (2003) articulates that language-learning children often reveal what is on their minds through gestures and not in speech. Children produce their first gestures before their first words, and their first gesture + word sentences before their first word + word sentences (Goldin- Meadow, Goodrich, Sauer & Iverson, 2007). They further observe that gestures often offer a mechanism by which children can point out their thoughts to mothers, who then attune their speech to those thoughts, and potentially facilitate language learning. Mothers instinctively translate their children's gestures into words, thus providing them with a well-timed model for the words they need to hear (*ibid.*). Gestures that a language learning child produces can reflect the child's readiness to learn new words and sentences, and may play a fundamental role in bringing about the acquisition of new words and sentences (Goldin-Meadow at el., 2007). So, children use their hands to tell their mothers what they want to say next (*ibid.*).

In their study with young children, Iverson and Goldin-Meadow (2005) observe that they often communicate using gestures before they are able to speak. They examined ten children making the transition from single words to two-word combinations, and what they found is rather interesting. They found that the gestures that children produce early in language development provide a way for them to communicate information that they cannot yet express verbally. For example, pointing gestures (e.g. pointing at cup) offers children a technique for referring to objects before they have words for those objects. Moreover, gesture-plus-word combinations offer children a technique for communicating two pieces of information within a single utterance before they can produce two-word utterances (e.g. pointing at a cup while saying mine). Thus, changes in gesture not only antedates, but also predicts changes in language, suggesting that early gesture may be paving the way for future development in language (Iverson & Goldin-Meadow, 2005).

Novack and Goldin-Meadow (2015) affirm that gestures add a spatial or imagistic component to spoken language, and since they are not restricted to the linear, ruled-based system of spoken language, they have the potential to express ideas that may be difficult to convey in words.

2.4 DIFFICULTIES AROUND GESTURES

When people talk they gesture, and those gestures often reflect thoughts not expressed in their words (Goldin-Meadow, 1999). However, at times people produce gestures that convey different information from the message they convey in speech. This happens when their words say one thing, while their hands tell a different story. These responses have been labelled as "mismatches" (Goldin-Meadow, 2000).

In her study, Goldin-Meadow (2000) observed a learner learning the concept of mathematical equivalence, explaining how she solved the problem 4 + 3 + 5 = __ + 5, by adding together all the numbers on both sides of the equation to get her (incorrect) answer of seventeen. Her gestures told quite a different story as she explained her problem-solving strategy, by producing one sweeping motion on the left side of the equation, and a separate sweeping motion on the right side of the equation, indicating that she recognized that there were two sides to the problem. This happens when a word and a gesture combination conveys information that does not necessarily work hand in hand (Goldin-Meadow, 2004). Goldin-Meadow and Singer (2003) observe that learners who produce gesture–speech mismatches are readier to learn than learners who do not produce mismatches. In confirmation, Goldin-Meadow (2004) states that learners who are developmentally ready to learn a new concept may well produce a lot of speech-gesture mismatches when explaining their reasoning.

Church and Goldin-Meadow (1986) observe that learners whose gestures convey different ideas from their speech when they explain a task are more likely to profit from instruction in that task than children whose gestures are unnecessary with their speech and they are revealing for all to see that they know more than they say. When it comes to teachers, Goldin-Meadow (2000) states that teachers produce speech-gesture mismatches when they are indicating an uncertainty about how best to teach a certain concept. Goldin-Meadow (2000) further adds that learners are less likely to learn if teachers use gestures that do not correspond with their verbal instructions.

In a teaching-learning context, it is thus important for both teachers and learners to be aware that the gestures they use indeed enhance learning and do not give mixed messages.

2.5 VISUALISATION

2.5.1 Definitions of visualisation

The term visualisation is defined in different ways by various researchers. Whilst most definitions embrace the notions of imagery (external or internal) in some form or other, some mainly focus on visualisation from a product perspective whilst others emphasise the process dimension of visualisation. There are also those who see visualisation as a complex interaction between process and product.

Arcavi (2003) for example, defined visualization as "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" (p. 217). Nemirovsky and Noble (1997) described visualisation as a tool that penetrates or travels back and forth between external representations and learners' mental perception.

Chiappini and Bottino (1999) view visualisation as visual imagery that plays a central role in all meaning, understanding and reasoning. According to Zimmermann and Cunningham (1991), "mathematical visualisation is the process of forming mental images mentally and using such images effectively for mathematical discovery and understanding" (p.3). Hitt Espinosa (1997) indicates that to visualise is the ability to create rich, mental images which the individual can manipulate in his mind and rehearse different representations of the concept; while Presmeg (2006) views visualization as the process of constructing and transforming both visual mental imagery and all of the inscriptions of a spatial nature that may be implicated in doing mathematics. Furthermore, Ho (2010) viewed visualization as the ability to see and understand a problem situation.

For the purpose of this study, visualisation is seen as having both a product and process dimension—the product being the gestures used, and the process relating to how these gestures are used.

2.5.2 The roles of visualisation in the teaching-learning of mathematics

> Seeing is believing, or so the saying goes. We depend on our sight for many things in life —using a map to find our way, using a picture to aid recognition, or using diagrams to better describe what our words fail to communicate. In the math classroom, sometimes the solution to a problem is right before our eyes (Ho, 2010, p.2).

In the context of this study, teachers' gestures can be used as visual tools in the mathematics classroom. When a teacher gestures, the learners use their sight to observe the teacher's gestures. They then begin a visualisation process of what was gestured to solve the problem/s at hand.

Jasute (2013) asserts that mathematics is one of the subjects which relies on visualisation for the explanation of theories, methods and problems. Therefore, the notion of visualisation representation should be emphasised in all aspects of the mathematics classrooms (Bishop, 1989). Dreyfus (2002) assert that what learners 'see' in a representation can be linked to their conceptual structures, and further proposed that visualisation should be regarded as a powerful and effective learning tool.

Jencks and Peck (1972) report that using visual models in problem solving facilitates learners' comprehension and create a solution-finding opportunities. Zimmerman and Cunningham (1991) maintain that visualisation supplies depth and meaning to understanding, serves as a reliable guide to problem solving and inspires creative discoveries. They further propose that in order to achieve this understanding, visualisation should not be isolated from the rest of mathematics, implying that symbolical, numerical and visual representations of ideas must be formulated and connected. Jencks and Peck (1972) further argue that when working with concrete models, learners establish links within the logic of problem solving and develop distinctive formal rules — a process in which the teacher's function is simply to find a good model for the problem. They also maintain that visualisation also has a crucial function in enhancing problem-solving skills by playing an active role in ensuring long-term recall. Arcavi (2003) emphasises that visualisation is an operational mode and the process of solving a problem is carried out through visualisation. In agreement, Ho (2010) maintains that in as much as the ability to solve problems is at the heart of mathematics, visualisation is at the heart of mathematical problem solving.

Rosken and Rolka (2006) state that in mathematics learning, visualisation can be a powerful tool to explore mathematical problems and to give meaning to mathematical concepts and the relationship between them. In his study, Ho (2010, p.3) noted the following five processes that learners went through when they solved a given mathematics problem.

1. **Understanding** the spatial relations of the elements in the problem.
2. **Connecting** to a previously solved problem.
3. **Constructing** a visual representation (in the mind, on paper, or through the use of technological tools).
4. **Using** the visual representation to solve the problem.
5. **Encoding** the answer to the problem.

Fischbein (1987) claims that visualisation organises data in meaningful structures and guides the analytical development of a solution. He further claims that visualisation can as well be an analytical process which concludes with a generic solution. According to Arcavi (2003), visualisation has a powerful role in promoting understanding — as a support and an illustration of symbolic results, and as a tool for solving conflicts between incorrect intuitions and correct solutions.

Therefore, the usefulness and necessity of using visualisation for each mathematical domain within this field should not be taken for granted (Arcavi, 2003). Yilmaz, Argun and Keskin (2009) reveal that mathematics deals with generalization related to abstract ideas, so the role that generalisation plays in the development of mathematical knowledge is very crucial in the teaching and learning of mathematics. They argue that visualisation can serve as a guiding factor in the development of generalisations, and can also organise data in meaningful structures since it involves mental images that go through different transformations.

In their study on visualisation in the teaching and learning of absolute value, Konyalioğlu, Aksu and Senel (2012) observe that the teachers' use of visualisation attracted learners' attention to the subject, relieved classroom boredom and caused learners to develop positive attitudes towards the concepts. Moreover, the teachers' use of a visualisation method turned the passive behaviours of some of the learners into more active and participative behaviours.

As this study argues that gesturing is a form of visualisation, teachers should use this form of visualisation strategically and purposefully. A more detailed discussion on visualisation and gesture follows in 2.5.5.

Visualisation improves learners' understanding of concepts; it helps in the development of visual reasoning skills and the initial engagement of learners' interest. It enhances comprehension, self-confidence and creativity and provides important training for learners to do mathematics in the classroom and beyond (Rogness, 2011 & Konyalioğlu, Aksu & Senel, 2012). Yilmaz, Argun and Keskin (2009) observe that visualisation plays an essential role when making general relations and rules, and therefore it is very important to encourage mathematics teachers at all levels to use it in their teaching practices. This can be done by the use of pictures, images, diagrams on paper or with technological tools to develop the generalisation process successfully in the learners' mathematical thinking (*ibid.*).

Arcavi (2003) acknowledges the power of visualisation '**to make the invisible visible'**, stating that since mathematical concepts are abstract, it would be useful to make concepts visible (through visualisation) for effective learning. Jencks and Peck (1972) assert that visualisation helps learners particularly in the beginning phases in which the basic concepts are taught. Konyalioğlu, Aksu and Senel (2012) state that visual thinking may be a strong alternative resource for learners, by bringing in new ways of thinking in mathematics and also underlining the importance of visualisation and visual reasoning within mathematics teaching.

In his study, Ho (2010, p.3) identified seven visualisation roles that learners used to solve problems.

1. To **understand** the problem

   By representing the problem visually, learners can understand how the elements in the problem relate to each other.

2. To **simplify** the problem

   Visualisation allows learners to identify a simpler version of the problem, solving the problem and then formalising the understanding of the given problem and identifying a method that works for all such problems.

3. To see **connections** to a related problem
   This involves relating the given problem to previous problem-solving experience.

4. To cater for individual **learning styles**.
   Each learner has his/her own preference when it comes to the use of visual representations when solving problems.

5. As a **substitute** for computation
   The answer to the problem can be obtained directly from the visual representation itself, without the need for computation.

6. As a tool to **check** the solution
   The visual representation may be used to check for the reasonableness of the answer obtained.

7. To **transform** the problem into a mathematical form
   Mathematical forms may be obtained from the visual representation to solve the problem (Ho, 2010).

2.5.3 Difficulties with visualisation

Many learners' difficulties with visualisation have been identified by different researchers. Konyalioğlu, Aksu and Senel (2012) articulate that "relying too much on visualization may prevent mathematical thinking due to the limiting effect of a single-case scenario represented by an image" (p. 615). Steenpaβ and Steinbring (2014) warn that mathematical visual images can be confusing elements that do not necessarily convey the concept effectively to learners, and can thus lead to misunderstanding. Gagatsis and Elia (2004) state that some learners do not have sufficient training associated with the use of visual representations. Guzman (2002) mentions that, visualisation can be difficult, and incorrect use of it can lead to errors in different ways. Dreyfus (1992) therefore stressed that it is important for both teachers and learners to be aware of difficulties that might arise due to improper or inappropriate use of visualisation, such as difficulties in reading graphs correctly, a lack of distinction between geometrical images and their visual presentation, and in the case of this study, misunderstanding of gestures and their meanings.

Arcavi (2003) classifies the difficulties surrounding visualisation into three main categories: **cultural, cognitive and sociological**. The **cultural** category refers to the beliefs and values regarding what doing mathematics would mean, what is acceptable and what is not. The **cognitive** difficulties refer to the discussion regarding the issue of whether visual thinking is easier or more difficult. In addition, reasoning with concepts in visual settings may imply that there are not always procedurally "safe" routines to rely on and as a consequence this mode of cognition is rejected by students. The **sociological (socio-cultural)** difficulties refer to the issue of teaching learners from various backgrounds. Some learners may come from a visually deprived culture and for them visualisation may complement possible deficits.

Goldenberg (1991) notes that some learners have difficulties in recognising transformations implied in diagrams. Yerushalmi and Chazan (1990) observe learners' inability to see a diagram in different ways. Diezmann (2000) states that diagrams are important tools when it comes to problem solving. He further maintains that for learners to interpret and use diagrams correctly they need to know the importance of diagrams in problem solving, which diagram is appropriate for a given situation, and how to use a diagram to solve a problem. However, the benefits of any tool are closely associated with the users' knowledge of the tool, their opportunities to observe master craftsmen, and the development of their skills in using the tool (Diezmann, 2000). He further stresses that advocating that learners draw a diagram without addressing their difficulties and educating them about diagrams is rather a waste of a very good tool. I therefore argue that visualisation can only work well when one is aware of its scope and is able to use it flexibly. Similarly, learners need to interpret gestures appropriately and correctly in order to make sense of the mathematics they are trying to infer.

2.5.4 Gestures as visualisation tools

Castellon and Enyedy (2006) argue that gestures are important visual resources that can play a valuable role in the teaching and learning of mathematics. They can be used as an important bridge between imagery and speech and may be seen as a nexus bringing together action, memory, speech and mathematical problem solving (Alibali & Nathan, 2012).

Castellon and Enyedy (2006) suggest that when gestures are combined with speech, they form important visual tools that are readily available to all teachers and learners and can be used to support meaningful conversations. Speakers often use hand gestures to illustrate concrete images as a well as abstract concepts (Mc Neill, 1992).

Kosslyn, Behrmann and Jeannerod (1995, p.1339-1140) propose four "cognitive steps" that one follows when one visualises:

Step one : image generation
Step two : image inspection
Step three : image transformation
Step four : image use

These four steps resonate well with my study because when a teacher gestures and the learner forms a visual image as a result of that gesture, these steps can form a logical base to begin a visualisation process of what was gestured. A hypothetical example to illustrate this is a teacher tracing the outline of a triangle (in the form of a gesture) when talking about the perimeter of a triangle. The learner would follow these steps: the learner produces an image of a triangle in his/her mind after witnessing or experiencing the particular gesture of the outline of a triangle (image generation). The learner then examines this mental image or visualisation and establishes its consequences and implications (image inspection). The learner would then operate on and change this image to suite her/his understanding. This might entail changing the shape into other related known shapes, if need be (image transformation). Finally, the learner might use that image to compare or answer the question at hand (image use).

The above example illustrates how visualisation in conjunction with gestures can play an important role in the teaching and learning of mathematics (Arcavi, 2003; Konjalioglu, Aksu & Senel, 2012). Based on this, I argue that the usefulness and necessity of using visualisation and gestures in mathematics education should not be taken for granted.

2.6 THEORETICAL PERSPECTIVE – ENACTIVISM

This study was informed by an enactivist premise. Varela et al. (1991) view enactivism as a theory that explains the co-emergence of a learner and his/her setting. Towers and Martin (2015) describe enactivism as a "theory of cognition that has its roots in biological and evolutionary understandings and views human knowledge and meaning-making as processes that are understood and theorised from a biological and evolutionary standpoint" (p. 249). Begg (2013) defines enactivism as "a way of understanding how all organisms including human beings, organise themselves, and interact with their environments" (p.81). Varela et al. (1991) argue that the individual and the environment must be considered together, that one cannot separate knowledge from doing and from the body, and that knowing is doing — which in the end is inseparable from self-identity or being. Fenwick (2000) asserts that enactivism has two major premises: the first premise is that the mind, body (gestures), and world (the learning environment) are indivisible, and the second premise is that learning occurs through feedback within the system. Enactivism believes that the personal history of the subject and the setting affect the outcomes of events (*ibid.*). The outcome of a specific learning activity is determined by the environmental considerations such as time, place, etc., as well as by the participant's gender, cultural background or action (Li, Clark & Winchester, 2010).

According to the enactivist perspective, in a teaching setting a teacher is an integral part of any of the learners' environment (Khan et al., 2015). What the teacher does is thus also an integral element of the co-evolving of the individual (in this case the learner) and the environment (in this case the teacher). Proulx (2009) articulates that learning takes place through the learners' own construction as it interacts with its environment. Thus, learning is dependent on, but not determined by the environment. Proulx (2009) further states that the environment in which learners are placed is of fundamental importance to trigger learning. The teacher acts as a trigger for learners and has to be active in the teaching and learning process, where his or her actions are seen as triggers for the learners' learning (*ibid.*). This resonates well with my study as the gestures that I am focusing on are the actions that Proulx is referring to.

In this study, the learners observe the teacher's gestures and make meaning with and of them. The co-evolvement of the learners with their environment (and vice versa) happens through the medium of gestures. It is my assertion that this co-evolvement is an important

element in the learning process. Gestures are considered in relation to speech and with the whole environment where mathematical meanings grow.

Vygotsky (1997) articulates that "gesture is specifically the initial visual sign in which the future writing of the child is contained as the future oak is contained in the seed. The gesture is writing in the air and the written sign is very frequently simply a fixed gesture" (p. 133). It requires perceivable signs and so the environment is crucial in the teaching-learning process (Arzarello, Ferrara, Robutti, Paola, & Sabena, 2005).

2.6.1 Embodied cognition

In enactivism, embodiment refers to the bringing together of the mind and body through a practice of open-ended reflection (Varela et al., 1991). According to Di Paolo, Rohde and De Jaegher (2007) and Begg (2013), cognition is an 'embodied action' and in enactivism, thinking and learning are grounded in bodily actions. Begg (2013) further states that knowledge should not be seen as an object but as an action. Li, Clark and Winchester (2010) state that, "all living systems have to be involved in cognition and cognition is active rather than passive" (p.8). Alibali and Nathan (2012) argue that mathematical cognition is embodied in two senses: it is based in perception and action, and it is grounded in the physical environment. Antle, Corness and Droumeva (2008) argue that an embodied view of cognition grants the body situatedness in the environment, a central role in shaping the mind. Antle, Corness and Droumeva (2008) further state that the "critical concept underlying embodied cognition is that humans only think the way they do because they have human bodies and live in the social, physical environment that they live in" (p.66).

