AN INVESTIGATION OF HOW A VISUAL TEACHING APPROACH CAN POSSIBLY ADDRESS ISSUES OF MATHEMATICS ANXIETY AT A SELECTED SCHOOL IN THE OSHIKOTO REGION OF NAMIBIA.

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DANIEL NGHIFIKEPUNYE NGONGA

Student No.: 00N4897

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ABSTRACT

This Namibian case study aimed to explore a visual teaching approach (VTA) used by three selected teachers to address issues of mathematics anxiety (MA). The three teachers took part in an intervention program that was looking at how a VTA could be grown in the context of an after-school club (ASC) at my school. The selected teachers were the senior primary teachers at my school. The focus of the research was on how they taught mathematics using visuals after participating in an intervention programme. Their VTA made use of manipulatives, visuals, and concrete materials. The learners of the participating teachers completed a big MA pre-test, small MA tests, and a big MA post-test to determine their levels of MA as the teaching programme unfolded. The study hoped to create awareness amongst teachers and education researchers about the significant use of a VTA in the teaching and learning of mathematics to address issues of MA among the learners. It aimed to answer three research questions. One was on teachers' use of a VTA in the context of an ASC; the second one was on comparisons of learners' MA big pre and post-tests to detect any change of MA, and the last was on the enabling and constraining factors encountered when using a VTA. The main argument was that a VTA can encourage learners to be more confident and less anxious about doing mathematics.

This study was framed by a constructivist perspective and its design and methodology were underpinned by an interpretive paradigm. This mixed-method research study employed video-recorded observations and stimulated recall interviews, learners' MA test results, and the teachers' focus group interviews as the means of collecting data. To generate rich data and support validity, four lessons per selected teacher were observed and video recorded; 54 learners completed the MA tests of 16 questions, and three teachers answered seven questions each in the focus group interview (FGI) after the stimulus recall interviews (SRI) which were done immediately after the lesson presentations.

The study found that the participating teachers incorporated a variety of visuals into their lessons to make the mathematics fun, inspiring, visible, hands-on, and activity-oriented. They engagedthe learners and also found that the use of visuals motivated learners and reduced their MA.

Keywords: mathematics anxiety, visual teaching approach, visuals, after-school club,

constructivism, interpretive and mixed-method.

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DEDICATION

This study is dedicated to

My wife: Mrs. Ngonga Ndamona Aishe-Oiwa

and

My mother: Mrs. Ndeutapo Selma (Mk Wandeu)

and

My seven children: Andreas, Anna, Natalia, Ascent, Toini, Alright, and Alina

who are the primary celebrators of my successful academic accomplishment in the absence of my late dad: Tate Shuumbili shaNgonga (Kashava kOmundonga) who is resting in peace.

DECLARATION OF ORIGINALITY

I, Daniel N. Ngonga, Student number g00N4897 declare that this thesis entitled: An investigation of how a visual teaching approach can possibly address issues of mathematics anxiety at a selected school in the Oshikoto region of Namibia is my work, written in my own words. Where I have drawn on words or ideas of others, these have been acknowledged according to Rhodes University Education Department referencing guidelines.

Daniel N. Ngonga

Signature:  Date: 30 July 2021

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LIST OF ACRONYMS

ACE	Advanced Certificate in Education
ASC	After-school club
AT	Advisory Teachers
AV	Assessing Visuals
BEd	Bachelor of Education
BETD	Basic Education Teacher Diploma
BODMAS	Brackets of Division Multiplication Addition and Subtraction
DV	Designing Visuals
FGI	Focus Group Interview
ELLD	English language learners' dictionary
ICT	Information Communication and Technology
JP	Junior Primary
L1	Lesson 1
L2	Lesson 2
L3	Lesson 3
L4	Lesson 4
LCE	Learner-Centred Education
LSP	Learner Support Programme
MA	Mathematics Anxiety
MV	Manipulating Visuals
MEC	Ministry of Education and Culture
MESC	Ministry of Education, Sports, and Culture
MOE	Ministry of Education
NIED	National Institute for Educational Development
SRI	Stimulus Recall Interview
SP	Senior Primary
T1	Teacher 1 (Ms Tuuda)
T2	Teacher 2 (Sir Kukuta)
T3	Teacher 3 (Ms Uukunde)
VTA	Visual Teaching Approach

CHAPTER 1

CONTEXT OF THE STUDY

"Mathematics anxiety can delay academic success. Fortunately, some scholars are working tirelessly to help the learners get over it."

Allen, A. & Allen, H., (2010)

1.1 INTRODUCTION

This research study aimed to investigate how a visual teaching approach can possibly address issues of mathematics anxiety at a selected school in the Oshikoto region of Namibia. Three teachers participated in an intervention programme to teach mathematics using visuals. In this chapter, I introduce my study by giving its background. Here I discuss how my study relates to the teaching of mathematics, giving more emphasis to the teaching of using visuals in a Namibian context and its relation to visualization in mathematics education. The chapter further outlines the research goals and research questions that guided this study. This chapter also gives a brief outline of the methodology employed, and the rationale of the study. The final part of this chapter deals with the structure of the thesis by providing a preview of what is discussed in each ensuing chapter.

1.2 BACKGROUND TO THE STUDY

The educational fight against mathematics anxiety (MA) started some years back. Many studies addressing MA have been conducted at international and national levels (Kaulinge, 2013; Siebers, 2015; Taylor, 2017). For years, mainstream thinking about MA assumed that learners fear mathematics because they are not good at it (Taylor, 2017). However, a growing body of research shows a much more complicated relationship between mathematics ability and anxiety (Siebers, 2015). Taylor (2017) pointed out that learners who fear mathematics tend to avoid mathematics-related classes, which decreases their mathematics competencies. He further allocated the MA symptoms into two categories as psychological symptoms and physiological symptoms. The psychological symptoms include feeling nervous before a mathematics class, panicking, going blank during a test, or feeling helpless while doing homework. The physiological ones include sweating palms, racing heartbeat, or an upset stomach as 'having butterflies' when a mathematics class starts. With experience spanning 23 years of teaching mathematics, I concur that often learners experience MA when doing mathematics tasks in class or writing mathematics tests. Some people find themselves 'blanking out' in mathematics tests, even though they understand the material, can do the homework, and have prepared well for their tests (Ellen, 2016; Siebers, 2015; Kaulinge, 2013). Ellen (2016) observed that it can be very frustrating to feel prepared, only to receive a low score on a test or an exam.

According to Dzambara (2012), the educational system in Namibia implemented learner-centred education (LCE) as the heart of the new educational system ten years ago. The policy on quality education entrusted the curriculum developers "to develop instructional strategies that make it possible for learners from varying backgrounds and with differing abilities to progress" (Namibia. Ministry of Education and Culture [MEC], 1993, p. 39). It further stipulated that the basic education system saw mathematics as a subject designed to promote functional numeracy and mathematical thinking by helping learners to develop positive attitudes towards the subject, acquire basic mathematical concepts, and develop a "lively, questioning, appreciative and creative intellect" (p. 56). The use of appropriate teaching visuals and resources was encouraged as a potential means to achieve this vision. The Broad Curriculum document of the Basic Education Teacher Diploma (BETD) in Namibia clearly outlines the Ministry of Education's expectations from teachers concerning LCE and the use of teaching aids in schools (Namibia. Ministry of Education [MoE], 2009, p. 2). The intervention of my study has thus integrated the use of designed and prepared visuals in a visual teaching approach (VTA) by the participating teachers in the context of afternoon sessions.

The context of my study is an after-school club that, according to Graven and Stott (2012), can make mathematics fun and enjoyable for the learners. The learners' MA will be monitored throughout my study through MA tests. Notions of MA serve as the entry point in this action research study. To partake in the fight against learners' MA, my research study unpacked and interrogated a VTA. A VTA is an approach that *inter alia* advocates the use of visual aids. A VTA classroom promotes learners' engagements, confidence, and motivation, is hands-on, activities-oriented, and it makes mathematics fun. The visuals and tasks in my intervention were designed collaboratively by the three teachers and me, taking the local context, environment, and costs into account. Integral to the VTA in my study were a set of four lessons that each of the three participating teachers taught.

This study used an intervention programme approach to create an environment that enabled teachers to teach, using visuals in their classes. This intervention programme was designed in such a way that it allowed teachers to create their teaching visuals and use them in the lessons to reduce MA in their learners. The use of visuals throughout this intervention programme integrated the constructivism theory which, according to Vygotsky (1978), emphasises social factors involved in the construction of knowledge. This study was aimed at incorporating the use of visuals in the context of an after-school club (ASC), which provides free time for the learners to enjoy the fun of mathematics (Graven & Stott, 2012). The teachers benefit from this context because the learners are engaged in the excitement of their lessons without being constricted to normal school rules and regulations.

To measure any change in the participating learners' MA as a result of the intervention, various MA tests were administered to the learners of the participating teachers. The tests were sourced from the MA tests designed by Ellen (2016). They consisted of six questions in the small MA tests and ten questions in the big MA pre and post-tests.

1.3 RESEARCH GOALS AND QUESTIONS

1.3.1 Research goals

This case study aimed to investigate how a visual teaching approach can possibly address issues of mathematics anxiety at a selected school in the Oshikoto region of Namibia. The goals and objectives of this case study were twofold, aiming to:

- Critically scrutinise how the three selected grade 5-7 teachers use a visual teaching approach when teaching in the context of an after-school club, as a result of participating in an intervention programme. It also wanted to find out if, as a result of the intervention there was any discernible change in learners' mathematics anxiety;
- Explore and gain insight into enabling and constraining factors when teaching with a

VTA in an after-school club.

1.3.2 Research questions

(a) How do three selected Grade 5-7 teachers use a visual teaching approach in the context of an after-school club, as a result of participating in an intervention programme?

(b) How does the adoption of a VTA result in any change in MA amongst the learners of the participating teachers?