2.6.1.1 Gestures as embodied actions

Pozzer-Ardenghi and Roth (2007) emphasise that teaching involves not only the words and sentences a teacher utters and writes on the board during a lesson, but also all the hand/arm gestures, body movements, and facial expressions a teacher performs in the classroom.

Learning environments that do not support learners' use of body and gestures can limit what and how they learn (Roth & Lawless, 2002), and thus gesturing is an important bodily action that is integral to the learning process. Kendon (1990) provides evidence that

listeners' body movements and gestures are coordinated with those of speakers. Alibali et al. (2014) suggest that listeners may better grasp speakers' embodied meanings when these meanings are expressed in gestures. Firstly, speakers' (i.e. teachers') gestures can help listeners (learners) to grasp the speaker's referential intentions by indexing objects and inscriptions in the socially shared environment. Secondly, the speaker's gestures can help listeners to grasp the speaker's semantic intentions by helping the listeners to simulate relevant actions and perceptions. Alibali et al. (2013) affirmed that by representing an abstract action through a familiar physical action, the teacher's gestures may help the learners to grasp the instructional material, thereby promoting the common ground.

Alibali and Nathan (2012, p.248) articulate that "gestures are often taken as evidence that the body is involved in thinking and speaking about the ideas expressed in those gestures". They further indicate that pointing gestures reflect the grounding of cognition in the physical environment, representational gestures manifest mental simulations of action and perception, and some metaphoric gestures reflect body-based conceptual metaphors. Thus, gestures reveal that some aspects of mathematical thinking are embodied. Furthermore, from an embodied cognition perspective, pointing gestures have meaning because they index objects and locations in the physical world (Alibali et al., 2014).

Alibali et al. (2014) state that the embodied cognition perspective also has implications for understanding gestures' roles in communication. They further suggest that listeners (learners) may better grasp speakers' (teachers) embodied meanings when those meanings are expressed in gestures.

Hostetter and Alibali (2004), Gallagher (2005), McNeill (2005) and Alibali and Nathan (2007) articulate that a person who uses his/her body (i.e. gestures) to reveal knowledge, thinking, and knowledge must be bonded/integrated with the body. I therefore argue that it is very valuable for teachers and learners to express their knowledge of mathematics in gestures.

2.6.2 Co-emergence

Thompson and Varela (2001) defined emergence as the construction of a new process out of the interaction of different existing processes or events. Schäfer (2016) viewed co-emergence as a "coupling together of the learning and teaching process or the integration of

the two" (p.318). He further stated that co-emergence suggests that teaching and learning should not be separated, because they are mutually dependent on each other as they develop and grow together (p.318).

According to Fenwick (2000), the enactivist perspective claims that learning can only be understood in terms of co-emergence. Each participant's understandings are tangled with the others, and individual knowledge co-emerges with collective knowledge. Thus, the environment, the teacher and the learner emerge together in the process of learning (Fenwick, 2000). In the context of this study, teachers and learners co-emerge through gestures.

Sumara and Davis (1997) emphasise that it is not an individual organism that shapes the environment, or the environment that conditions the organism; rather the two are engaged (p.414). Sumara and Davis (1997) suggest that "all of our understandings are situated in and co-emerge with complex webs of experience, and so we can never discern the direct causes of any particular action" (p.412).

2.6.2.1 Gestures as co-emergent process

Begg (2013) articulates that with enactivism, humans and the world are inseparable; they co-emerge — thus cognition (learning) cannot be separated from being (living) and knowledge is the domain of possibilities that emerges as we respond to and cause changes within our world (p.82). Begg (2013) states that living organisms (humans) and their environment should be considered together and one cannot separate knowing from doing and from the body; and that knowing is doing which in the end is inseparable from self-identity or being (Begg, 2013). In the context of this study, it is the body (gestures) and the learning environment that are connected. Gallagher (2005) articulates that the body allows us to interact with the environment and since people use their bodies (i.e. gestures) to express knowledge, it is argued that knowledge itself must be deeply tied to the body (Alibali & Nathan, 2007).

Goodwin (2003) states that, seeing a gesture helps the learners to understand how the speech they hear relates to the objects they see, because speech, gesture and the environment all give meaning to one another. Mustafa, Nusantara, Subanji and Irawati (2016) observe that

learners' gestures can represent attitudes, emotions and feelings: so gestures can explain the process that is going on in the minds of the learners during the learning of mathematics.

2.9 CONCLUSION

This chapter discussed the two main concepts of this study which are gestures and visualisation. It also looked at the literature on enactivism which forms the theoretical framework of this study. Under gestures, various definitions were provided, the types/nature of gestures discussed, the roles and functions of gestures in the teaching and learning of mathematics were elaborated on, as well as some of the difficulties experienced when using gestures. On visualisation, the following aspects were discussed: the definition of visualisation, the roles of visualisation in the teaching-learning of mathematics, difficulties around visualisation as well as gestures as visualisation tools. Lastly, it looked at enactivism through the following discussion points: definitions of enactivism, embodied cognition, gestures as embodied action co-emergence and gestures as a co-emergent process.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter outlines the research methodology I used to answer the following research questions: a) what are the types of gestures that selected junior primary teachers use in the teaching of mathematics? And b) what are the selected teachers' views and perceptions of the roles and functions these gestures play as visualisation tools in the teaching of mathematics? This chapter discusses the research orientation, research methodology, data analysis, validity and reliability issues, and finally, the ethical considerations for this research project.

3.2 RESEARCH ORIENTATION

This study was situated in an interpretive paradigm using a mixed method approach. I used both qualitative and quantitative methods to analyse the data (Bertram & Christiansen, 2014).

3.2.1 Interpretive paradigm

According to Maree (2007, p.60) an interpretive paradigm researcher aims to "offer a perspective of a situation and to analyse the situation under study to provide insight into the way in which a particular group of people make sense of their situation or the phenomena they encounter ", in this case a group of junior primary school teachers. In addition, Cohen, Manion and Morrison (2013) highlight that interpretive research is characterised by individuals to understand their interpretations of the world around them. In order to maintain the phenomenon under investigation, one has to make an effort to get inside the person and to understand him/her from within (*ibid.*). Moreover, Bertram and Christiansen (2014) state that interpretive researchers do not predict what people will do, but rather describe and understand how people make meaning of their particular actions.

In this study, as I intended to understand the selected teachers' views and perceptions of the roles and functions their gestures play as visualisation tools in the teaching of mathematics,

I did not set out to predict what they did, but I observed them in action and in the moment. I then interviewed them and interpreted the gestures they used and utterances they made about using these gestures. Together with them, I attempted to understand the nature of their gestures and how they made meaning of their own use of their gestures in their classrooms.

3.2.2 Mixed methods approach

This study used a mixed methods approach. According to Ivankova, Creswell and Stick (2006), a mixed methods approach is a procedure for collecting, analysing, and "mixing" or integrating both quantitative and qualitative data within a single study for the purpose of gaining a better understanding of the research problem (p.3).

In the context of this study, I analysed all the recorded lessons quantitatively on my own using my analytical tool illustrated in Table 3.1. I used descriptive statistics such as a bar graph and a pie chart to analyse the occurrences of the five categories of gestures that the participating teachers used in the lessons that I video-recorded. Maree (2007) described a quantitative research approach as a process of collecting and analysing numerical data in a systematic and objective way.

A qualitative research approach on the other hand, attempts to collect rich descriptive data of a particular phenomenon with the intention of developing an understanding of what is being observed or studied (Maree, 2007). The choice of this approach is well aligned with the purpose of this study, which is to analyse both the types of gestures that selected mathematics teachers used and their views and perceptions of their gestures as visualisation tools in the teaching of mathematics. Through observations and interactions (stimulus-recall interviews) with them, I understood their use of gestures better.

3.3 RESEARCH METHODS

3.3.1 Case study

This research took the form of a case study. Bertram and Christiansen (2014) defined a case study as a "systematic and in-depth study of one particular case in its context, where the

case may be a person (such as a teacher, a learner, a principal or a parent), a group of people (such as a family or a class of learners), a school, a community, or an organisation" (p.42).

For my study the case was three selected junior primary phase (Grades 0-3) mathematics teachers. The unit of analysis of my case study was firstly the types of the observed teachers' **gestures** and secondly their views and perceptions of the roles and functions these gestures play as visualisation tools in the teaching of mathematics. A case study methodology aligns very well with my study because it involves observing and interviewing a particular case (a group of three teachers) in particular context, in order to: (a) analyse the types of gestures they use in their teaching of mathematics; (b) understand their views and perceptions of the roles and functions these gestures play as visualisation tools in the teaching of mathematics.

3.3.2 Research design

This study unfolded in five phases and the detail of each phase is explained below.

Phase one: Workshop

In this phase, I invited all (seven in total) the mathematics teachers from the junior primary phase (Grades 0–3) at that school to a workshop where I explained in detail what this research was all about; and that their gesturing practices were important phenomena to study and research. We then discussed the types, roles and functions of gestures. I provided them with a possible definition of gestures, and described the types of gestures as well as the roles and functions of gestures in the teaching-learning process. This was a good opportunity for the teachers to learn and become aware of gestures and their possible worth in teaching. I further brought in the importance of using visualisation in the teaching of mathematics. We discussed this and I suggested a possible definition of visualisation. We then discussed the roles of visualisation in the teaching of mathematics. I also made them aware that when they gesture, the learners visualise what is gestured. Thus, gestures are visualisation tools. In the workshop I also discussed the teachers' roles in the research project. I briefly outlined in broad brushstrokes my observation intentions when I video record their lessons. After the workshop I asked for volunteers to participate in my presentation. Three teachers volunteered.

Phase two: Developing and refining of data collection and analysis tools.

On the basis of the previous phase, I developed and refined my observation schedule which formed the basis of my analytical tool. I then developed and refined my interview questions that I used during the stimulus-recall interviews after the observations. Further, in this phase I piloted the video-recording process with one of the participating teachers to test my video recording skills and also established the most strategic position to place the camera in the classroom in order to capture the teacher's gestures most optimally.

Phase three: Observation of participants.

In this phase, I observed my participants at mutually agreed times as they presented their lessons. I observed a sequence of lessons that were conceptually coherent as I wished to observe the types of the gestures at different times of developing a particular mathematical concept. I video recorded each of the three teachers ten times in the first term of 2018. I focused on capturing as accurately and comprehensively as possible the gestures that the teachers used during their lessons presentations. This helped me to answer research question one.

Phase four: Interviews

In this phase, I engaged with the participants by conducting two one-on-one stimulus-recall interviews (Fox-Turnbull, 2009) with each teacher in the first term of 2018. Fox-Turnbull (2009) defines stimulated recall as a "research method that allows the investigation of cognitive processes through inviting participants to recall their concurrent thinking during an event, when prompted by a video sequence or some other form of visual recall" (p.205). My aim here was to establish the participating teachers' views and perceptions of the roles and functions of their own gestures as visualisation tools in the teaching of mathematics. This helped me to answer research question two.

Phase five: Analysis of data

In this phase I subjected my data to my analytical tool which I discuss below.

Table 3.1 below is the analytical instrument that I used for both observations and interviews for each teacher for each lesson.

Table 3. 1: Analytical instrument

Name of the teacher:				
Topic taught:		***Grade:***	***Lesson:***	***Date:***
Gestural categories	***Definition of each gesture***		***Tally***	***Frequency***
Pointing (deictic)	These are gestures that indicate objects, persons or locations in the physical world via pointing (e.g. pointing to a picture on the chalkboard to refer to that picture).			
Iconic(illustrators)	These are gestures that illustrate what is being said. They add details to the mental image that the speaker is trying to convey. They depict semantic content directly via the shape or motion trajectory of the hand(s) (e.g. tracing a triangle in the air to mean the triangle).			
Metaphoric	These are gestures that are used to shape, reinforce, affirm and explain ideas or actions, either with specific shapes such as finger pinches and physical shaping, or more general waving of hands that symbolises the complexity of what is being explained. Metaphoric gestures present images or abstract concepts in a concrete form via metaphors.			
Beat (motor)	These are simple, repetitive hand movements that keep the rhythm of speech. They can be as short as a beat or as long as needed to make a particular point. Beat gestures are mostly used to for making emphasis and grabbing attention. A teacher can use beat gestures to emphasise certain points or grab learners' attention. Beat gestures are often produced when speakers are searching for words and they need to buy time to find these words.			
Symbolic (emblems)	These are gestures that are used to substitute or support speech. In fact, emblems often stand alone from speech. For example, most learners know that if a teacher holds a finger tightly to his/her lips that means 'be quiet' and the thumbs-up sign means 'okay'.			

(Adapted from McNeill, 1992)

Table 3.2 below summarises the entire research process.

Table 3. 2: Summary of the research process

Phases	Instrument	Purpose	Data	Analysis
Phase 1: Workshop	Consent letters	• Explains in detail the nature of the research project • Gets participants (volunteers) and consent	Not applicable	Not applicable
Phase 2: Developing and refining of data collection and analysis tools	Observation and Interview schedules	To ensure readiness for data collection	Not applicable	Not applicable
Phase 3: Collection of data through observations	Observations	Generate data	Types of teachers' gestures	Quantitative
Phase 4: Collection of data through interviews	Interviews	Generate data	The roles and functions of gestures as visualisation tools	Qualitative
Phase 5: Analysis of data		Analyse the findings	Video-taped and verbal responses	Qualitative and quantitative

3.3.3 Research techniques

The data for this study was collected through observations and stimulated recall interviews.

3.3.3.1 Observation

The observation of this research study involved video-recording a total of thirty mathematics lessons taught by the selected teachers. I asked a friend who was inducted and trained on the use of a video camera to record all the gestures that the selected teachers used when they taught their mathematics lessons. As a non-participant observer, I was seated at the back of the class with my observation schedule, recording the occurrences of each gesture throughout the lessons. According to Maree (2007), a non-participant observer looks at a situation from a distance. I worked with the three participants for the entire first term of 2018. Each teacher was video recorded ten times in this period (i.e. total of thirty lessons).

During observation, a researcher "observes what is actually taking place there" (Bertram & Christiansen, 2014, p.84). Maree (2007) states that observation seeks to discover what people do by watching them in action as they express themselves in different situations and activities. One may consider it to be the most direct means of studying people in certain aspects. Maree (2007) indicates that observation enables the researcher to gain a deeper insight and understanding of the phenomenon being observed through hearing and seeing, and thus begins to experience reality as the participants do.

Tables 3.3, 3.4 and 3.5 below show the sequence of lessons that I observed for each teacher.

Table 3. 3: Sequence of lessons for teacher A

Name of the teacher: Teacher A		**Grade: 0**
Date	**Lesson**	**Topic taught**
01.02.2018	1	Measurement (time i.e. days of the week)
02.02.2018	2	Seriation (ordering)
09.02.2018	3	Measurement (day and night)
14.02.2018	4	Measurement (length)
15.02.2018	5	Spatial relations
16.02.2018	6	Number concept
20.02.2018	7	Measurement (mass i.e. heavy and light objects)
21.02.2018	8	Number concept
28.02.2018	9	Measurement (capacity i.e. full and empty)
01.03.2018	10	Seriation (pattern using shapes)

Table 3. 4: Sequence of lessons for teacher B

Name of the teacher: Teacher B		**Grade: 2**
Date	**Lesson**	**Topic taught**
01.02.2018	1	Place value
08.02.2018	2	Time (days of the week and months of the year)
14.02.2018	3	Ordering and Comparing
15.02.2018	4	Doubling and halving
16.02.2018	5	Geometrical figures (2D shapes)
20.02.2018	6	Multiplication
26.02.2018	7	Decomposition of numbers
28.02.2018	8	Money (Namibian currency)
02.03.2018	9	Problem solving
08.03.2018	10	Addition

Table 3. 5: Sequence of lessons for teacher C

Name of the teacher: Teacher C		Grade: 3
Date	**Lesson**	**Topic taught**
31.01.2018	1	Decomposition of numbers
05.02.2018	2	Doubling and halving
06.02.2018	3	Time (days of the week and months of the year)
14.02.2018	4	Geometrical figures (3D shapes)
16.02.2018	5	Problem solving
21.02.2018	6	Money (Namibian currency)
22.02.2018	7	Money (Namibian currency) continuation
27.02.2018	8	Length
01.03.2018	9	Place value
08.03.2018	10	Problem solving

3.3.3.2 Interviews

I engaged each teacher in two one-on-one stimulus recall interviews in the first term of 2018. Theobald (2008) states that, "during video-stimulated recall, participants watch a video-recording of a specific event in which they were involved, and then discuss their participation in that event" (p.2). The first set of interviews was done half way through the first term and then another set was conducted at the end of the term. While watching their own video-recorded lessons, each participant was encouraged to recall and reflect on his/her gestures during the lesson presentations that were evident in the video recordings. The questions that were posed to them specifically focused on the roles that each of their gestures played in each of their video recorded lessons. The questions about, and joint analysis of the video recordings, were based on the gestural categories evident in the analytical framework discussed below. Importantly, I was also interested in understanding the teachers' own views on the visualisation roles of their gestures in the teaching of mathematics. Through these verbal interactions between me and the participants, I managed to obtain in-depth information that could not be sourced in any other way. Henning, Van Rensburg and Smit (2004) articulate that during interviews the researcher can ask a series of questions to obtain detailed information. These interviews are unique in the sense that they involve the collection of data through direct verbal interaction between me and my participants.