(c) What are the enabling and constraining factors when teaching with a visual teaching approach in an after-school club?

1.4 RESEARCH METHODOLOGY

My study was located within an interpretative paradigm and used mixed qualitative and quantitative methods for data analysis. This mixed-methods case study employed video-recorded observations stimulated recall interviews, and focus group interviews, as well as tests as the means of collecting data. As my study intended to analyse ways of how a VTA can be used in mathematics teaching, I found the interpretive paradigm to be appropriate for my study. The interpretive paradigm enabled me to observe how teachers used a VTA as a visualization tool to facilitate learners' visual engagements in their lessons. The case in this study consisted of three selected Grade 5-7 mathematics teachers teaching in an after-school club (ASC), using a VTA to try and mitigate against symptoms of MA. The teachers were identified in this study by their pseudonyms, Ms Tuuda (T1), Sir Kukuta (T2), and Ms Uukunde (T3). These three teachers participated in a six-week intervention programme on how to use a VTA when teaching in the context of an after-school club. The case study unfolded in three phases which were: awareness workshops and programme design; implementing the intervention programme; and focus group interviews (FGI). During the intervention programme, teachers taught four lessons each, and data was collected through lesson observations and stimulus recall interviews. The collected data were qualitatively analysed. After that, I conducted a focus group interview (FGI) with all the teacher participants. Bertram and Christiansen (2014) stated that FGIs aim to "explore and describe people's perceptions and understandings that might be unique to them" (p. 82). Therefore, the FGI explored the enabling and constraining factors undergone throughout the intervention. The final data set of this study were analysed quantitatively. It was from the tests measuring the learners' MA of the teacher participants. This was determined by comparing the big pre-test withthe big post-test to figure out if the adoption of a VTA brought in any change in MA amongst these learners. This comparison was done after the intervention programme.

The theory that underpinned this study was constructivism. That was because a constructivist theory of learning states that a typical constructive classroom environment is practically-oriented and designed to enhance hands-on and mind-on learning for all the learners (Cohen, Manion, & Morrison, 2010). At the core of this study was an intervention programme that enabled the participating teachers to interact and experience the use of a VTA in the context of an ASC. At the heart of a VTA are classrooms equipped with designed visuals to foster teaching and learning in the form of hands-on manipulatives and teaching aids that encourage learners' engagement, inspire learners, and are task-oriented.

1.5 RATIONALE OF THE STUDY

I anticipate that the findings of this study will encourage more mathematics teachers at all levels across Namibia to promote the use of visual manipulatives and concrete materials in teaching and learning. As suggested by my participants, I also recommend that educational planners, advisory teachers, and further researchers start advocating the compulsory use of visuals in lessons presentations. This would directly contribute towards improvements in mathematics in Namibia, particularly in the northern regions where many schools are more disadvantaged in terms of teaching resources. It is hoped that this study will create awareness of a VTA that uses mathematical visuals in the teaching and learning of mathematics at my school. The findings of this study will also be useful and informative to teacher-trainers, curriculum designers, researchers, and textbooks authors.

1.6 OVERVIEW OF THE SUBSEQUENT CHAPTERS

Here I provide an overview of the thesis:

1.6.1 Chapter Two: Literature review

This chapter discusses and reviews literature related to the study. It consists of four main sections, namely: (1) Mathematics anxiety; (2) Visualization; (3) After-school clubs, and (4) Constructivism – which is the theoretical underpinning of the study.

1.6.2 Chapter Three: Methodology

This chapter gives a detailed account of the research methodology used in this study. It pays special attention to the research orientation and research methods employed e.g. the interpretive paradigm, mixed-methods case study, the qualitative and quantitative approaches, and how data was collected and generated. It presents the research site, selection of the participants, and short descriptions or narratives of the data analysis. The chapter closes by discussing the ethical considerations, validity, reliability, limitations, and some challenges of the study.

1.6.3 Chapter Four: Data analysis and presentation

This chapter presents the data and discusses the findings of my research project. Firstly, it presents data drawn from twelve lesson observations and stimulus-recall interviews. Secondly, it outlines the analysis of the learners' MA test results and lastly, it presents the analysis and findings of the three participating teachers' FGI.

1.6.4 Chapter Five: Findings and recommendations

This chapter concludes this case study by presenting a summary of the main findings of the study and its significance. It also submits some recommendations arising from the findings. The chapter discusses the limitations encountered during the research processes and makes suggestions for further research. Finally, it ends this thesis by sharing my reflections and experiences as a researcher.

1.7 CONCLUSION

In this chapter, I discuss the problem statement of the research and present the context and background of this Namibian case study. From there I outline the research goals and questions plus the methodology and the study's rationale. I then conclude this chapter by briefly reviewing the logical flow of subsequent chapters to this one. The chapter ends with a conclusion.