3.3.4 Research site and participants

This study was conducted at a primary school in the Omusati region of the Outapi circuit in northern Namibia. The school offers Grades 0-7. The participants in this study were three mathematics teachers at the junior primary phase (Grades 0-3). The initial target was four teachers as I was hoping that each grade would be represented by one teacher. However, in the end only three volunteers participated as one withdrew for personal reasons. They were from Grades 0, 2 and 3 respectively. The curtailed number of participants did not affect the criteria for my research.

The selection of the teachers in this study was purposeful. According to Bertram and Christiansen (2014), in purposive sampling, the researcher makes specific choices about which people or groups to include in the sample. In most cases, purposive sampling is used

in order to access knowledgeable people i.e. those who have in depth-knowledge about a particular issue due to their professional role, expertise or experience (Ball, 1990). The participants were selected based on the following specific criteria: Firstly, the teachers needed to show an interest in the research and be willing for me to observe and video record their gestures whilst they taught. Secondly, they needed to be willing to reflect on their teaching and share their opinions about their teaching. Their participation was of course voluntary.

The junior primary phase suited this study because in my experience visualisation is highly emphasised at this phase and many images are expressed as gestures.

3.4 DATA ANALYSIS

The analysis of the lessons was two-pronged.
Firstly, I analysed all the recorded lessons quantitatively on my own using the analytical tool illustrated in Table 3. I used descriptive statistics (bar graphs and a pie chart) to analyse the occurrences of the five types of gestures.

Secondly, the transcribed interviews were analysed qualitatively whereby the categories in the analytical tool as depicted in table 3.1, were once again used as guiding themes to analyse the participants' utterances. The interview schedule (see appendix E) assisted in categorising and thematising the participants' responses.

The above mixed method approach was however dominated by the qualitative analysis and thus can be categorised as a sequential explanatory design (Greene, Caracelli & Graham, 1989).A mixed method sequential explanatory design implies collecting and analysing first quantitative and then qualitative data in two consecutive phases within one study (Ivankova, Creswell & Stick, 2006). In this design, a researcher first collects and analyses the quantitative (numeric) data before qualitative (text) data are collected and analysed. Secondly, qualitative data build on the quantitative data and the two phases are connected in the study (Ivankova, Creswell & Stick, 2006).

3.5 VALIDITY AND RELIABILITY

To ensure validity for this study, I piloted the following research processes. Firstly, I piloted the video recording process to ensure that my recordings captured the appropriate data I required for analysis. Secondly, whilst piloting the video-recording process, I also piloted my observation schedule which formed the basis of my analytical tool. I specifically looked at the types of gestures that the teacher used and whether they matched with the ones in my observation schedule. This enabled me to see if my observation schedule was reliable and effective to generate appropriate data.

The use of a video-recording device for observations and an audio-recording device for stimulus-recall interviews ensured that my data was comprehensive and authentic. During my data analysis process, I sought the opinion of my supervisor to determine whether I had made appropriate interpretations and drawn valid conclusions from the data. Lastly, I took my findings and interpretations to the participants for member checking before making final conclusions.

3.6 ETHICS

3.6.1 Respect and dignity

The participants were fully informed about their participation in the study and they were given the choice to participate or not. The willing ones were made aware that the participation was voluntary and they had the right to withdraw at any time. I also made it known to them that their privacy and sensitivity would be protected by not disclosing their information in any way that might identify them or that might enable them to be traced. All the data would remain confidential between my supervisor and me.

3.6.2 Transparency and honesty

Official written consents to carry out this study were obtained from all stakeholders in the research process (i.e. the Director of Education in the Omusati region, the school principal, parents and teachers) (see appendices B, C, D, E). The nature of the study and the description of

what the teachers' participation would involve (duration and the activities to be carried out) were clearly outlined.

3.6.3 Accountability and responsibility

Collected data will be kept in a safe place. Participants were not exposed to any physical or mental stress, thus they were respected and treated fairly.

3.6.4 Integrity, academic professionalism and researcher positionality

I reported my findings in a complete and honest way, without tampering with the data and their analyses. I was aware of my position as a mathematics teacher in the same circuit as my participants, and as a result, I assured them that my position would not disturb their teaching in any way nor should it compromise their responses. I reassured my participants that their participation in this study would not impact their standing with respect to their schools or district office in any way. This research is my own work and where I used another person's ideas, acknowledgement is done fully.

3.7 CONCLUSION

This chapter discussed in detail the research orientation (paradigm and approach); the research methodology (methods, research design, research techniques, research site and participants); the data analysis process; validity and reliability, and finally, the ethical considerations for this research project.

CHAPTER 4

ANALYSIS AND DISCUSSION OF RESULTS

4.1 INTRODUCTION

This chapter presents and discusses the findings of my research project. The data presented in this chapter was drawn from thirty video- recorded lesson observations and stimulus-recall interviews. The chapter begins with an analysis of each teacher's lessons by following the following structure:

- Profile of each teacher
- Brief overview of the ten lessons of each teacher
- Descriptions and discussions of the five types of gestures used by each teacher in the ten lessons
- Interview responses for each teacher

It concludes with the summary of the five types of gestures used by the three teachers, and finally with a summary of interviews on their views and perceptions of the roles and functions these gestures play as visualisation tools in the teaching of mathematics.

Due to the limited scope of this thesis, I will only report in detail on teacher A and teacher B using the above template. For teacher C's ten lessons, I will simply present a summary of her lessons in a table form.

4.2 TEACHER A (GRADE 0)

Teacher A is a Bed honours (Bachelor of Education degree) holder. She had accumulated two years of teaching experience at the time of the study.

Below is the brief overview of the ten observed lessons of teacher A.

The learning objectives and basic competencies of all her ten lessons were taken from Namibia Ministry of Education pre- primary phase syllabus English version (MoE, 2008).

4.2.1 Lesson 1: Measurement (time i.e. days of the week)

Learning objective: Learners will expand their mathematical vocabulary

Basic competency: Learners should be able to name the days of the week.

Teacher A introduced her lesson by asking the learners to count from one to five. The learners counted on their fingers. She then asked the learners to mention the seven days of the week. She pointed to them one by one as she asked them. The learners mentioned the days of the week from Sunday to Saturday while counting on their fingers. She then wrote the seven days of the week on the chalkboard in the correct order. She went on further by teaching them a nice song about the seven days of the week in the correct order i.e. from Sunday to Saturday. Learners, together with the teacher sang the song smilingly and actively.

4.2.2 Lesson 2: Seriation (ordering)

Learning objectives:

1. Learners will develop skills in visual and tactile perception, discrimination and sequencing.

2. Learner will expand their mathematical vocabulary.

Basic competency: Learners should be able to arrange pictures /objects in a specific order or pattern, using relevant vocabulary such as big, bigger and biggest; small, smaller, smallest; light, lighter, lightest; heavy, heavier, heaviest; short, shorter, shortest; long, longer, longest; smooth, smoother, smoothest etc.

In her introduction, teacher A called (by to pointing them) Joel, Maria, Selma and Simon (not their real names) to the front of the class. She then asked the rest of the learners (the ones that remained seated) to arrange the four learners from the shortest to the tallest. Before the learners started with the arrangements, teacher A demonstrated short (moving her right hand downwards) and tall (moving her right hand upwards). The learners copied these gestures quickly and correctly. Further, teacher A took five paper cards with stars of different sizes. She asked the learners to paste them on the chalkboard from the smallest to the biggest. The learners enjoyed the activity as it came easily to them. Teacher A

concluded her lesson by giving learners an activity. She gave each learner two pieces of paper (a blank piece of paper and one with five giraffes of different heights). Learners cut out all the giraffes and pasted them on the page in order of size, from the shortest to the tallest. While learners were busy with this activity, a disruption occurred when two learners started fighting for a pair of scissors. Teacher A did not say a word, she just frowned and nodded her head, and the learners stopped fighting.

4.2.3 Lesson 3: Measurement (day and night)

Learning objective: Learners will acquire an understanding of a period of time, the duration of time ant the continuity of time.

Basic competency: Learners should be able to differentiate between day/night, morning/afternoon/evening and a long/short time.

Teacher A began her lesson by singing a song about daily activities (i.e. brushing teeth, washing face, combing hair and then running to school). As she sang the song, teacher A illustrated the mentioned activities with corresponding gestures. Teacher A illustrated brushing teeth using her right index finger close to her open mouth by moving it forward and backward. Further, she demonstrated washing her face by putting her right hand near her face and moving it in a circular motion. She demonstrated combing hair with her right hand close to her head while moving it backwards. Lastly, she illustrated running by running on the spot. Both the teacher and the learners sang the song repetitively, illustrating all the mentioned activities with their hands. The song mentioned that all these activities are done early in the morning. Further, teacher A asked the learners to mention day and night activities. They mentioned day activities among others such as going to school, playing, etc. Night activities included sleeping and many more.

Teacher A concluded the lesson by pasting a poster divided into two columns (day and night time activities) on the chalkboard. She then put pictures of both day and night activities (sun, children and a teacher in the class, children sleeping, children going to school, moon, clouds, children playing and stars) on the mat. She pointed to the learners one by one, and asked them to paste the activities in the right column. Learners liked the activity because it had colourful pictures. They smilingly pointed to the pictures and discussed them before pasting them onto the board.

4.2.4 Lesson 4: Measurement (length)

Learning objective: Learners will become aware of and make comparisons between the lengths of objects.

Basic competency: Learners should be able to compare the length of two objects/containers, using relevant vocabulary such as long/short /tall.

Teacher A called two learners to the front of the class. Her selection was purposive as she only pointed to the shortest and tallest learners in the class. She asked the remaining learners to compare the two learners and tell her which one is tall/short. In response, they all shouted while pointing "*Senta is short and Aluteni is tall*". Further, she gave a piece of paper with the word 'short' written on it to the short learner (Senta) and another piece of paper with the word 'tall' written on it to the tall one (Aluteni). She then asked the whole class to repeat after her as she read 'short' and 'tall'. She illustrated both short (moving her right hand downwards) and tall (moving her right hand upwards) with her hands. Learners copied her gestures as they repeated after her.

Before the concluding activity, teacher A drew three children of different heights on the chalkboard. She then pointed to two learners to go to the chalkboard. She tasked one learner to shade the tallest child, while the other one was tasked to circle the shortest child. She demonstrated **tall** by moving her right hand upwards; **short** by moving her right hand downwards; **shade** by making a half fist with an index finger and a thumb next to each other while moving her right hand sideways and **circle** by drawing a circle in the air.

As a concluding activity, teacher A gave each learner a piece of paper with four children of different heights. The learners were expected to circle the shortest child and colour in the tallest one. The learners enjoyed the activity, especially the colouring part.

4.2.5 Lesson 5: Spatial relations

Learning objectives:

1. Learners will develop an awareness of spatial orientation, becoming aware of their bodies in relation to their surroundings, and of the position that objects have in relation to one another.

2. Expand their mathematical vocabulary.

Basic competencies:

1. Learners should demonstrate and describe the relation of the body or an object to other objects in their surroundings in terms of direction and comparison.

2. Use relevant vocabulary such as: in front of, behind, below, above, on top of, underneath, inside, outside, far, near, right, etc.

As an introduction, teacher A took a roll of toilet paper and a box. She then put the roll in the box, behind the box and in front of the box. She asked the learners to describe the spatial position of the roll of toilet paper to the box as she demonstrated. Later on, teacher A told the learners (the whole class) to stand behind their chairs, in front of their chairs and on their chairs. The learners enjoyed this activity very much. Some smiled while others laughed as they did this activity.

Teacher A concluded her lesson by showing learners pictures on the worksheet of a dog behind the basin, above the basin and in front of the basin. She asked the learners to describe the relation of the dog to the basin as she pointed to the pictures one by one.

4.2.6 Lesson 6: Number concept

Learning objective: Learners will develop an awareness of the numerical symbols that are represented by a group of objects.

Basic competency: Learners should be able to associate numerals with the spoken number names or groups of objects up to nine.

In her introduction, teacher A took a basin of bottle tops. She told the learners to count the bottle tops as she picked them up one by one until she picked the ninth bottle top. She then took two bottle tops from the same basin at once and asked the learners to tell her how many bottle tops she took. They gave the answer in speech by shouting '**two**' and some of them holding up two fingers.

Teacher A went on by showing the learners a page with a big **'2'** written on it. She pointed to the **'2'** with her right index finger as she read it. She then showed the learners how to write the number **'2'** on the chalkboard using chalk as well as in the air using their index fingers. She further demonstrated to the learners how to construct a number **2** using some clay. Later on she gave each learner some clay to construct the number **2.**

In conclusion, teacher A gave each learner a page of coloured pictures of the same two objects (i.e. two balls, two boxes, two cups and two pencils). She then told the learners to count each of the same objects and write the number name next to the objects. The learners were excited to look at the colourful pictures and they smiled when they did the activity.

4.2.7 Lesson 7: Measurement (mass i.e. heavy and light objects)

Learning objective: Learners will become aware of and make comparisons between the mass of objects.

Basic competency: Learners should be able to compare the mass of two objects/containers using relevant vocabulary such as heavy or light.

In her introduction, teacher A held a piece of paper and cell phone in both hands up in the air. She asked the learners which object was heavier. She later gave one learner a box and a small ball. She told the learner to compare the two objects and tell the rest of the class which one was heavy, and which one was light. Teacher A repeated the same activity with different objects.

Teacher A then took a balancing scale to compare the mass of two objects, one at a time. She asked the learners which object was heavy and which was light, as she put different objects on the scale. Learners watched as the balancing scale sides moved up and down. She explained to the learners that when objects have the same mass the balancing scale would stand still and be at the same level on both sides.

Teacher A concluded her lesson with an activity. She handed a piece of paper to the learners with different objects illustrated on it (i.e. a pencil, a bag of cement, a ruler, a brick, a fifty kilogram bag of maize meal and a watermelon). She asked the learners to colour in all the heavier objects and leave out the lighter ones.

4.2.8 Lesson 8: Number concept

Learning objective: Learners will appreciate and understand the need and convenience of counting in everyday life.

Basic competency: Learners should be able to manipulate objects and count up to seven.

Teacher A introduced her lesson by telling the learners to count up to seven beads on an abacus (counting frame) that was on her table. She pointed to individuals to count as she moved the beads on the abacus one by one. Later, she took a basin filled with bottle tops and called the learners one by one to pick only seven bottles tops from the basin. As they picked, she instructed them to count the bottle tops.

Then teacher A pasted cards with different fruits (i.e. apples, bananas, watermelons, oranges, grapes and pears) in groups of three, four, five, six and seven on the chalkboard. She asked the learners to circle only a group of seven fruit. She illustrated **'circle'** by drawing a circle with her right index finger in the air.

As a concluding activity, Teacher A gave each learner a piece of paper showing objects in groups. She instructed the learners to circle each group of seven objects only.

4.2.9 Lesson 9: Capacity (full and empty)

Learning objective: Learners will become aware of and make comparisons between capacities of objects.

Basic competency: Learners should be able to compare capacities of two containers using relevant vocabulary such as full or empty.

In her introduction, teacher A took two empty 500ml cool drink containers. She filled both containers (full and half-full) with water from the bucket that was in the classroom. She told

the learners to compare the two containers in terms of their capacities. The learners responded that one container was full while the other one was half-full. Teacher A then emptied both containers (poured the water into the bucket) and asked one learner to refill them with water (full and half-full).

Teacher A continued her lesson by drawing three cool drink containers of the same size on the chalkboard. She then shaded two of them (indicating full and half-full) and left one container un-shaded. Teacher A asked one of the learners to put a cross inside the full container and shade the empty container.

Teacher A concluded her lesson with an activity. She gave each learner a piece of paper with illustrations of four bottle containers (two containers were full, one container was half-full and one container was empty) of the same size. She told the learners to put a cross inside the full containers, and colour the empty container. She clearly explained the activity to the learners in both speech and gestures. She illustrated colouring by making a half-fist with an index finger and thumb next to each other while moving her right hand sideways. She further illustrated a cross by drawing in the air with her right index finger. Learners stared at the teacher as she explained to them. They gave her their full attention.

4.2.10 Lesson 10: Seriation (patterns using shapes)

Learning objective: Learners will develop an awareness of the patterns of objects, shapes and numbers.

Basic competency: Learners should be able to copy a given pattern.

As an introduction, teacher A took some beads and a long thread from the basin. She then came up with bead patterns of two colours only (i.e. blue and white). Learners watched her as she put the beads on the thread. She repeated the exercise with beads of different colours (black, green, yellow and red) before she pointed to a few learners to do the same activity while others observed them.

Teacher A then drew different patterns using shapes on the chalkboard and asked the learners to copy them.

As a concluding activity, she handed a piece of paper to every learner with different patterns using shapes to copy.

Figure 4.1 below shows the types and frequency of occurrences of gestures used by teacher A in her ten lessons.