The following chapter discusses the review of the literature of this study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to provide the contextual framework for the study. Firstly, the chapter deliberates on issues of MA, which serves as the entry point into this case study. Literature on MA is reviewed here in terms of concepts and causes, and parent and teacher involvement in inducing MA in learners. Secondly, the chapter focuses on visualization processes, such as the use of visual aids and the adoption of a visual teaching approach (VTA). This approach is at the heart of the intervention programme framing this study. Thirdly, this chapter deals with the context of the study which is an after-school club (ASC). The investigation is then split into the origins of ASCs, their benefits, and an exploration of opportunities that can be experienced within ASCs. Lastly, the theoretical underpinning concludes this chapter by unpacking cognitive constructivism, which aligns with learners' engagement; and social constructivism, which is framed within the context of teaching and learning.

2.2 MATHEMATICS ANXIETY (MA)

2.2.1 Definition of anxiety and MA

Latterell (2005, p. 24) defined MA as "an intense fear of mathematics that prevents a person from being able to do mathematics". Sparks (2011) described MA as a kind of negative emotional feeling created when engaging in activities requiring mathematical computations. She continued to explain that MA creates fear for, and discomfort in mathematics and can lead to fewer learners pursuing mathematics and science in school and tertiary institutions. Legg and Locker (2009) defined MA as "a general fear or tension associated with anxiety-provoking situations that involve interactions with mathematics" (p. 471). Similarly, Geist (2010) referred to MA as a serious obstacle in today's schooling and he defined it as a negative attitude towards mathematics. Along the same lines, Richardson and Suinn (1972) defined mathematics anxiety as a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations.

Furthermore, Ashcraft (2002) also defined mathematics anxiety as a "tension, apprehension or fear that interferes with mathematics performance" (p. 17). He further clarified that people with high mathematics anxiety normally consider themselves not capable of handling many mathematical-related problems in educational set-ups. One of the problems observed by Kumari (2015) was that MA can cause physical symptoms such as trembling while manipulating numbers. As an experienced mathematics teacher, I have also observed some learners sweating and trembling when engaging in mathematics activities that they are struggling with. In many cases, these learners' solutions are deleted two to three times, and sometimes even the correct solution or answer is also deleted. This is a clear manifestation of MA.

Furner and Gonzalez-DeHass (2011) emphasized that anxiety is not the sole reason for low mathematics achievement but is a "critical academic problem that educators should be informed about. [They should also be aware of] its nature as well as its solutions" (p. 231). Ruffins (2007) found that MA engenders psychological symptoms like panic, nervousness, and helpless feelings before participating in a mathematics lesson. These symptoms can also be observed in other school subjects apart from mathematics. Ruffins gave an example of a Grade 5 English lesson in which the teacher was using the game called 'Bingo' to teach vocabulary for rectangles and squares. The teacher divided the learners into six groups of four and gave each group a piece of paper, a ruler, pencil, glue, and pair of scissors. The teacher sketched a 3x2 rectangle on the chalkboard and divided it into six squares. She then asked the groups to (a) accurately copy it onto paper; (b) cut out two rectangles and two squares from their diagram and (c) paste them into the group workbook. The set rules of the game were that they all had to start at the same time and each group should shout 'Bingo!' when they had finished. Ruffins (2007) observed that of the six groups, only two managed to complete the task in the 40-minute lesson, while the others panicked and showed signs of anxiety and helplessness. Although this example shows that learners' anxiety is also observed in subjects other than mathematics, it is interesting to note that the English teacher chose a mathematical problem to solve. Nevertheless, research about anxieties in the teaching and learning processes should also be conducted in other subjects.

2.2.2 Concepts of MA

There are several ideas and conceptions around the notion of MA. According to Bower (2011), learners who normally avoid taking mathematics courses are in most cases those who have already felt threatened by mathematics by the age of 12. He further emphasized that these learners consistently did poorly in the mathematics class and achieved low marks in mathematics tests.

From as early as four decades ago, Wigfield and Meece (1988) identified the need for research to investigate how learners' mathematics achievement is influenced negatively by mathematics anxiety. Ashcraft and Kirk (2001, p. 224) found evidence that "MA affects learners' achievement in mathematics". They found substantial evidence of poor mathematics achievement as a result of mathematics anxiety. These poor achievements were not so much observed in the basic whole number operations of simple addition or multiplication (e.g., 7 + 9; 6 x 8) but were prominent when somewhat more difficult arithmetic problems were tested (for example, evaluate: $y^2 + 5$ when $y = 3$).

Ho (2010) highlighted the need for researchers to examine the negative effects of mathematics anxiety on learners' achievement in mathematics. In her study, she found that learners with high mathematics anxiety showed smaller working memories. This means that these learners make more mistakes/errors on the tasks or activities when compared to others. I argue here that it is important for the teacher to take cognizance of this and not become impatient if learners make mistakes, or if they take longer than expected to grasp a particular concept.

Ho (2010) further stressed that mathematics anxiety negatively affects learners' behaviour in mathematics lessons. This behaviour is typically observed by the teachers when their learners are working in groups or are involved in discussions to find solutions to mathematics problems. In my experience, some examples of negative behaviour include learners trying to hide their faces when I ask a question. This avoidance of eye contact prevents a teacher from communicating effectively with the learners. In some cases, learners look stressed and frustrated when working in a group. Those learners do not contribute openly to the group discussion and avoid taking on some of the group's responsibilities like writing, drawing, chairing, or presenting.