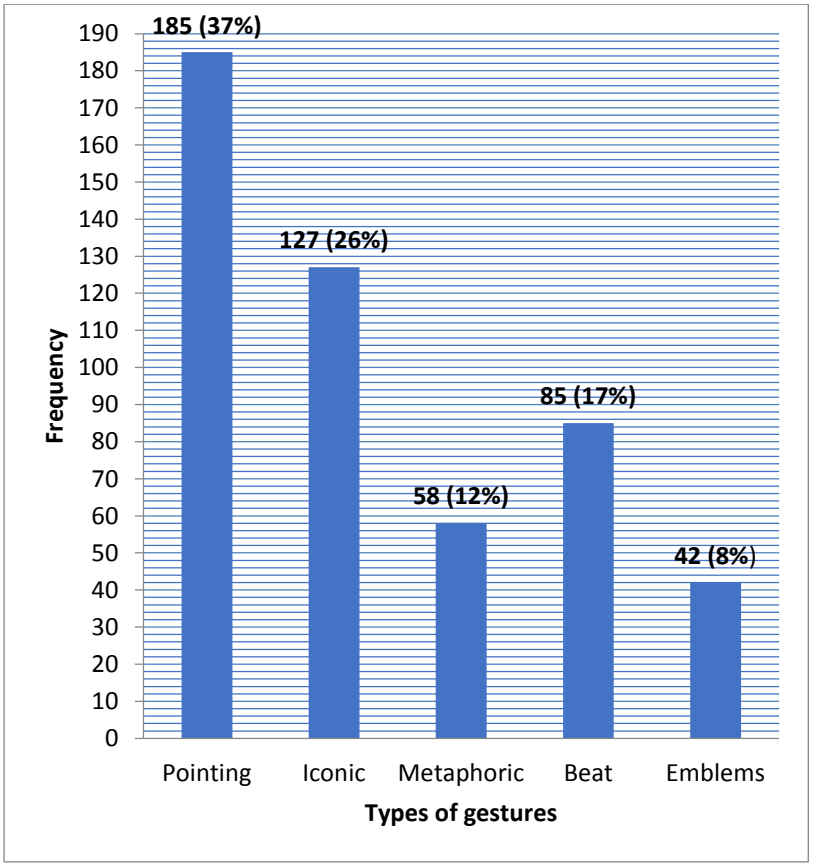

Figure 4. 1: Types of gestures used by teacher A in the ten observed lessons (cumulative frequencies)

4.2.11 Descriptions and discussions of the five types of gestures used by teacher A in her ten lessons

1. Pointing (deictic) gestures

I observed that teacher A used a lot of pointing gestures in every lesson, as shown in Figure4.1above. She pointed 185 times in her ten lessons. She pointed to the learners to give her answers. Teacher A also pointed a lot to the pictures, shapes and objects. She pointed to objects in the classroom when she sent the learners to bring the chalk, the book, the paper, the glue stick, the pair of scissors and many more. Teacher A pointed to the pictures on the chalkboard indicating to the learners that she was referring to that specific picture. Further, teacher A pointed to the pictures on the worksheet for the learners'

activities emphasising what needed to be done for every question. Figure 4.2 below shows teacher A pointing to one of the learners to give her an answer.

Figure 4. 2: Teacher A pointing to Nelao (not her real name) to give her an answer

2. Iconic (illustrators) gestures

Teacher A used 127 iconic gestures in her ten lessons by doing the following: she used the bodies of the learners in relation to their chairs to illustrate 'in front of', 'behind', 'on top of' and 'under'. During one lesson, teacher A used her body to illustrate all the mentioned activities mentioned in the song that she and the learners sang together:

This is the way I brush my teeth, brush my teeth, brush my teeth, this is the way I brush my teeth early in the morning. This is the way I wash my face, wash my face, wash my face, this is the way I wash my face early in the morning. This is the way I comb my hair, comb my hair, comb my hair, this is the way I comb my hair early in the morning. This is the way I run to school, run to school, run to school this is the way I run to school early in the morning.

Teacher A further used her hands to demonstrate mathematical relationships such as length (short and tall), mass (heavy and light) and volume (small and big). Below is figure 4.3 showing teacher A using the bodies of the learners in relation to their chairs to illustrate spatial relations, particularly 'under'.

Figure 4. 3: Teacher A using the bodies of the learners to illustrate the concept 'under'

3. Metaphoric gestures

Teacher A used fifty eight metaphoric gestures to create physical representations of mathematical concepts. She used available materials such as clay to construct numbers and bottle tops for counting as well beads for making mathematical patterns. Moreover, teacher A used pictures to represent day and night. Figure 4.4 below represents teacher A using pictures as representations for day and night.

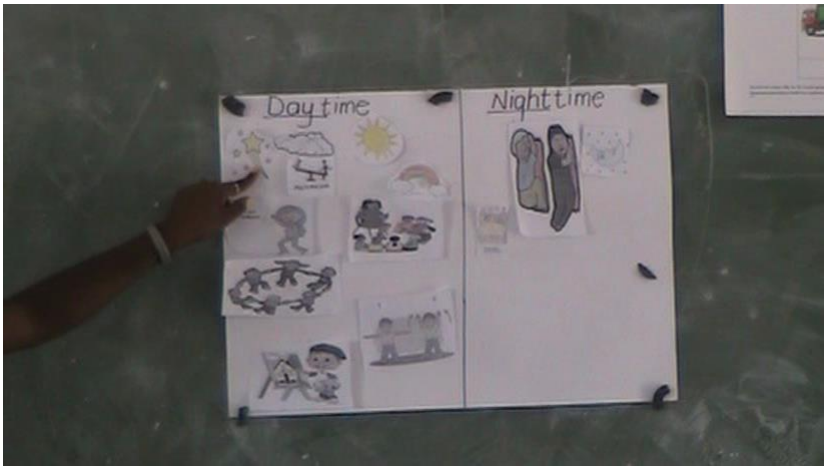

Figure 4. 4: Teacher A using pictures as representations for 'day' and 'night'

4. Beat (motor) gestures

In her ten lessons, teacher A used eighty five beat gestures. I observed her moving her hands repetitively to search for words in her mind in the '*Oshimbalanhu*' language. Teacher A is an '*Oshikwanyama*' speaking person, and most of the time it was difficult for the learners to understand everything she said. I further observed teacher A using a song to reinforce the seven days of the week. Movements of her hands to grab learners' attention were important to her. Figure 4.5 below shows teacher A using a song to reinforce the seven days of the week

Figure 4. 5: Teacher A reinforcing the seven days of the week

5. Symbolic (emblems)

Emblems were used least by teacher A. She used forty-two emblems in her ten lessons, mainly to request silence from her learners and for approval. To request silence, Teacher A held her index finger close to her mouth. She never shouted when learners made a noise. When learners asked for permission to go outside, teacher A nodded her head for approval. During one lesson, a learner came into the class a bit late and asked softly "*Teacher nanduu wemo /may I please come in "* ? In response, teacher A did not say a word: she just nodded her head for a **yes**. The thumb-us sign was also used for good work. Figure 4.6 below shows teacher A requesting silence from her learners by holding her fingers tightly to her lips.

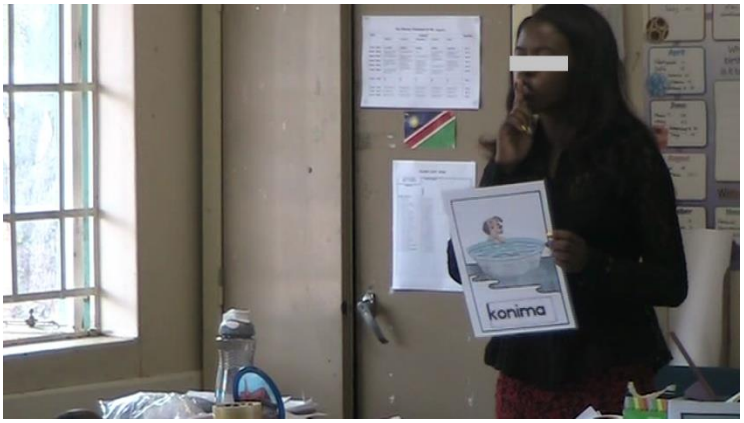

Figure 4. 6: Teacher A requesting silence from her learners by holding her fingers tightly to her lips

4.2.12 Interview responses for teacher A

1. Does gesturing help you in communicating with your learners? Please elaborate.

Teacher A indicated that gesturing helps her in communicating with her learners. She stated that

> *I use gesturing to communicate in the lesson to praise my learners. If a learner gets 3/3, I will just make a thumb-up sign to mean good, or if a learner does good on the chalkboard instead of me saying very good, its correct I will just hold my thumb like this and the learner will see ohooo its correct I have to go and seat down.*

She further indicated that gestures are very useful at the junior primary phase.

> *At pre- primary phase we use a lot of gestures* e.g. *when we are teaching about numbers, I just write numbers in the air like number two (2) in the air and the learners can already see that the teacher is writing number 2 or if I am teaching about shapes and I want the learners to learn about a circle, I will just draw a circle in the air.*

2. What different kinds of gesturing do you think you use? Please provide examples and identify them in the video recording when this happened.

Teacher A indicated that she used pointing gestures, iconic gestures, metaphoric gestures, symbolic gestures and beat gestures. She stated that she pointed to the learners to request answers. *"In the videos, I pointed to the learners to give me the answers".* She also pointed to numbers, pictures and shapes. *"I pointed to the pictures/shapes on the worksheet".*

Teacher A used iconic gestures for illustrations. *"I also used iconic gestures to illustrate what I am saying".* Teacher A praised her learners and disapproved of their bad behaviour using symbolic gestures. *"I used symbolic gestures to tell the learners to keep quiet by holding my finger next to my lips or if they did well I indicated to them with a thumb up sign".* She further used metaphoric gestures to reinforce and affirm her actions.

> *I also used metaphoric gestures to shape, reinforce, and to affirm ideas or actions that I am telling to the learners".* She concluded by saying *"I have also used beat gestures by moving my hands when I am searching for a word for example I want to say something and I forget it, I have to search for that word in my mind like mmmmmm, aaaaaaaaaaa.*

3. What gestures do you think you use most? Why?

Responding to this question, teacher A stated that she used pointing gestures frequently, followed by iconic gestures. *"When I have pictures or shapes on the chalkboard and I want learners to look at them, I have to point them".* Teacher further stated that *"... when I want the learners to give me answers I will just point at that specific learner and the learner stands to give me the answer.* Still on pointing, teacher A stated that *"when I am giving an activity on a paper, I always point to the activity explaining to the learners* so *that they will see and understand what I am explaining to them".* Teacher A mentioned that she used iconic gestures to represent object attributes, actions and spatial relationships.

> *In one of the videos, I was teaching length (short & tall) as well as ordering (small & big). So, as I was explaining these concepts I was also demonstrating them to the learners with my hands e.g. short my hands were closer to the ground and tall my hands have to go up, up, up, in the sky".* She went on by saying *"I was teaching spatial relations concepts such as in front of, behind, below, above, on top of and under. As I was teaching these concepts I was using a chair to demonstrate to the learners what I was saying.*

4. What role does gesturing play in your teaching? Please provide examples and identify them in the video recording when this happened.

Teacher A responded *"gesturing really play a lot of roles in my classroom".* She mentioned that gesturing aided her learners' understanding of mathematical concepts.

> *Gesturing aids learners' understanding of mathematical concepts because if you are teaching and you are gesturing, you are illustrating what you are saying and as a result learners will both see and hear at the same time.*

In addition, teacher A stated that, gesturing helped learners to visualise abstract concepts.

> *As you are gesturing you are illustrating what you are saying by forming a mental image or picture. So, learners will keep those images/pictures in their mind and in that way, gesturing help the learners to visualise abstract concepts.*

Lastly, she mentioned that gesturing helped learners that appeared to be confused understand mathematical concepts.

> *Gesturing also helps when for example learners get confused or struggle to understand concepts, the teacher can use gestures in clarifying the concepts to learners.*

5. What do you want to achieve by gesturing? Please elaborate.

Teacher A responded that she gestured because she wanted her learners to understand mathematical concepts. "*I want my learners to understand and learn concepts more easily and fast".* She further wanted to remove boredom. *"I want my lessons to be super, super interesting and not boring".* Moreover, teacher A wanted to accommodate all learners with different learning abilities. "*I also want to include all learners with different learning styles because I don't want any of my learners to be left behind."* Teacher A further stated that she gestured because she wanted her learners to gesture too. "*I also want to create a classroom environment where my learners also use gestures by imitating me as a teacher".*

6. Do you think we should encourage teachers to gesture during their lesson presentation? Please elaborate.

Teacher A indicated that teachers should be encouraged to gesture during their lesson presentations because gesturing removes boredom in the classroom. *"Your lessons won't become boring when you gesture".* She further revealed that gesturing attracts learners' attention. *"At junior primary phase, this little children the only way they can catch your full attention is when the teacher gestures".* Further, teacher A mentioned that *"gesturing helps learners visualise abstract concepts in their mind".*

7. Do you think gesturing is in-born or not? Please elaborate.

In response, teacher A indicated that gesturing is inborn. She observed that when people talk, they always gesture. "*I think it is in-born because it is almost impossible for a person to speak without gesturing.* She went on by saying *"Every time a person is speaking, the person is moving his/her hands".* She further indicated that even blind people who have never seen people gesturing, do gesture when they speak.

> *If you see a blind person talking, that person gestures but he/she have never seen someone gesturing because they can't see. Where do you think that person picked it up from? It is just because they were born with that ability to gesture.*

Furthermore, teacher A mentioned that even though gesturing as an inborn thing, it can still be learnt in schools to support the teaching-learning process. She concluded

> *But I also think gesturing can be learnt and practiced in schools if teachers are made aware of it and learn the importance and impacts it has on learners' learning.*

4.3 TEACHER B (GRADE 2)

Teacher B had 18 years of teaching experience at the time of the study. He is a BETD (Basic Education Teacher Diploma) holder.

Below is the brief overview of the ten observed lessons of teacher B.

The learning objectives and basic competencies of all his ten lessons were taken from Namibia Ministry of Education junior primary phase English second language and mathematics syllabus (MoE, 2015).

4.3.1 Lesson1: Place value

Learning objective: Learners will recognise digit position and place value.

Basic competency: Learners should be able to identify the place value of hundreds, tens and units in three-digit numbers e.g. in the number 347 the value of the three is three-hundred, the value of four is forty and the value of seven is seven.

In his introduction, teacher B asked the learners to count in twos up to fifty. Learners counted on their fingers. Teacher A then wrote 10, 102 and 86 on the chalkboard and asked the learners to read each of the numbers. He pointed to the numbers as the learners read them. He then told the learners that, the lesson for the day would be about place value. Teacher B explained to the learners that the value of a digit in a number is called its place value. Referring to the numbers that he had written on the chalkboard (i.e. 10, 102 and 86), teacher B gave the place value of each of the digit. He pointed to every digit as he explained. Learners nodded their heads in understanding.

He emphasised by moving his hands continually that they should always start from the right to left when giving the place value of a number. Teacher B concluded his lesson by giving an activity.

4.3.2 Lesson 2: Time (days of the weeks and months of the year)

Learning objective: Learners will understand and use time correctly.

Basic competency: Learners should be able to name the days of the week and the months of the year in the correct order.

Introducing the day's lesson on the months of the year, teacher B asked the learners how many days there are in a week. The learners responded loudly enough in a chorus *"seven*", at the same time using their hands to illustrate 'seven'. Teacher B wrote the days of the week on the chalkboard in the correct order. He pointed to the days of the week from Sunday to Saturday while learners were reading them. He further asked the learners how many months there are in one year. He pointed to Tutaleni (not his real name) who said there are twelve. He then pointed to individual learners to mention the twelve months of the year while writing them on the chalkboard. Furthermore, teacher B took the 2018 year calendar showing the learners twelve months of the year by pointing to every month right from January to December. Learners enjoyed looking at the colourful calendar. It really attracted their attention. Teacher B concluded his lesson by giving a very short activity that consisted of three questions.

4.3.3 Lesson 3: Ordering and comparing

Learning objective: Learners will use mathematics vocabulary for ordering and comparing numbers logically and analytically.

Basic competency: Learners should be able to order and compare numbers from one to one-hundred using appropriate vocabulary: 'more/less than', 'equal to', 'how many', 'greater/smaller than' (by introducing the symbol '>' for 'more than' and '<' for 'less than').

In his introduction, Teacher B asked the learners (the whole class) to count from fifty to one-hundred. Learners did that as loudly as they could with smiling faces. The majority of the learners counted on their fingers.

To start ordering and comparing, teacher B drew two loaves of bread of different sizes on the chalkboard and named them A and B. He asked the learners which loaf they would choose if they were offered. They all responded "*the big one*" and at the same time pointing to it. He then asked them why they chose the big loaf and their response was for them to get full. Further, teacher B brought in a story of a crocodile with the name Cadice. Apparently Cadice eats numbers only, preferably big ones. But when Cadice sees equal numbers, it eats both of them. The bad part about Cadice is that he does not close his mouth. Teacher B went on by writing the following symbols (<, > and =) on the chalkboard demonstrating the mouth of Cadice. In the example, '8 > 2' Cadice's mouth opened toward '8'; in '12 < 15', Cadice ate '15' and in the example '7=7', Cadice ate both numbers. It was such an interesting story that the learners loved it. They all listened and watched as the teacher drew Cadice on the chalkboard. Later on, teacher B pointed to the symbols on the chalkboard as he read them one by one to the learners (greater than >, less than > and equal to =). It caught the learners' attention especially when teacher B illustrated 'greater than' (forming an acute angle with his right hand) and less than (forming an acute angle with his left hand). Learners copied the teacher's gestures.

Teacher B concluded his lesson by giving a class activity on ordering and comparing.

4.3.4 Lesson 4: Doubling and halving

Learning objective: Learners will understand the principle of doubling and halving numbers

Basic competencies:

1. Learners should be able to double numbers up to 50 without carrying e.g. 23+23=46; with carrying e.g. 9+9=18.

2. Halve even numbers up to 50 and odd numbers up to 19. E.g. half of 44 is 22 and half of 19 is 9, remainder 1.

In his introduction, teacher B asked the learners how they understood 'half'. There was silence in the class for almost a minute before teacher B drew a big apple on the chalkboard and shaded it green. He then cut it in half. Without being asked, Judith (not her real name) raised her hand and teacher B pointed to her. Judith as loud as she could said "*Sir to half is to divide in between*". Teacher B smilingly nodded his head for a yes and the rest of the class clapped hands for Judith. He told the learners that they would learn about doubling and halving. Teacher B then told the learners that doubling is to multiply by two and halving is to divide by two, as he divided an apple into two equal parts.

Later, teacher B wrote some examples on the chalkboard on doubling and halving. He pointed to individual learners to give the answers on the chalkboard. Learners used different methods/ways (counting on fingers, counting sticks, small circles drawn on the chalkboard and repeated addition) for both doubling and halving. Teacher B gave feedback to every question and commented on the learners' methods/ways. He pointed to every number as he explained.

The concluding activity consisted of questions on doubling and halving.

4.3.5 Lesson 5: Geometrical figures (2-D shapes)

Learning objective: Learners will identify, name and explore the attributes of two-dimensional (2-D) shapes and three-dimensional (3-D) figures.

Basic competency: Learners should be able to identify and name 2-D shapes: square, circle, rectangle, equilateral triangle and oval.

Teacher B introduced his lesson by asking questions on the previous lesson on doubling and halving. Teacher B then told the learners that they would be learning about shapes such as a square, triangle, circle and rectangle. He told them that those shapes are classified as 2-D shapes. As every class has a TV, teacher B inserted a USB flash drive for the learners to watch the 2-D shapes on the screen. The learners watched shapes such as a triangle, square, circle and a rectangle. The presenter mentioned the main properties of each shape. As the presenter explained, teacher B illustrated the mentioned shapes using a motion trajectory of his hand(s) (i.e. tracing all the mentioned shapes in the air). Later on, teacher B played a very nice song about the shapes that they had watched before. The song emphasised that 2-D and 3-D shapes can be found in the learners' environment. Squares as windows in buildings, rectangles as drawers in the kitchen, doors and many more. The learners enjoyed watching TV. Even Nguluwe (not his real name), who at times made a noise in some lessons, did not make a noise during this lesson. The colourful shapes on the TV screen attracted his attention.

4.3.6 Lesson 6: Multiplication

Learning objective: Learners will understand basic mathematical concepts to master multiplication and numeric notation.

Basic competency: Learners should be able to multiply any two-digit numbers up to twenty by any number between one and ten, through addition or doubling.

The introduction was a recap on the previous lesson (subtraction). Since the day's lesson was on multiplication, teacher B wrote a few examples on the chalkboard on multiplication. He pointed to every number with a ruler as he explained. He told the learners that multiplication is repeated addition as indicated in the examples he gave to the learners.

Teacher B concluded his lesson by giving a class activity on multiplication. Learners used different ways such as counting on fingers, counting sticks and drawing small circles on a rough piece of paper to get the answers.

4.3.7 Lesson 7: Decomposition of numbers

Learning objective: Learners will understand how to break down and build up numbers

Basic competency: Learners will break down and build up two-digit numbers up to 99 with and without concrete objects e.g.: 25=20+5 or 15+10 etc.
20+17=37 or 30+7=37

Teacher B told the learners that the day's lesson would be about building up numbers. He further told them that built-up numbers are written out so that the value of each digit is shown e.g. 85=80+5. He pointed to the numbers on the chalkboard as he explained. He then called individual learners on the chalkboard by pointing to them to build up 43, 76, 89 and 92. In conclusion, teacher B gave an activity on breaking down and building up numbers.

4.3.8 Lesson 8: Money (Namibian currency)

Learning objective: Learners will understand how to use Namibian Currency

Basic competencies:

1. Learners should be able to name and identify all the coins and notes: $10, $20 and $50 notes and discuss their value and relevant properties e.g. size, markings, colour and value

2. Select various sets of coins and notes up to $50 which add up to a stated cost.

Teacher B started his lesson by asking the learners to name Namibian money. They named $10, $5, $1, $20, 5c, 10c, 50c, $50, $100 and $200. Teacher B then pasted a poster of Namibian money onto the chalkboard from 5c to $50. He then asked the learners to identify the properties of each item of currency in terms of size, marking, colour and value. He pointed to the money as he explained their properties.

Teacher B selected various sets of coins and notes up to $50 which added up to a stated cost. He gave examples such as 50c +50c=$1; $1+$1=$2; $10+$10=$20 and many more.

4.3.9 Lesson 9: Problem solving

Learning objective: Learners will solve story problems in everyday contexts using addition, subtraction, grouping or sharing and using any logical strategy

Basic competency: Learners should be able to use different strategies to solve problems in the range 1-5 one to fifty, by applying the four operations.

Introducing the lesson about problem solving, teacher B wrote the following questions on the chalkboard

1. Mother has 3 hens and each hen has 6 chicks. How many chicks all together?
2. Maria buys 22 pens; she gave 8 pens to a friend. How many pens does Maria have now?
3. Mom has 12 cakes. She divides them among her 3 children. How many cakes does each child get?

Teacher B asked the learners to solve the story problems. For question one, some learners drew hens on the chalkboard with six counting sticks next to each hen. Then they added all the counting sticks together and got the result of eighteen. In short, $6\times3=18$. For question two, the majority of the learners drew twenty-two small circles on the chalkboard, and then cancelled out eight, of which remain fourteen. In short, $22-14=8$.

For question three, the majority of the learners drew twelve small circles on the chalkboard and put them in groups of three and got four. In short, $12\div3=4$.

Teacher B concluded his lesson by highlighting the different strategies used by the learners.

4.3.10 Lesson 10: Addition

Learning objective: Learners will understand basic mathematical concepts

Basic competency: Add two or more numbers between zero and one-hundred mentally or by jotting, using the following strategies: Counting on (suitable sums only,e.g. 28+3), doubling and halving e.g. 30+40=30+30+10; applying known numbers facts; doing stepwise addition e.g. 58+23=58+20+3=78+3=81;and breaking down numbers and building up numbers e.g. 58+23=(50+20)+(8+3)=70+11=81.

This was an addition lesson and teacher B started it by giving a short activity to the learners on addition.

Learners took a bit of time to get the answers. They use strategies such as counting on their fingers and counting sticks. Teacher B introduced to them the method /strategy of adding in columns, emphasising that that they should always start from right to left.

Figure 4.7 below shows the types and occurrences of gestures used by teacher B in his ten lessons.

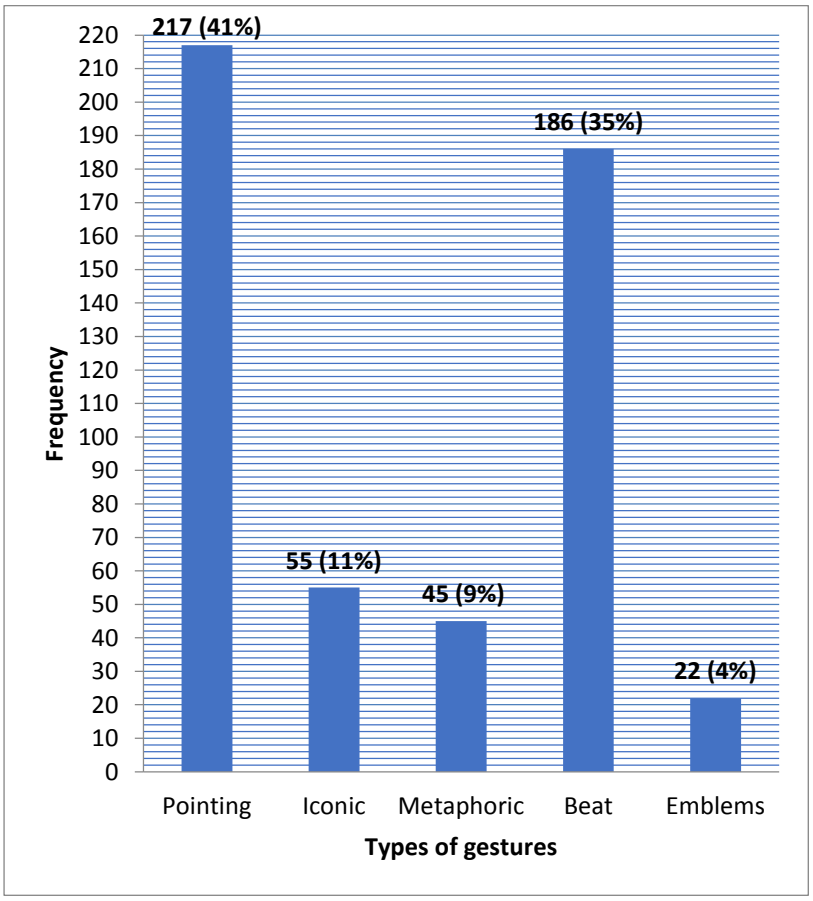

Figure 4. 7: Types of gestures used by teacher B in the ten observed lessons (cumulative frequencies)

4.3.11. Descriptions and discussions of the five types of gestures used by teacher B in his ten lessons.

1. Pointing (deictic) gestures

I observed that teacher B used a lot of pointing in all his ten lessons compared with other gestures. He pointed 217 times. He pointed to the learners when he asked them questions. Further, I observed teacher B pointing to the numbers on the chalkboard as he gave examples to the learners. He is one of the teachers that gave clear examples before he gave a class activity, and he pointed to everything that he wrote or pasted onto the chalkboard when he explained. Teacher B further pointed to the money on the poster when he taught Namibian currency. He pointed to the money as he explained the properties of the money in terms of size, markings, colour and value. He also pointed to the TV screen as he explained the physical properties of the 2-D shapes. I also observed teacher B pointing to the 2018 year calendar when he taught the twelvemonths of the year. Figure 4.8 below shows teacher B pointing to the numbers on the chalkboard as he gave examples of the decomposition of numbers.

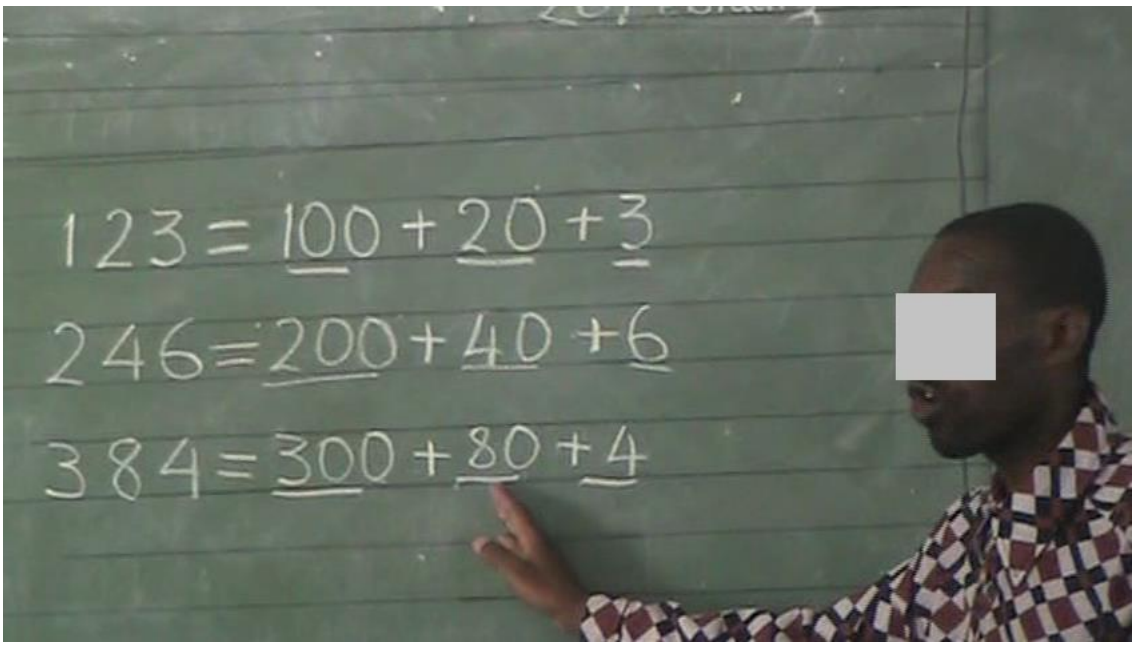

Figure 4. 8: Teacher B pointing to the numbers on the chalkboard as he explained to the learners

2. Iconic (illustrators)

Teacher B used fifty-five iconic gestures in his ten lessons to illustrate what he said. In one of the lessons, he taught the 2-D shapes (circle, triangle, square and rectangle), and he illustrated all of them with his hands. The learners watched him as he drew them in the air. Below is teacher B drawing a circle with his hands in the air while learners are watching it (circle) on the TV screen and listening to the song '*A circle goes round and round'*.

Figure 4. 9: Teacher B illustrating to the learners how a circle goes round

3. Metaphoric gestures

In total teacher B used forty-five metaphoric gestures. It was very interesting when I observed him demonstrating greater than (>) and less than (<) with his arms. Further, he also brought to class a 2018 year calendar to emphasise the 12 months of the year. When teacher B taught doubling and halving, he drew an apple on the chalkboard, then cut it in half to demonstrate 'halving'. Figure 4.10 below shows how teacher B illustrated greater than (>) and less than (<) symbols with his hands when he taught comparing and ordering.

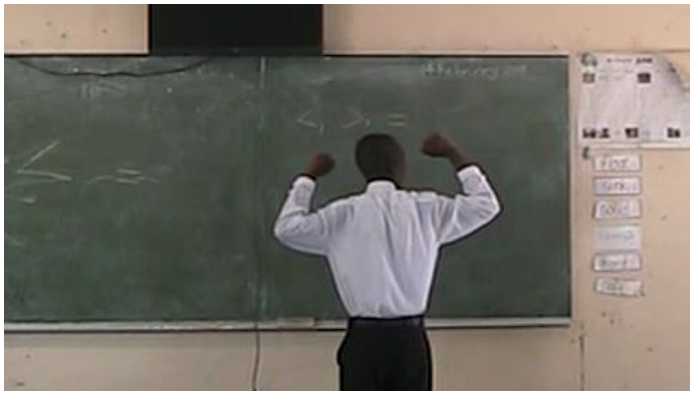

Figure 4. 10: Teacher B illustrating less than (<) with his left hand and greater than (>) with his right hand

4. Beat (motor) gestures

Teacher B used 186 beat gestures in his lessons to capture the learners' attention and to reinforce mathematical concepts. There were a few learners in his class who looked out of the window and made some noise, but teacher B made sure he caught their attention either by knocking on their tables with his hands or pipe, or regularly beating of his fingers. Moreover, I observed that teacher B emphasised most of mathematical concepts with his hands. Below is teacher B emphasising multiplication (four times two gives eight) during one of his lessons as seen in figure 4.11

Figure 4. 11: Teacher B emphasising multiplication

5. Symbolic (emblems)

Teacher B used fewer symbolic gestures compared to his other gestures. He only used twenty-two symbolic gestures in all his ten lessons. He used symbolic gestures to show his learners that he was pleased with their work (by using the thumbs-up sign) or disapproved of their behaviour (by shaking his head).

4.3.12 Interview responses for teacher B

1. Does gesturing help you in communicating with your learners? Please elaborate.

In response to this question, teacher B responded that gesturing is not only an integral component to everyday communication; it is also an important communicative visual tool in the classroom. He stated that "*gesturing helps me to communicate with my learners because it attracts the full attention of the learners".* He further added that

> *gesturing while teaching helps the learners to follow during lesson presentations because any movement or gesture you make, it will attract learners to look at you.*

He concluded by saying

> *when you are saying something and pointing to it, you will see that all the learners are looking at where you are pointing, rather than just saying something without pointing to it.*

2. What different kinds of gesturing do you think you use? Please provide examples and identify them in the video recording when this happened.

Responding to this question, teacher B mentioned using pointing gestures, iconic gestures, metaphoric gestures, symbolic gestures and beat gestures. He used pointing gestures to direct learners' attention to what he told them.

> *As you have seen in the video, I used pointing referring to the numbers or pictures on the chalkboard. I also used pointing referring to the pictures or information on the poster. I also pointed to the learners asking them to give me answers or pointing to something to attract learners' attention. I have also pointed to the TV screen when the learners where watching the 2D shapes just to make some emphasises on the properties of the shown shapes.*

Teacher B used iconic gestures to illustrate mathematical concepts, metaphoric gestures to emphasise and reinforce what he said, and beat gestures to attract learners' attention.

> *In the video recordings, I have used symbolic gestures to show the learners that I'm happy or not happy with their work. There are times whereby I nodded my head when a learner said the right answer or shook the head when the answer is not correct.*

3. What gestures do you think you use most? Why?

Teacher B responded *"in many occasions, I use pointing and beat gestures".* He noted that learners at the junior primary phase lose focus easily and as a result gesturing brings their attention back to the lesson. *"Learners at the junior primary phase lose focus easily, and for me, I either use pointing or pictures to attract their attention.* Teacher B used beat gestures to make emphasis and search for words in his mind. *"Like in beat gestures, I use it to*

emphasise the point, or searching for information or a word". He concluded *"I have observed in my videos that I can't just speak with my hands still, so I like gesturing a lot".*

4. What roles does gesturing play in teaching? Please provide examples and identify them in the video recording when this happened.

Teacher B mentioned that gesturing assisted him in clarifying, explaining, highlighting and emphasising mathematical concepts. He further indicated that learners pay attention to gestures and learn from them. Teacher B further observed that *"gesturing and visual aids such as counting sticks or pictures give mathematical concepts visible embodiments".* Lastly, he stated that *"learners in verbal plus gesture found to be more attentive".*

5. What do you want to achieve by gesturing? Please elaborate.

Teacher B mentioned that he uses gestures because he wants to accommodate all learners with different learning capabilities.

> *Every learner is unique, and can learn in different ways. Some learners learn better from gestures, while others learn well just from speech so, by using both gestures and speech in my lessons, I include all the learners learning methods, which is a whole child approach.*

6. Do you think we should encourage teachers to gesture during their lesson presentations? Please elaborate.

Teacher B agreed that teachers should be encouraged to gesture during their lesson presentations. He observed that learners learn better and perform well when one presents his/her lessons using both gestures and speech, compared to a lesson presented using speech only. Further, teacher B noted that gesturing encourages active participation, removes boredom and increases memory.