In addition to Ho's findings in the above paragraph, Smith (2004) considered MA as a cause of fear of mathematics. This manifests itself as a feeling of discomfort while doing mathematics, resulting in skipping mathematics classes and feeling sick when mathematics lessons start (as cited in Kumari, 2015).

Some researchers like Ashcraft and Moore (2009), Jain and Dowson (2009), and Wong (2005) identified some ideas on the concepts of MA. Wong (2005) emphasized that apart from the fear of any contact with mathematics, MA also includes avoiding direct communication with the mathematics teacher. For example, the learner may encounter some difficulties in the mathematics task but she/he is afraid of asking for help from the teacher. Jain and Dowson (2009) claimed that MA is a feeling of being threatened by mathematics about the use of numbers, symbols, and language. Ashcraft and Moore (2009) observed MA in the learners' negative reactions in situations that include numbers and mathematics calculations. They elaborated that those reactions may develop from minor ones to serious ones, like a learner starting with skipping a few minutes of mathematics lesson until she/he ends up dodging the entire mathematics lesson and hiding in the bathroom.

From all the above, it is clear that MA causes frustrations in some learners when dealing with mathematical activities. I thus argue that teachers should be in a position to identify these frustrations and try to eliminate them by making use of confidence-building methods in their mathematics teaching. The stress associated with MA does not only affect learners but can also prevent teachers from teaching mathematics effectively - which in turn could eventually lead to the learners' poor performance (Kumari, 2015). Therefore, viewing some causes of mathematics anxiety is very significant at this point.

2.2.3 Causes and reasons of MA

Smith (2004) identified three causes of MA. The first cause relates to the pressure caused by the time limits of tests, the second is the fear of public embarrassment, and the third is the influence of parents and teachers. The tests' time pressure often leads to a fear of failure. The fear of embarrassment refers to the shaming of low-performing learners in mathematics by other learners, teachers, and the public at large. And parents' influence refers to the parents' lack of motivation and interest in mathematics. Sometimes teachers' ineffective teaching practices and non-engagement with their learners can cause anxiety and frustration amongst the learners.

In this study, the above causes were taken into account by my participating teachers when we planned and implemented our intervention programme. We were mindful to devise teaching strategies, such as a VTA, that would enable the teachers to actively engage with learners to thus possibly overcome their MA.

Ashcraft (2002) advocated for the need for research on the origins of MA, to examine both its emotional and cognitive components. He further indicated that the causes of *mathematics anxiety* are undetermined, but some teaching styles are implicated as risk factors. In agreement with Smith (2004) above, Geist (2010) stated that some factors that lead to negative attitudes towards mathematics are teachers' fast teaching speed and over-frequent scheduling of mathematics tests. These factors can undermine learning processes by not giving learners enough time to interact with the subject content or enough of a chance for the construction of ideas (Scarpello, 2007; Tsui & Mazzocco, 2007; Popham, 2008). Beilock (2008) added that MA is caused by inappropriate teaching and assessment methods. He further pointed out that the overemphasis on memorization of procedures and facts and the lack of differentiating individual needs were typical factors that could lead to MA. Thus, this type of teaching leads to an incoherent and disorganized view of mathematical knowledge, which in turn can result in a lack of confidence and a negative attitude in dealing with mathematical problems (ibid.).

Tobias (1993) observed that by teaching mathematics in separate and discrete sections, because of how the teachers themselves were taught, they often unknowingly contribute to fostering MA. He continued by stating that learners are being tested in the same manner through summative assessments as their teachers were tested when they were students. Teachers reward learners for generating correct answers and not for showing that they understand the processes of how problems were solved, and that is the same style in which they were assessed. Instead of looking at the attempts to solve a mathematics problem, some teachers treat errors by shaming the learners. The consequence of the shaming results in learners developing a fear of making mistakes. He then argued that feelings of embarrassment create a sense of MA. So, for some learners to avoid errors, they simply sit at the back of the classroom hoping for the teacher to conclude the lesson.

In my study, the above scenarios are addressed through an intervention programme where participating teachers collectively plan and execute a series of lessons that make explicit use of visuals to make their teaching more accessible, and then reflect on their teaching (Beilock, 2008). This intervention takes place in an after-school club (ASC) at the school in which I teach. In this study, the empirical field is thus this after-school club.

Lucadamo (2016) suggested that apart from team planning, teachers should explicitly assist learners to improve their attitudes and confidence in their performance in mathematics by making use of parents to motivate their children towards mathematics. She further emphasized that parents can also make mathematics doable at home. Thus, it is also a wise idea to discuss parents' roles in the issue of MA.

2.2.4 The Parental role in MA

The prime aim of most education systems is to assist learners to achieve at high levels while they are in school and when they reach the workplace (Eccles, 2007). Eccles (2007) further elaborated that the parents play a major role in learners' mathematics success even though some of them normally consider the classroom as the only place where the learners' mathematics achievements are developed. For Eccles (2007), the parents are the first informal teachers of their children before they even start schooling.

Researchers found that some parents are themselves anxious about mathematics and they have a fear of the subject which they transmit onto their children (Ashcraft, 2002; Maloney & Beilock, 2012). Internationally, mathematics anxiety is associated with low mathematics achievements in learners (Lee, 2009). However, there is still little known about how the parents' negative feelings towards mathematics might relate to their offspring's mathematics attitudes. The question arises as to how the parent or teacher might affect a child's mathematical success and mathematics anxiety (Beilock, Gunderson, Ramirez, & Levine, 2010). Parents of young children widely believe that mathematics education is merely the function of schooling and that their role in their children's mathematics achievement is not as important as their role in other subjects, such as reading (Cannon & Ginsburg, 2008). However, learners often turn to their parents for mathematics help and teachers may ask parents to work on homework with their children (Beilock & Maloney, 2012).

An American national public radio (NPR) (2018) publication entitled "How to make sure your mathematics anxiety doesn't make your kids hate mathematics" highlighted the parents' own fear of mathematics as one reason for imposing mathematics anxiety onto their offspring. The publication asserted that many learners develop mathematics anxiety as a result of their own parents' negative predispositions towards mathematics.

Beilock and Maloney (2012) advised parents with negative attitudes towards mathematics that although it is acceptable if they are not good at mathematics, they need to realize that their negative dispositions send a destructive signal and message to their children, who in turn may lose confidence in mathematics leading to feelings of anxiety. She concluded that some children themselves may view their parents as being successful without having a mathematics background, thus reinforcing the idea that they do not need mathematics.

According to Lucadamo (2016), parents need to communicate with their children's teachers about their difficulty in helping their children at home. In the same vein, she pointed out that a parent can also ask his/her child to teach him/her an unfamiliar concept the learner was taught in the mathematics class at school.

2.2.5 Teachers' roles

There are many ways in which teachers can influence a child's mathematics experience. As parents, if teachers are afraid of mathematics or do not value the subject and show a negative attitude towards it, learners will take on that anxiety and grow up with that fear towards mathematics themselves (Beilock & Maloney, 2012). In my experience, when learners do not understand certain concepts, they need a teacher to show a willingness to help them understand, and where possible, the teacher should at least change teaching strategies to tackle the concepts from a different perspective such as using visuals to illustrate the concept. In her work, Smith (2004) found that a teacher giving written work every day, insisting there is only one correct way to complete a problem, and assigning mathematics problems as punishment for misbehaviour can cause learners to dislike mathematics and develop a fear for that subject.

Recognizing an ever-increasing mathematics anxiety epidemic, Ansari (2017) suggests that a lot of teachers go into primary school teaching because they don't want to teach high school mathematics due to their fear of the subject. According to him, these teachers often serve as blocking agencies for the learners to continue with mathematics into the higher grades and tertiary institutions, by influencing them with their mathematics anxiety.

2.2.6 Classroom experience

In my experience as a principal of a comprehensive school in Namibia, there are only a few deliberations taking place in my country to address MA in schools. Therefore, Mateya (2008) asserts that the problem of MA in Namibian learners remains neglected in our society. More so, Dorothea (2015) also found that some teachers impose strategies that brought forth significant changes in some learners' levels of MA. Nevertheless, as far as the classroom context is concerned, Scarpello (2007) argued that teachers play a major role in reducing mathematics anxiety by choosing effective teaching methods. In particular, Peker (2016) argues that by enhancing teachers' levels of self-efficacy, mathematics anxiety could be reduced. Anxiety scores among learners were found to decrease when they were exposed to different classroom approaches (Dove & Dove, 2015). The use of manipulatives and hands-on learning of mathematics concepts, for example, brought about a remarkable reduction in mathematics anxiety of student teachers in college classrooms (Gresham, 2007). A study with student teachers by Finlayson (2014) found that making would-be teachers aware of their mathematics anxiety could empower them to develop strategies and approaches which could enable them to overcome their learners' mathematics anxiety in their classrooms.

The findings of Tobias (1993), Beilock (2008), and Geist (2010) emphasized that a significant cause of MA is inappropriate teaching. Therefore, I argue that if we change our teaching approaches, issues of MA can possibly be addressed. My intention in this study is thus to initiate an intervention programme that promotes and nurtures a VTA that makes explicit use of visual materials. This will hopefully inject motivation, inspiration, and confidence into the learners. In return, it may decrease their levels of MA. At the heart of the intervention is thus a VTA that usesvisual and activity-based tasks to make mathematics visible.

2.2.7 Learners' attitudes towards mathematics

Singh, Granville, and Dika (2002) demonstrated that the factors influencing attitudes in mathematics are interrelated with the learners themselves, their families, and their schools. "Among all that, attitudes are regarded by those researchers as the most important and key factors to be taken into account when attempting to understand and explain learners performance in mathematics" (p. 325). They defined an attitude towards mathematics as "a disposition towards an aspect of mathematics that also has been acquired by an individual through his or her beliefs and experiences but which could be changed" (ibid.).