> *A teacher who gestures while teaching, will notice active participation from the learners compared to a teacher who only speak without gesturing.* He continued by saying *"a lesson whereby a teacher speaks without gestures tends to be boring and learners start sleeping than a lesson whereby a teacher gestures.*"

In conclusion, teacher B revealed that "*learners remember more when themselves and their teacher gesture".*

7. Do you think gesturing is in-born or not? Please elaborate.

In response to this question, teacher B stated that gesturing is inborn because it is hard for people to talk without gesturing. *"A person can even gesture while talking to himself/herself* ". He concluded *"it is only that some people gesture more, while others not".*

4.4 TEACHER C (GRADE 3)

Teacher C had 25 years of teaching experience at the time of the study. She is a BETD (Basic Education Teacher Diploma) holder.

For teacher C, I have only presented a summary of her ten lessons in table form. See Table 4.1 below.

The learning objectives and basic competencies of all her ten lessons were taken from Namibia Ministry of Education junior primary phase English second language and mathematics syllabus (MoE, 2015).

Table 4. 1: Teacher C's summary of the ten observed lessons.

Lesson	Learning objective	Basic competency	Brief description of lesson
1. Decomposition of numbers	Learners will understand how to break down and build up numbers.	Learners should be able to break down and build up two- and three-digit numbers in different ways up to 500, with and without concrete objects.	Teacher C started her lesson by writing the following numbers on the chalkboard: 67 = 60 +……, 67 = 50 +…. and 67 = 49 +….,.She then asked the learners which number should be added to: 60 to give 67; 50 to give 67 and lastly to 49 to give 67. She then concluded her lesson by giving an activity.
2. Doubling and halving	Learners will understand the principle of doubling and halving numbers.	Learners should be able to double numbers up to one-hundred with and without carrying.	In her introduction, teacher C asked the learners to count up to one-hundred. Later on, she wrote some examples on doubling and halving on the chalkboard. For the learners' activity, she wrote six questions on the chalkboard –three questions on doubling and the rest on halving.
3. Time (days of the week and months of the year)	Learners will understand and use time correctly.	Learners should be able to name the days of the week and the months of the year in the correct order.	Teacher C recapped on the previous lesson on doubling and halving. She then told the learners about the lesson of the day (weeks and months of the year). She asked the learners to mention the seven days of the week and later on the twelve months of the year. She concluded her lesson by giving a class activity**.**
4. Geometrical figures (3-D shapes)	Learners will identify, name and explore the attributes of three-dimensional (3-D) figures.	Learners should be able to measure 3-D shapes.	Teacher C pasted a poster on the chalkboard with 3-D shapes (cube, cuboid, cylinder, sphere and a cone) and explained to the learners the attributes of those shapes. She then demonstrated to the learners how to measure the length, breadth and the height of the cuboid using a ruler. For the learners' activity, teacher C gave each learner a piece of paper showing3-D shapes (cuboid and a cylinder). Learners were asked to measure the length, breadth and height of the cuboid and the height of the cylinder.
5. Problem solving	Learners will solve story problems about everyday contexts using addition, subtraction, grouping or sharing and using local strategies.	Learners should be able to use different strategies to solve problems, and write story problems using number sentences in the number range one to one-hundred, by applying the four operations.	As an introduction, learners counted in threes up to thirty. Teacher C then told the learners about the lesson of the day (problem solving). She gave three examples on problem solving and concluded her lesson with a class activity.
6. Money (Namibian currency)	Learners will understand how to use Namibian currency.	Learners should be able to name and identify all the coins and N$10, N$20 and N$50 notes and discuss their value and relevant properties e.g. size, markings, colour and	After a recap on the previous lesson, teacher C asked the learners to name Namibian money. They named the coins and notes from 5c to N$200 as per the teacher's instruction. Teacher C pasted the real coins on the chalkboard as well as the poster of Namibian notes. She then selected various sets of coins and notes up to N$200 which added up to a stated cost. E.g. 5c + 5c = 10c, N$10+N$20 =N$30, N$100 + N$100= N$200 and many more. No

		value.	conclusion was made because the bell rang while she was still giving examples.
7. Money (Namibian currency) continuation	Learners will understand how to use Namibian currency.	Learners should be able to select various sets of coins and notes up to N$50 which add up to a stated cost.	As an introduction, teacher C asked the learners some questions on the previous lesson. She then gave a class activity on doubling and halving of money.
8. Length	Learners will understand the importance of measuring length and its application to everyday life.	Learners will use standard units of centimetre and metre to measure length (rulers for more accurate measurements, tape for curved lines, etc.) and write down measurements using the correct abbreviations: m, cm.	Teacher C started her lesson by telling the learners about the day's lesson (measuring length). She then gave each learner a ruler and a piece of paper with three drums (A, B and C) of different heights. She then pasted the same paper on the chalkboard and demonstrated to the learners how to measure the height of drum A. She then told the learners to measure the heights of drums B and C.
9. Place value	Learners will recognise digit position and place value.	Learners should be able to identify the place value of hundreds, tens and units in three-digit numbers e.g. in the number 958 the value of the 9 is 900, the value of 5 is 50 and the value of the 8 is 8.	Teacher C started her lesson by writing 345, 476 and 895 on the chalkboard. She then asked the learners to give the value of each number. Teacher C did not waste any time. After emphasising on few points, she gave a class activity.
10. Problem solving	Learners will solve story problems about everyday context using addition, subtraction, grouping or sharing and using any logical strategies.	Learners should be able to use different strategies to solve problems and write story problems using number sentences in the number range one to one-hundred by applying the four operations	Teacher C taught this lesson once before. Perhaps the learners did not master the basic competency and that's why she decided to teach it for the second time. She gave few examples on word problems before a concluding activity.

Figure 4.12 below shows the types and occurrences of gestures used by teacher C in her ten lessons.

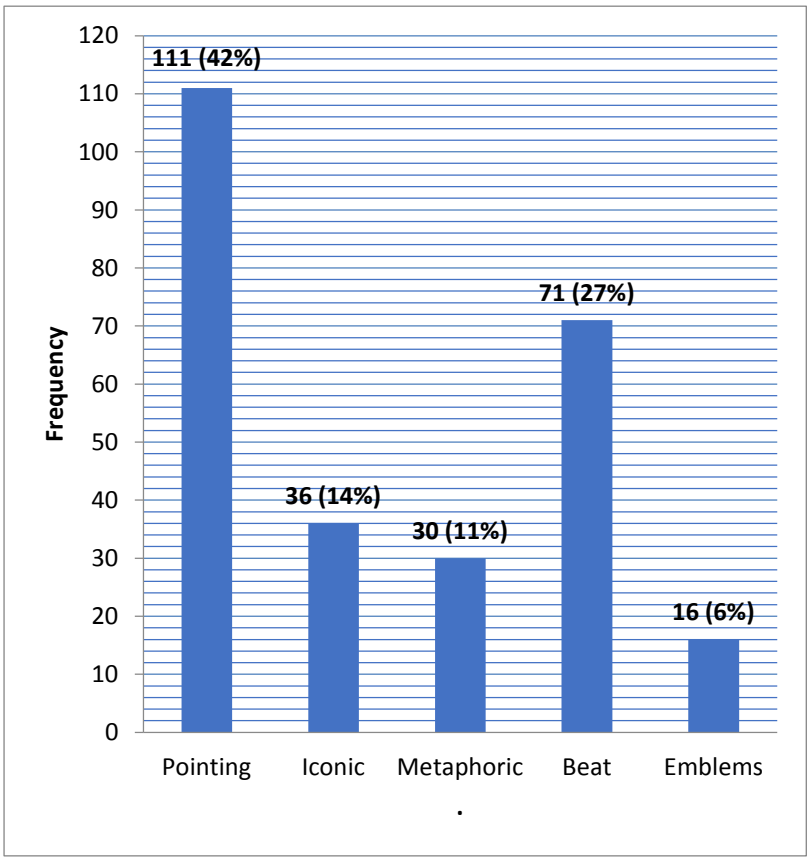

Figure 4. 12: Types of gestures used by teacher C in the ten observed lessons (cumulative frequencies)

4.4.1 Descriptions and discussions of the five types of gestures used by teacher C in her ten lessons.

1. Pointing (deictic) gestures

Teacher C used a lot of pointing gestures in all her ten lessons, compared to other gestures. She pointed 111 times. She pointed to the learners when she asked them questions. She further pointed to the numbers on the chalkboard when she gave examples and explained the class activities to the learners. I further observed teacher C pointing to Namibian money (coins and notes) as she explained their values and relevant properties in terms of size, markings, colour and value. Figure 4.13 below is evidence of teacher C pointing to Namibian

money that she pasted on the chalkboard as she explained their values and properties when she taught about Namibian money.

Figure 4. 13: Teacher C pointing to Namibian money

2. Iconic (illustrators) gestures

I observed that teacher C did not use iconic gestures as much as she used pointing and beat gestures. She only used thirty-six iconic gestures in her ten lessons. When she taught 3-D shapes (cube, cuboid, cone, cylinder, and sphere), she illustrated these shapes by tracing them in the air as she described their properties. When teacher C taught measurement (height), her hands illustrated height as she demonstrated to the learners how to measure the height of the drums using a ruler. Below is Figure 4.14 of teacher C illustrating to the learners how to measure the heights of the drums.

Figure 4. 14: Teacher C illustrating 'height'

3. Metaphoric gestures

Teacher C used thirty metaphoric gestures in her ten lessons. She used counting sticks and bottle tops as a substitute for numbers. She manipulated these counting sticks and bottle tops for addition and subtraction. Figure 4.15 below serves as proof that counting sticks are being used by the learners for addition and subtraction.

Figure 4. 15: Counting sticks as metaphors for numbers

4. Beat (motor) gestures

Teacher C used seventy-one beat gestures in her ten lessons. In most cases, she used beat gestures to emphasise her points and capture the learners' attention by making rapid flicks of her fingers and hands. I also observed teacher C moving her hands repetitively whenever she was searching for certain words in her mind.

5. Symbolic (emblems)

Teacher C used symbolic gestures the least. She only used sixteen emblems. I observed her shaking her head when learners gave wrong answers.

4.4.2 Interview responses for teacher C

1. Does gesturing help you in communicating with your learners? Please elaborate

Teacher A indicated that gesturing helped her in communicating with her learners. She stated that *"gesturing and speech work together and when I am teaching while gesturing at the same time, my learners understand me very well".*

2. What different kinds of gesturing do you think you use? Please provide examples and identify them in the video recording when this happened.

In response, teacher C mentioned using pointing gestures, iconic gestures, metaphoric gestures, symbolic gestures and beat gestures. Concerning pointing gestures, teacher C mentioned that "*as you can see in the video recording, I used pointing gestures in all my lessons as I have pointed to the learners and to the numbers on the chalkboard".* She went on by saying *"I have also used iconic gestures to demonstrate concepts to my learners".* Teacher C continued by saying

> *I used metaphoric gestures as you can see in the video to explain some actions, beat gestures to emphasise what I was saying and symbolic to show my learners to keep quiet.*

3. What gestures do u think you use most often? Why?

Teacher C mentioned using pointing gestures the most, followed by beat gestures. She revealed that she used pointing gestures to request answers from her learners. *"Sometimes when I forget the learners' names instead of wasting time in searching their names, I just point to them".* She further indicated that she used pointing gestures to direct learners' attention to numbers and objects (pictures, posters, Namibian money) that she referred to. *"I pointed to the numbers on the chalkboard, when I am giving examples to the learners".* She continued

> *I pasted real Namibian coins on the chalkboard and I pointed to them when I showed my learners that this is 5c, 10c, 50c, N$1, N$5 and N$10. Again, I have used a lot of beat gestures to emphasise my points.*

Teacher C further indicated that she used beat gestures to look for words in her mind. *"Sometimes when I forget a word, I use beat gestures as I just move my hands repetitively while searching for that word"*.

4. What roles do gesturing play in your teaching? Please provide examples and identify them in the video recording when this happened.

Responding to this question, teacher C stated that gesturing played a lot of roles in her teaching. She mentioned active participation. *"Gesturing will make the learners to participate in the lessons".* She further revealed that gesturing attracted her learners' attention. *"Gesturing makes the learners to look at me and observe what I am doing".* Teacher C went on by saying gesturing assisted her in emphasising mathematics concepts. Lastly, teacher C mentioned that *"gesturing helps the learners understand mathematical concepts easily and fast.*

5. What do you want to achieve by gesturing? Please elaborate

Teacher C revealed that she gestured simply because she wanted her lessons to be well understood by all learners, her learners to perform well, to attract the learners' attention, to explain concepts more clearly to her learners, and lastly she wanted her lessons to be more interesting.

6. Do you think we should encourage teachers to gesture during their lesson presentations? Please elaborate.

Smilingly, teacher C responded "*yes*" (while nodding her head) to this question. She strongly believed that teachers should be encouraged to gesture during their lesson presentations. Teacher C indicated that gesturing is very useful to learners, particularly young ones. *"Gesturing is good for young learners and it can make learners to pass well".* She however revealed that not **all** teachers are aware of the importance of gesturing to the teaching-learning process. "*Some teachers, more especially old ones do not know that gesturing is very important during lesson presentations".* She went on by saying *"even me, I did not know much about gestures, only after you told me that's when I learnt more about them".* In

conclusion, teacher requested me to conduct teachers' workshops on gesturing. *"Please make workshops especially to us old teachers because we don't know much about gesturing".*

7. Do you think gesturing is in-born or not? Please elaborate

Teacher C strongly believed that gesturing is in-born. *"Gesturing is an in-born thing because when people talk, they move their hands and other body parts".* She further stated *"not only teachers, but even pastors, councillors, headmen and others gesture when delivering their speeches".*

4.5 SUMMARY OF GESTURES USED BY THE THREE TEACHERS

According to the literature, teaching involves not only the words and sentences that a teacher utters and writes on the board during a lesson, but also all the hand/arm gestures, body movements, and facial expressions a teacher performs in the classroom (Pozzer-Ardenghi & Roth, 2007). When I observed these teachers' thirty lessons, I noted that they did not only present their lessons in speech alone, they used gestures too. A total of 1 286 gestures were used to support their teaching and illustrate mathematical concepts. These concepts were mostly concrete, but some were abstract. They used 513 (40%) pointing gestures, 342 (27%) beat gestures, 218 (17%) iconic gestures, 133 (10%) metaphoric gestures and 80 (6%) emblems. Interestingly, the participant teachers passed on the gesturing practice to most of the learners. This is in agreement with the literature, that by gesturing themselves, not only do teachers improve the quality of a lesson but they also create a classroom culture that includes gesturing (Goldin-Meadow, 2004).

Further, even though the participant teachers used different teaching styles such as visual, auditory and kinaesthetic, their teaching was dominated by a **visual** approach. These teachers did not only use gestures as visualisation tools, they also had other visual aids (concrete objects) such as counting blocks, counting sticks, an abacus, bottle tops, beads, posters, real Namibian money and pictures in their classrooms. This goes hand in hand with Flevares and Perry's (2001) statement that learners must attend to the visual as well as the vocal means of expressing information to gain access to all of the information presented in mathematics lessons. Below is figure 4.16 showing the five types of gestures used by the three teachers.

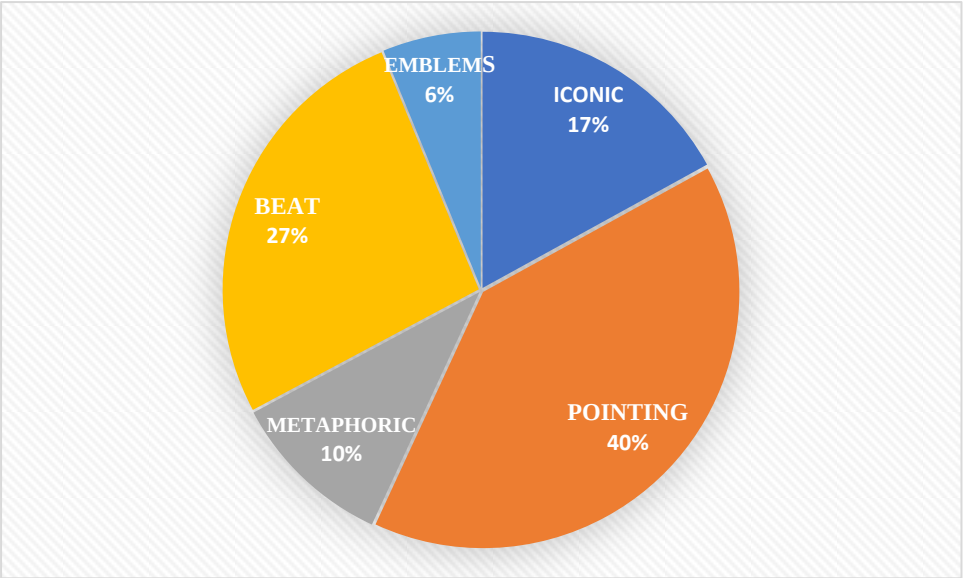

Figure 4. 16: Summary of the five types of gestures used by all three teachers in their observed lessons

1. Pointing (deictic) gestures

According to the literature, speakers often use pointing gestures to indicate persons, objects, directions, inscriptions or locations in the physical environment (Alibali et al., 2014).I observed that the participating teachers used a lot of pointing gestures in their lessons compared to other gestures, in order to point to learners, objects, inscriptions and locations in the classroom. They pointed to the learners when they asked them specific questions. It was at the beginning of the year and the teachers did not know all the learners by their names, so pointing to the learners was the only option. Further, in the case where there were learners in the same class sharing a name (e.g. two Gideons or Nelaos), instead of the teacher calling them by their surnames, they just pointed to the one they referred to. Moreover, teachers pointed to the numbers, shapes and pictures on the chalkboard, activities and pictures on the worksheets as well as to the money pasted on the chalkboard to index what they were referring to.