Fraser and Kahle (2007) also highlighted that research indicates that the learning environment at home, at school, and within the peer group accounts for a significant amount of changes in learners' attitudes and this has an impact on the marks achieved by learners. O'Leary (2014) from Canada, in her PhD thesis that researched the roles of mathematics experiences and personality traits in MA, grouped the main factors that have shown to be associated with MA into three main categories, namely: situational, dispositional, and environmental as cited from (Baloglu & Kocak, 2006).

1. Situational factors are defined as the ones that associate an individual learner with the subject itself (in this case mathematics). These factors look at how a learner situates him/herself in mathematics as a subject in terms of understanding its language, symbols, mathematical skills, and instructional methods (e.g. having one correct answer only and rigidity) (O'Leary, 2014).
2. Dispositional factors can be referred to as some changes in behaviours to reduce MA. These are personality factors that make a learner more likely to experience and attend to his/her MA threats (Baloglu & Kocak, 2006). These factors are addressed using motivation, self-esteem, and confidence.
3. Finally, environmental factors are associated with the home environment and society in general, e.g. parents' attitudes and their influences, teachers, and their negative reinforcements toward mathematics (Baloglu & Kocak, 2006).

Even though all the above factors contribute to MA, most research focuses on situational factors and pays little attention to dispositional and environmental factors (O'Leary, 2014). My study will thus address this gap by bringing together all three categories. My study will address the situational factors as there will be a specific focus on mathematics content, language, and skills. It will focus on a specific instructional method, namely a VTA. It will address dispositional factors as it wishes to change learners' dispositions and levels of anxiety. It also focuses on environmental factors as it is located in the community of the learners' school.

Zan and Martino (2007) supported the above dispositional factors by finding that a positive attitude towards mathematics implies a positive emotional change – which can lead to high achievements for the learners in mathematics. These high achievements bring about confidence and a feeling that mathematics is beneficial. On the contrary, learners with negative attitudes towards mathematics tend to lose confidence and end up being overpowered by mathematics anxiety – which in turn brings about low performances and a negative disposition towards mathematics. Thus, multiple studies nowadays are advocating the use of visualization to address factors associated with MA. Visualization is thus discussed in the next section.

2.3 VISUALIZATION

2.3.1 Definitions

Researchers who have shared their definitions and ideas about the roles of visualization include Bhagat and Chang (2015), Mesaros (2012), Dzambara (2012), and Arcavi (2003).

Starting with Arcavi (2003), he 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, to depict and communicate information, thinking about and developing previously unknown ideas and advancing understandings. (p. 217).

The above definition emphasizes the important roles that visualization plays in the teaching and learning of mathematics. Those roles and significances are noted by some other researchers like Makina and Wassels (2009) and Bhagat and Chang (2015). Makina (2010), for example, affirmed that visualization is very important in teaching for understanding mathematics because it helps teachers to engage learners in realistic situations and facilitates interesting lessons by making mathematics visible and tangible.

Of particular relevance to the above point, Mesaros (2012) suggested that the primary aim of visualization in teaching mathematics is to facilitate and support the learners' mathematical problem-solving processes. He further said that visualization helps in transforming a mathematical problem into a visual form. He indicated that this visual form enables the learner to better see and understand the problem when trying to find its solution with the assistance of physical resources such as manipulatives.

As mentioned earlier, my study aims at implementing a VTA in mathematics teaching. This VTA incorporates various visual aids and makes use of "teaching resources such as coloured chalks, posters, graph boards, chalkboard instruments, charts, mathematical sets, geometric models, color papers, improvised visuals made using available resources as well as other physical artefacts that facilitate teaching and learning" (Dzambara, 2012, p. 11). Refer to the photograph in Figure 2.1 which shows some of the visual artefacts used in the intervention programme. The aim of using these resources is to inspire learners, motivate them and build confidence in them to diminish their sense of mathematics anxiety. The focus of my study was initially on teachers so that they could generate data for my research study while they were teaching using a VTA. In conjunction with this, I then tested the learners' associated MA.

2.3.2 Visual thinking

Stokes (2002) defined visual thinking as an ability to associate with the world around us. He further stated that "without images and imaginations, thinking is impossible" (p. 1). Stoke is supported by Sandell (2008), when she indicated that "images are key to comprehending and communicating with the environment around us" (p. 2). Allen and Fraser (2007) referred to visual thinking as associated with "the process of specializing and generalizing, conjecturing and justifying" (p. 104). Particularly in the study of Allen and Fraser, visual thinking is referred to as the sharing of information through pictures or diagrams. The participating learners in my study would be expected to express their ideas and thoughts through images and sketches. According to Thornton (2008), integrating visual thinking in mathematics classrooms has been overlooked in the past even though it is considered vital in mathematics. Allen and Fraser (2007) linked visual thinking to mathematical thinking. They suggested that these two types of thinking provide learners with an ability to explore and relate their prior knowledge to the classroom`s problem at hand.