2. Iconic (illustrators) gestures

I observed that the teachers used iconic gestures to represent object attributes, spatial relationships and actions that related to what they were saying at that moment. McNeill (1992) observes that iconic gestures are closely related to speech, describing what is spoken,

through hand gesture. In one of the lessons, teacher A illustrated object attributes such as short, tall, big, small and many more with her hands. Further, teacher A demonstrated to the learners some actions such as brushing teeth, washing the face, combing hair and running to school. I further observed teacher A using the bodies of the learners in relation to their chairs to illustrate spatial relationships, such as 'in front of', 'behind', 'on top of' and 'under'. Further, teacher B and C illustrated the 2-D (circle, triangle, square and rectangle) and 3-D (cube, cuboid, cone, cylinder and sphere) shapes with their hands.

3. Metaphoric gestures

I observed that the participating teachers used metaphoric gestures to shape and explain abstract concepts by creating physical representations. Teacher B illustrated mathematical symbols such as greater than (>) and less than (<) with his arms. The literature states that some metaphoric gestures reflect body-based conceptual metaphors. Thus, they reveal that some aspects of mathematical concepts are embodied (Alibali & Nathan, 2012). Further, teacher B used a year calendar to emphasise the twelve months of the year. Moreover, I observed him drawing an apple on the chalkboard, then cutting it in half to demonstrate 'halving'. Available materials such as clay to construct numbers, bottle tops for counting and beads for making mathematical patterns were used by teacher A. She also used pictures to represent day and night. Counting sticks as a substitute for numbers were among the local materials used in the class by all the teachers. They manipulated these counting sticks for addition and subtraction. This is in agreement with Alibali et al. (2013) who affirm that by representing an abstract action through a familiar physical action, the teacher's gestures may help the learners to grasp the instructional material, thereby promoting the common ground.

4. Beat (motor) gestures

The participating teachers used simple up-and down rhythmic movements of their hands when they were searching for words in their minds, to grab learners' attention and to emphasise what they said. Songs and music were also used in some lessons by teacher A and B to reinforce mathematical patterns.

5. Symbolic (emblems)

Emblems where used the least, compared to the other gestures. According to McNeill (1992), emblems, such as the 'thumbs up' or 'peace sign', are hand configurations that have a culturally specific meaning, and unlike co-speech gestures, they convey information independently of speech. On a few occasions the participating teachers nodded their heads for approval and disapproval of the learners' behaviour, held their fingers tightly to their lips to request silence and praised their learners' good work by using the thumbs-up sign. Mustafa, Nusantara, Subanji and Irawati (2016) observe that teachers' gestures can represent attitudes, emotions and feelings and can explain the process that is going on in their minds to the learners during the learning of mathematics.

4.6 SUMMARY OF INTERVIEWS

All the three teachers strongly believed that gesturing is an important visual bodily action that plays important roles during the interaction between learners and teachers in the mathematics classroom. The teachers' views and perceptions on the roles and functions of gestures are discussed below and they are coded as follow: (**TAQI: TA** stands for teacher A and **Q1** stands for question 1.

4.6.1 Gestures as a communicative tool

All teachers made an interesting observation that all people gesture when they speak/talk. They indicated that gestures' main purpose is to aid communication. TCQ7 observed that *"when people talk, they move their hands and other body parts. Even pastors, councillors, headmen and others gesture when delivering their speeches".* Further, TBQ7 noted that

> *it is hard for people to talk without gesturing. Not only teachers that gesture when they teach; many people gesture. A person can even gesture while talking to himself/herself. It is only that some people gesture more, while others not". It is almost impossible for a person to speak without gesturing.*

Similarly, TAQ7 observed that

> *every time a person is speaking, the person is moving his/her hands; the person is either pointing go there what, what like that. I think it is an in-born thing. But I also think it can be learnt and practiced in schools if teachers are*

> *made aware of it and learn the importance and impacts it has on learners' learning.*

Novack and Goldin-Meadow (2015) indicate that since gesturing occurs most often in communicative contexts, we might guess that gesture's main purpose is to aid communication. Castellon and Enyedy (2006) however state that gestures and speech are not only resourceful tools to communicate with the listener(s), but are also purposeful methods that facilitate learning in educational settings.

4.6.2 Gestures attract learners' attention

All the teachers noted that learners pay more attention to the information conveyed in gestures and learn from them. In support, TAQ6 stated that *"at junior primary phase, this little kids the only way they can catch your full attention is when the teacher gestures".* TBQ3 shared the same sentiment *"learners at the junior primary phase lose focus easily. For me, I either use pointing or pictures to attract their attentions".* He further indicated that

> *when you are pointing to something on the chalkboard, you will find out that all the learners will look at where you are pointing and they pay more attention to what you are saying, that means learners pay more attention to information communicated in both gestures and speech.*

In agreement, TCQ4 mentioned that *"gesturing makes the learners to look at me and observe what I am doing.* The above-mentioned resonates with Alibali, Nathan, Fujimori, Stein, and Raudenbush (2011) who observed that teachers use gestures to guide learners' attention to relevant aspects of the mathematical task at hand.

4.6.3 Gestures remove boredom

TA and TB revealed that gesturing removes boredom in the classroom. TAQ4 stated that

> *gesturing helps learners not to be bored in the lesson. It actually chases boredom because sometimes if a teacher does not gesture learners may become sleepy and loose interest in the lesson and this may hinder their performance.*

She further added that "*If you are just teaching and you are just straight not gesturing it even becomes boring".* Similarly, TBQ6 mentioned that

> *It is also noted that a lesson whereby a teacher speaks without gestures tends to be boring and learners start sleeping then a lesson whereby a teacher gestures.*

4.6.4 Gestures help learners understand mathematical concepts easily

All teachers emphasised that gesturing aids the understanding of mathematical concepts. TBQ4 stated that

> *learners learn concepts easily when a teacher demonstrates or illustrates them in gestures and as a result, they will not forget them easily because the picture will always be in their minds.*

He further indicated that

> *learners in verbal-plus gesture condition produce more correct judgement of symmetry and more advanced explanations of the concept, then learners in verbal only condition.*

In support of teacher B, TCQ4 highlighted that

> *gesturing helps the learners understand mathematical concepts easily and fast. When you are explaining while gesturing, learners will learn so fast.*

Moreover, TAQ4 added that *"gesturing helps my learners to understand concepts quickly and also learn fast not like when you are not gesturing".*

She went on by saying

> *gesturing also play that role that it aids learners' understanding of concepts because if you are teaching and you are gesturing, you are illustrating what you are saying and as a result, learners will both see and hear at the same time. For example, if you are saying tall, short, big, small etc. and you are illustrating with your hands, learners will say* ohooooo*....it is like this and they will never forget it".*

In addition, TAQ3 stated that

> *I was teaching spatial relations concepts such as in front of, behind, below, above, on top of and under. As I was teaching these concepts I was using a chair to demonstrate to the learners what I was saying. I demonstrated on top of by putting my hands on top of the chair and when I was demonstrating under, as I say the word under, my hands were also under the chair. I demonstrated all the mentioned spatial relation concepts to my learners with my hands.*

4.6.5 Gestures assist in clarifying, explaining and emphasising mathematical concepts to the learners

All the teachers mentioned that gesturing helps in clarifying, explaining, highlighting and emphasising mathematical concepts to the learners. TAQ4 mentioned that *"gesturing also "assists in clarifying, explaining, and emphasising mathematical concepts e.g. big and tiny etc."*

She further added that

> *gesturing also helps when for example learners get confused or struggle to understand concepts; the teacher can use gestures in clarifying the concepts to learners.*

Similarly, TBQ4 outlined that gesturing *"assists in clarifying, explaining, emphasising as well as in highlighting mathematical concepts to the learners".* In addition, TCQ4 also stated that *"gesturing helps me to emphasise mathematics concepts".* This is in agreement with Castellon and Enyedy (2006) who observe that teachers' gestures and talk assisted in clarifying, explaining, highlighting and emphasising mathematical concepts to their learners and resolved multiple meanings.

4.6.6 Gestures accommodate all learners with different learning abilities

All the teachers strongly believed that gesturing accommodates all learners in the classroom be they fast, average or slow. TAQ4 stated that

> *you know in the classroom you just don't have smart learners only. We have learners with different learning styles. So, gesturing accommodates all the learners with different learning abilities be it fast or slow learners. Fast learners might learn easily with speech alone while slow learners might learn easily when they both hear (speech) and see (gestures or pictures).*

In support, TBQ5 stressed that

> *every learner is unique, and can learn in different ways. Some learners learn better from gestures, while others learn well just from speech. By using both gestures and speech in my lessons, I include all the learners learning methods, which is a whole child approach.*

4.6.7 Gestures increase learners' performance and encourage recollection

All the teachers revealed that incorporating gestures in the teaching-learning process of mathematics increases learners' performance and makes learners remember/recall what their teachers taught them. In support, TBQ6 affirmed that *"*

> *learners learn better and perform well when the teacher presents his/her lesson in both gestures and speech compared to lessons presented in speech only.*

In agreement, TAQ4 mentioned that

> *learners also remember more when themselves and their teacher gestures; thus gesturing improves the quality of the lesson. Gesturing increases learners' performance.*

She further argued that *"If you as a teacher you gesture, learners will also imitate you and in the process they are learning".* Likewise, TCQ6 stated that *"gesturing is good for young learners and it can make learners to pass well".* The participant teachers are in agreement with Goldin-Meadow and Wagner (2005) who in one of their studies found that both children and adults remembered more words when they gestured than when they did not gesture.

4.6.8 Gestures encourage learners' active participation

All the teachers acknowledged that gesturing encourages learners' active participation. TCQ4 stated that *"gesturing will make the learners to participate in the lessons"* in agreement, TAQ4 indicated that *"gesturing makes your learners to participate actively".* Moreover, TBQ6 suggested that *"teachers should be encouraged to gesture during their lesson presentations because gesturing encourages active participation".* He further revealed that *"a teacher who gestures while teaching, will notice active participation from the learners compared to a teacher who only speak without gesturing".*

4.6.9 Gestures represent abstract concepts in a concrete form and help learners visualise them

Teachers A and B stated that gestures illustrate abstract concepts in physical form, thus learners will visualise an image in their minds and use it to solve the problem at hand.TAQ6confirmed that "*gesturing helps learners visualise abstract concepts in their mind and represent abstract concepts in a concrete form*". In addition, TBQ4 indicated that

"*gesturing and visual aids such as counting sticks or pictures give mathematical concepts visible embodiments*". Flevares and Perry (2001) state that non-spoken media such gestures, graphs, written symbols, and counting blocks can be essential to give mathematical concepts visible embodiments.

4.6.10 Gestural movements and utterances provide opportunities to teachers to articulate their thoughts and hunches without having to rely on speech alone.

All the three teachers indicated that when a person is searching for a word, gestural movements provide convenient ways of finding those words. TCQ3 declared that *"sometimes when I forget a word, I use beat gestures as I just move my hands repetitively while searching for that word"*. In support, TAQ2 stated that

> *I have also used beat gestures by moving my hands when I am searching for a word for example I want to say something and I forget it, I have to search for that word in my mind like mmmmmm, aaaaaaaaaaa.*

Similarly, TBQ3 indicated that "*like in beat gestures, I use it to emphasise the point, or searching for information or a word".*

4.7 CONCLUSION

This chapter presented and discussed the findings of the research project drawn from thirty lesson observations and stimulus-recall interviews. I firstly analysed each teacher's lesson and extracted all the gestures that the teacher used in the ten lessons. I then analysed each teachers' interview and concluded with a summary of the five types of gestures used by the three teachers and finally with a summary of interviews on their views and perceptions of the roles and functions these gestures play as visualisation tools in the teaching of mathematics. The themes used to categorise and discuss data came from the analytical tool and some emerged from the interviews.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This case study critically analysed the types of gestures that three selected mathematics teachers at the junior primary phase (Grades 0–3) used in their teaching, and for what purposes. The research questions that the study sought to answer were:

1. What are the types of gestures that selected junior primary teachers use in the teaching of mathematics?

2. What are the selected teachers' views and perceptions of the roles and functions these gestures play as visualisation tools in the teaching of mathematics?

This chapter concludes the study by presenting the following:

- Summary of findings
- Significance of the study
- Limitations of the study
- Recommendations
- Personal reflections
- Conclusion

5.2 SUMMARY OF FINDINGS

The summary of findings for this study is presented as they pertain to each research question.

Research question 1

What are the types of gestures that selected junior primary teachers use in the teaching of mathematics?

The types of gestures that the participating teachers used were drawn from classroom observations and are classified according to McNeill's (1992) framework; namely pointing

(deictic) gestures, iconic (illustrators) gestures, metaphoric gestures, beat (motor) gestures and symbolic (emblems) gestures.

1. Pointing (deictic) gestures

The participating teachers used pointing gestures in their lessons in order to point to learners, objects, inscriptions and locations in the classroom. All the participants pointed to the learners when they asked them specific questions. They also pointed to numbers, shapes and pictures that were placed on the chalkboard and appeared on activities in the various worksheets. Further, two of the teachers pointed to money that was pasted on the chalkboard to illustrate what they were referring to.

2. Iconic (illustrators) gestures

Iconic gestures were used by the teachers to represent object attributes, spatial relationships and actions that related to what they were saying. One of the participating teachers illustrated object attributes such as short, tall, big, small with her hands. Further, the bodies of the learners in relation to their chairs were used to illustrate spatial relationships such as in front of, behind, on top of and under were used by one of the participant. Moreover, two of the participating teachers illustrated the 2-D (circle, triangle, square and rectangle) and 3-D (cube, cuboid, cone, cylinder and sphere) shapes with their hands.

3. Metaphoric gestures

All the participating teachers used available materials in the learners' environment such as counting sticks and bottle tops as substitutes for numbers. At some point, beads were also used to make mathematical patterns by one participant. Moreover, pictures were also used to represent day and night as well as 2-D and 3-D shapes. Furthermore, one of the teachers illustrated mathematical symbols such as greater than (>) and less than (<) with his hands. A year calendar was used to emphasise the twelve months of the year. One of the teachers demonstrated 'halving' by drawing an apple on the chalkboard and then cut in half.

4. Beat (motor) gestures

All the participating teachers used simple up-and-down rhythmic movements of their hands when they were searching for words in their minds, to grab learners' attention and to emphasise what they said. Two of the teachers used songs and music in some lessons to reinforce mathematical patterns.

5. Symbolic (emblems) gestures

The participating teachers only rarely expressed their emotions and feelings to the learners by using symbolic gestures. They nodded their heads for approval and disapproval of the learners' behaviours, held their fingers tightly to their lips to request for silence and praised their learners' good work by using the thumb-up sign.

Research question 2

What are the selected teachers' views and perceptions of the roles and functions these gestures play as visualisation tools in the teaching of mathematics?

The participating teachers' views and perceptions were drawn from the stimulus-recall interviews, and the following themes emerged:

- **Gestures as a communicative tool**

All teachers made an interesting observation that all people gesture when they speak. Thus, gesturing is a form of communication because it serves as an important part of the whole speaking process. In the classroom setting, teachers indicated that they use gestures to communicate mathematical ideas to the learners.

- **Gestures attract learners' attention**

The participating teachers mentioned that gestures focus learners' attention on objects and inscriptions in the classrooms. When a teacher points to pictures, numbers, calendars, shapes and other objects, most learners will definitely look at what the teacher is pointing to. The teachers also observed that learners at the junior primary phase (Grades 0 –3) lose interest easily. Gestures assist the learners to keep focus and not lose concentration.

- **Gestures remove boredom**

The teachers mentioned that lessons only presented verbally tended to be boring compared to ones presented verbally, combined with gestures. Boring lessons may hinder the learners' ability to concentrate and instead lose focus by looking out of the windows, start making a noise or even go to sleep.

- **Gestures assist in clarifying, explaining and emphasising mathematical concepts to the learners**

The teachers suggested that using gestures enhances their verbal explanations of mathematical concepts and ideas. Making use of their whole bodies adds interest and assists in illustrating abstract concepts to learners.

- **Gestures accommodate all learners with different learning abilities**

The teachers strongly believed that gesturing speaks to all learners in the classroom. They said that gesturing can assist both the slow and quick learners.

- **Gestures increase learners' performance and encourage recall**

All the teachers revealed that incorporating gestures in the teaching and learning process of mathematics increases learners' performance and thus improves the quality of the lesson. They further were of the opinion that both teachers and learners remembered more concepts when they gestured than when they did not.

- **Gestures encourage learners' active participation**

All the teachers acknowledged that gesturing helps in getting learners to participate. They noted that a teacher who gestures while teaching will generate more active participation from the learners compared to a teacher who does not use gestures.

- **Gestures represent abstract concepts in a concrete form and help learners visualise them.**

The teachers indicated that gesturing and using visual aids such as counting sticks, bottle tops, beads, pictures and shapes give mathematical concepts visible embodiments, implying that learners will thus visualise an image in their minds that they can use to solve the problem at hand.

- **Gestural movements and utterances provide opportunities to teachers to articulate their thoughts and hunches without having to rely on speech alone.**

All the three teachers indicated that when a person is searching for a word in his/her mind, gestural movements provide convenient ways to articulate their opinion and hunches without having to rely on speech alone.

The teachers also believed that gesturing is inborn. This is evident because some teachers gesture a lot while others do not. Nevertheless, it would still be helpful if teachers are made aware of the usefulness of gestures and the importance of their strategic use. Furthermore, one of the teachers indicated that some teachers are quite ignorant that gestures form an important part of lesson presentation. Thus, she suggested teachers' workshops on gesturing would be very useful.

5.3 SIGNIFICANCE OF THE STUDY

This study enriched the participants' understanding and knowledge on the roles and functions of their gestures in the teaching of mathematics. I am therefore hoping that they will share their experiences, views and perceptions with other teachers at different schools through workshops. This would not only benefit the Namibian children of the participating teachers but would also assist in spreading the results of this research a little wider. The study is anticipated to contribute towards understanding the links between visualisation and gestures. It is further hoped that the findings of this study will create critical awareness in mathematics teachers, senior education officers, and directors of education, policy makers, curriculum

designers and researchers that teaching involves not only the spoken words and sentences and writing on a chalkboard, but also includes body movements and gestures.

5.4 LIMITATIONS OF THE STUDY

This study involved only three participants, although the initial target was four Grades 0 –3 teachers. This is a very small sample and thus its findings cannot be generalised across all the Grades 0 –3 in Namibia. Furthermore, due to the small scope of this study, it was not feasible for me to capture all the gestures of all the participants because some of the lessons were shorter than others.

5.5 RECOMMENDATIONS

Based on the findings of this research, I recommend the following to stakeholders such as teachers, learners, policy makers, curriculum designers, senior education officers and heads of departments. I also make recommendations for further research.

5.5.1 Recommendations for teachers and learners

The study indicated that the appropriate use of gestures is acknowledged as a legitimate teaching strategy that supports good teaching. I thus recommend that mathematics teachers integrate gestures into their lessons and use them strategically. In addition, teachers should observe each other's lessons when incorporating gestures in their mathematics lessons and learn from one another.

Further, the findings suggest that learners whose teacher gestures during a lesson are more likely to gesture as well, which in turn can assists the learning process. I therefore recommend that teachers should create opportunities for learners to gesture in the classroom, provided their gestures do not give mixed messages to the teacher and fellow learners.

5.5.2 Recommendations for policy makers and curriculum designers, senior education officers and heads of departments for mathematics

- Policy-makers should encourage curriculum designers to promote the incorporation of gestures as visualisation tools in the teaching of mathematics at all school phases.
- Senior education officers for mathematics should facilitate workshops in their regions whereby all mathematics teachers can be trained on how to incorporate gestures in their mathematics lessons and be encouraged to use them strategically.
- Heads of departments for mathematics should encourage their colleagues to use gestures and critically observe each other doing so.

5.5.3 Recommendations for further research

For further research, I recommend that a similar study be done with:

- A larger sample size and more research sites in order to provide a wider picture which could lead to generalisations of the results;
- Senior primary phase (Grades 4 –7), junior secondary phase (Grades 8 –9) and senior secondary phase (Grades 10 –11) teachers because their gestures and their roles might be different from the ones the junior primary (Grades 0 –3) teachers used;
- Learners because the narratives in this study were based only on teachers. The narratives told by learners might well be different.
- Hearing-impaired people since they are unable to hear and only communicate by using sign language, i.e. gestures. Their views and perceptions might add to a fuller understanding of the richness of using gestures strategically and meaningfully.

5.6 PERSONAL REFLECTIONS

It was a wonderful opportunity for me to take this inspiring, interesting and educative journey. In this section, I will share my research experiences throughout the entire journey.

Firstly, let me start with my writing skills. At the beginning of my journey, I made a lot of grammatical errors in my writing and I could not write in an academic style. Further, I struggled to reference and quote properly. I struggled to write clearly and unambiguously, leaving my supervisor with a lot of questions. He would often ask ‘what do you mean here?’,

‘why are you doing this’ and many more. Through the positive correction comments and encouragements from my humble supervisor, I improved with every draft I submitted to him. I am really thankful for that.

Moreover, this study opened my eyes to the virtues of reading. I had to read many articles, texts, books and journals in order to grapple with my research interest and questions on gestures and visualisation. I thereby broadened my knowledge base and understanding of many things that I did not know before. In addition, during this journey, I met fellow researchers and got an opportunity to listen to their ideas, research problems and findings in different areas.

Furthermore, it is through this study that I learnt that dealing with learners at the junior primary grades, particularly the ones in Grade 0 is not as easy as what I initially thought. One needs to be very patient, humble and caring. These learners have a very short concentration span and seem to lose interest easily. The use of pictures, concrete objects and teachers’ gestures attracts their attention and are therefore very important tools to use.

Finally, this study has developed me professionally and academically. I am no longer the same Nelao I was before I started this research process, and for that I am pleased.

5.7 CONCLUSION

This chapter concludes the study by presenting the summary of findings, significance of the study and limitations of the study. I also made some recommendations and reflected on my experience throughout my entire journey.

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APPENDICES

APPENDIX A: ETHICAL CLEARANCE

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

EDUCATION FACULTY • PO Box 94, Grahamstown, 6140
Tel: (046) 603 8385 / (046) 603 8393 • Fax: (046) 622 8028 • e-mail: d.wilmot@ru.ac.za

PROPOSAL AND ETHICAL CLEARANCE APPROVAL

Ethical clearance number 2018.01.01

The minute of the EHDC meeting of 5 October 2017 reflect the following:

2018.01.01 CLASS B RESTRICTED MATTERS
MASTER OF EDUCATION RESEARCH PROPOSALS

To consider the following research proposal for the degree of Master of Education in the Faculty of Education:

***Dietlinde Namakalu* (17N8214)**

Topic: An analysis of the roles of teachers' gestures as visualisation tools in the teaching of mathematics at the junior primary phase (Grades 0-3).

Supervisor: Professor M Schäfer

Decision: *Approved*

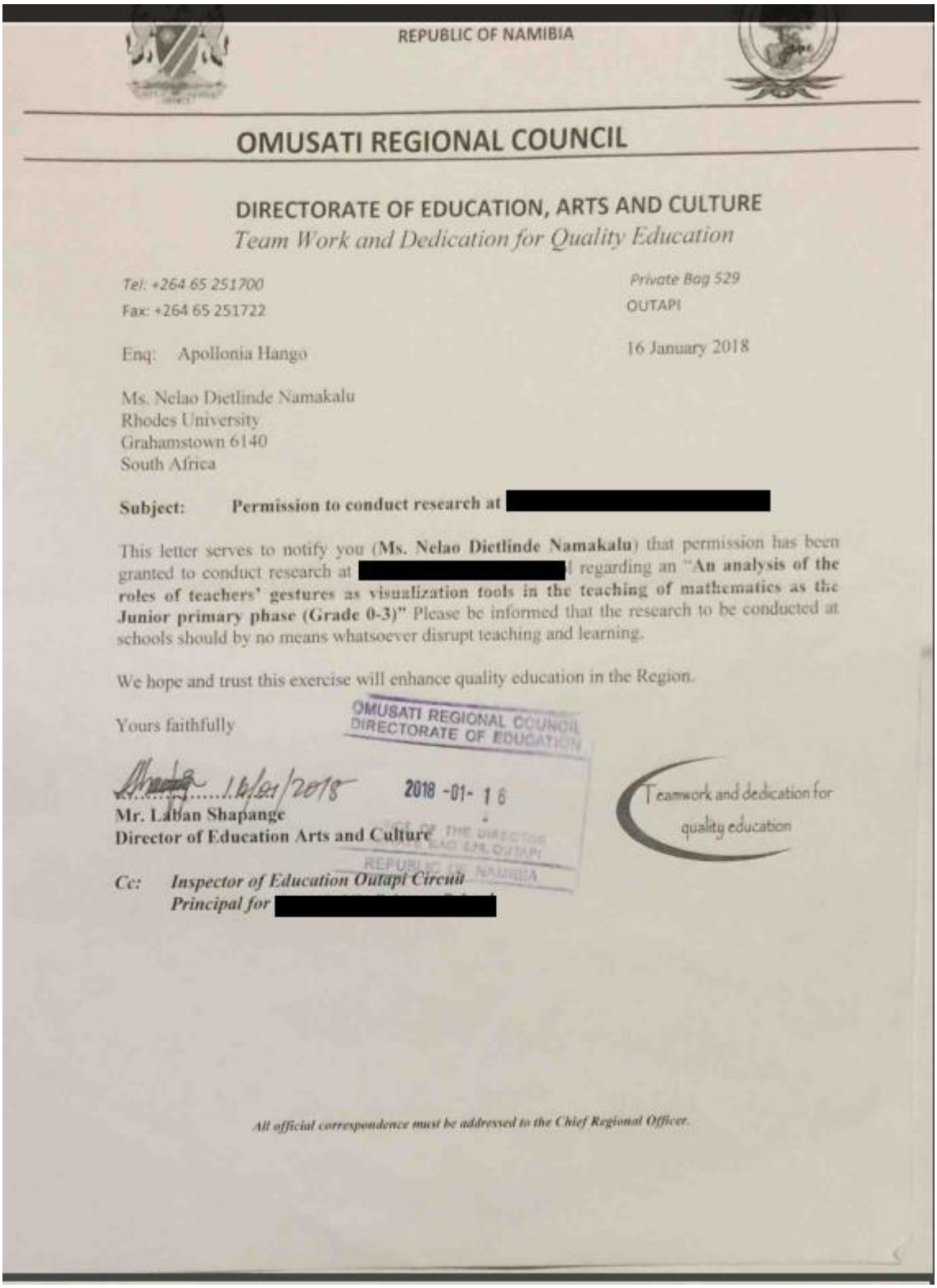
This letter confirms the approval of the above proposal was noted at the meeting of the Faculty of Education Higher Degrees' Committee on 5 October 2017.

The proposal demonstrates an awareness of ethical responsibilities and a commitment to ethical research processes. The approval of the proposal by the committee thus constitutes ethical clearance.

Sincerely

Ms Zisanda Sanda
Ethics Committee Secretariat, Rhodes University
8 January 2018

APPENDIX B: APPROVAL LETTER FROM THE DIRECTOR OF EDUCATION



REPUBLIC OF NAMIBIA

OMUSATI REGIONAL COUNCIL

DIRECTORATE OF EDUCATION, ARTS AND CULTURE

Team Work and Dedication for Quality Education

Tel: +264 65 251700
Fax: +264 65 251722

Private Bag 529
OUTAPI

Enq: Apollonia Hango

16 January 2018

Ms. Nelao Dietlinde Namakalu
Rhodes University
Grahamstown 6140
South Africa

Subject: Permission to conduct research at [redacted]

This letter serves to notify you (**Ms. Nelao Dietlinde Namakalu**) that permission has been granted to conduct research at [redacted] regarding an "**An analysis of the roles of teachers' gestures as visualization tools in the teaching of mathematics as the Junior primary phase (Grade 0-3)**" Please be informed that the research to be conducted at schools should by no means whatsoever disrupt teaching and learning.

We hope and trust this exercise will enhance quality education in the Region.

Yours faithfully

OMUSATI REGIONAL COUNCIL
DIRECTORATE OF EDUCATION
2018 -01- 16

16/01/2018

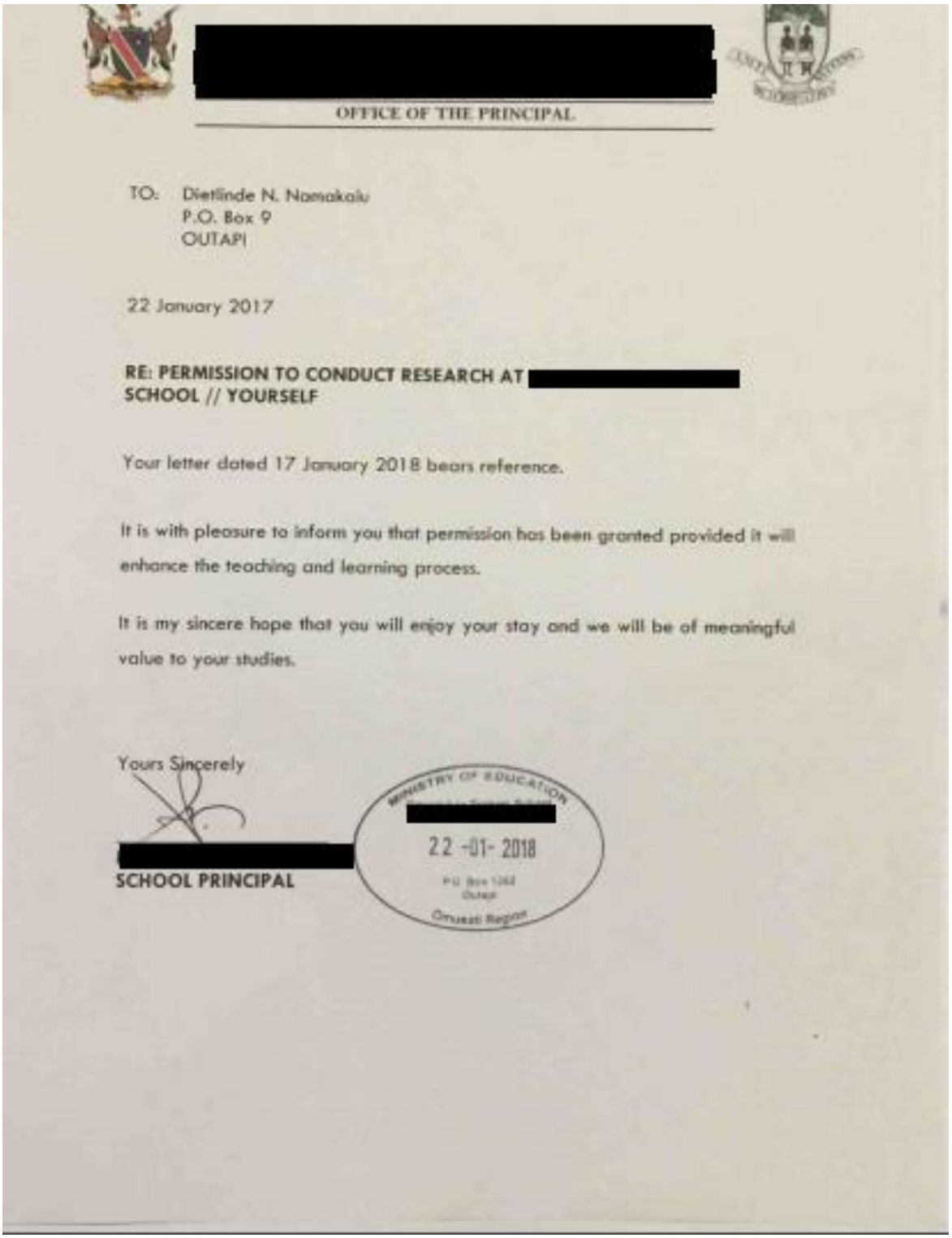
Mr. Laban Shapange
Director of Education Arts and Culture

Teamwork and dedication for quality education

Cc: Inspector of Education Outapi Circuit
Principal for [redacted]

All official correspondence must be addressed to the Chief Regional Officer.

APPENDIX C: APPROVAL LETTER FROM THE SCHOOL PRINCIPAL



[redacted]

OFFICE OF THE PRINCIPAL

TO: Dietlinde N. Namakalu
P.O. Box 9
OUTAPI

22 January 2017

RE: PERMISSION TO CONDUCT RESEARCH AT [redacted] SCHOOL // YOURSELF

Your letter dated 17 January 2018 bears reference.

It is with pleasure to inform you that permission has been granted provided it will enhance the teaching and learning process.

It is my sincere hope that you will enjoy your stay and we will be of meaningful value to your studies.

Yours Sincerely

[redacted]

SCHOOL PRINCIPAL

MINISTRY OF EDUCATION
[redacted]
22 -01- 2018
P.O. Box 1262
Outapi
Omusati Region

APPENDIX D: PERMISSION LETTER TO THE PARENTS

Dietlinde N Namakalu

P. O. Box 9

Outapi

12 January 2018

REQUEST FOR PERMISSION TO VIDEO RECORD IN THE CLASSROOM

Dear parents/guardians

I am Dietlinde Nelao Namakalu, a Master's degree student in Mathematics Education at Rhodes University (RU) in Grahamstown, South Africa. I will be conducting my research for my Master's full thesis at ……Primary School during the first term of 2018. This research requires me to observe and interview three mathematics teachers at the Junior Primary phase (Grades 0-3). During classroom observations, I will video record the teacher of your child as he/she presents his/her lessons. Learners will **not** be part of the video recording, but in case I video record one accidently, I will blurry (hide from view) him/her. This research will be conducted under the supervision of Professor Marc Schäfer.

This letter serves to request your permission to allow your child to be in the classroom during my data collection period.

If you require any further information, please do not hesitate to contact me on +264812201655 and at kalaokatate@gmail.com.

Thank you for your time and consideration in this matter.

Yours sincerely

Nelao Dietlinde Namakalu

Student number: 17N8214

Rhodes University

Parent Consent	
I, hereby voluntarily consent that you may video-record my child's teacher in his/her (child) presence for the purpose of the above-mentioned research.	
Signature:	Date: / /

APPENDIX E: PARTICIPATING TEACHERS' INFORMED CONSENT

Research Project Title:	An analysis of the roles and functions of teachers' gestures as visualisation tools in the teaching of mathematics at the junior primary phase (Grades 0-3)
Principal Investigator:	Dietlinde Nelao Namakalu

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 data collection requirements particular to this research, e.g. observation results, video recording and interviews will 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
- I understand that my personal details will not be reviled

Information Explanation

The above information was explained to me by: Dietlinde Nelao Namakalu

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

Voluntary Consent

I, hereby voluntarily consent to participate in the above-mentioned research.

Signature:	Date: / /

Investigator Declaration

I, Dietlinde Nelao declare that I have explained all the participation information to the participant and have truthfully answered all questions ask me by the participant.

Signature: *D. Namakalu*	Date: 19 / January / 2018

APPENDIX F: INTERVIEW QUESTIONS

1. Does gesturing help you in communicating with your learners? Please elaborate.

2. What different kinds of gesturing do you think you use? Please provide examples and identify them in the video recording when this happened.

3. What gestures do you think you use most? Why?

4. What roles does gesturing play in your teaching? Please provide examples and identify them in the video recording when this happened.

5. What do you want to achieve by gesturing? Please elaborate

6. Do you think we should encourage teachers to gesture during their lesson presentations? Please elaborate.

7. Do you think gesturing is in-born or not? Please elaborate.