The following three reasons were given by Thornton (2008, pp. 251-252) to explain the roles of visual thinking in mathematics teaching and learning:

1. There is a current trend to associate mathematics with modern technology. Using technology to discover a pattern is [often] seen as simplifying thinking. But accordingto Thornton's view, using visual methods provided by technology to observe patterns allows the learners to reflect on what they have thought of. So, technology assists them to

generate and test hypotheses and then possibly provide proof. In effect, technology does not devalue visual thinking but rather increases the value of visual methods.

2. Visualization can facilitate powerful approaches that can be used to improve mathematical results and solve problems. It can also be used by the learners to reason when solving mathematical problems. This is because a good visual aid like a meaningful picture can present a multitude of different pieces of information compared to the use of only words (Thornton, 2008) – as the saying goes: *A picture is worth a thousand words.*
3. Thirdly, teachers need to recognize the learner's styles of learning and their contexts and support them by developing visual materials that will suit the learners. This would help the learners to be motivated and inspired to develop new ways of solving mathematical problems.

To conclude, Young (2007) urged all mathematics educators to provide learners with visual tools to think with. These tools would enhance the learners' motivation and thus possibly address mathematics anxiety problems.

2.3.3 Visuals as teaching aids

Like Dzambara (2012), for this study, the term 'visual aids' is used as an umbrella term referring to all teaching resources found and used in the mathematics classroom to enhance teaching and learning. These are objects, images and other manipulate that teachers can use to support learning (Namibia: MoE, 2009). According to Konyalioglu, Asku, and Senel (2012), visual aids in mathematics are tools that are used to represent mathematical ideas and concepts. Konyalioglu et al. (2012) further stated that visual aids help in enhancing problem-solving skillsand can also play an important role in long-term recalling. Visual aids enhance comprehension and assist learners to come up with a variety of possible solution opportunities (Konyalioglu et al., 2012). Similarly, Bishop (2003), in his review of research on visualization in mathematics, concluded that there is value in emphasizing visual representations in all aspects of classrooms. He further explained that mathematics is concerned with the study of sets of connected ideas, patterns, and representations, of which many are visual.

In light of the above, teaching aids are defined as "constructed objects which represent reality" (p. 8) through which teachers can offer learners "an opportunity to reason and make their deductions" (ibid.) and enhance their natural tendency toward exploration and investigation

(Maduna, 2002). Moyer (2001) further supported this notion by pointing out that teaching aids are "objects that are designed to represent explicitly and concretely" (p. 176) abstract mathematical ideas. Teaching aids provide learners with hands-on experiences, and teachers need to promote the use of a variety of teaching aids to help learners focus on the underlying mathematical concepts and skills (Dzambara, 2012).

According to Park and Brannon (2013), engaging learners in visual representations and mathematical manipulatives can be helpful for their mathematical learning. Such manipulatives include base ten blocks, algebra tiles, fraction pieces, and pattern blocks, as well as geometric solids that can make abstract ideas and symbols more meaningful (Durmus & Karakirik, 2006). Furthermore, mathematical manipulatives have "the potential to lead to an awareness and development of concepts" (Swan & Marshall, 2010, p. 14) because hands-on learning builds a better understanding. The need for every learner to be provided with an opportunity to play with manipulatives in the teaching and learning process, rather than just concentrating on the teachers' demonstrations, is underscored (Dzambara, 2012). Ahmed (2004) maintained that the effective use of manipulatives and all other teaching aids used in the mathematics classroom will depend on the "type of tasks provided to learners, the role of the teacher as well as the climate and social culture of the classroom" (p. 327).

In the same vein, Dzambara (2012) observed that "because of the few and inadequate teaching aids supplied in mathematics by the Ministry of Education in Namibia, teachers need to tackle this problem by improvising and making their visual aids from their environments to use in their classrooms" (p. 75). Here are some sources where appropriate visual aids can be found around the Okankolo CS community (where my intervention takes place) as listed by Shravan (2017).

- Home materials – These materials include empty milk or washing powder boxes to make and illustrate 3D shapes. They can be used for hands-on learning experiences and can be manipulated physically.
- Reading materials – These are visuals such as newspapers and magazines. These can be used for teaching and learning statistics topics.

- Waste materials – These are waste materials that can be sourced from schools and at local shops, e.g. old plastic bottles (for capacity lessons), discarded sales posters (for discounts and mark-ups information).
- Community materials – These can be found in the immediate environments of the school. These include materials found in wooded areas, gardens, mahangu fields, filling stations, schools, and hospitals.

The use of visualization objects is nothing new and some previous studies have been advocating this practice for about forty years. For example, Suydam and Higgins (1977) carried out a study on the use of manipulatives and concluded that "lessons that used manipulative materials had a higher probability of producing greater mathematical achievements than the non-manipulative lessons" (p. 83). They administered achievement tests to learners to compare the results of manipulatives-taught lessons and non-manipulative presented classes in the USA. Analysis by Parham (1983) and Sowell (1989) also found that the fear of mathematics could be decreased by the sustained use of manipulatives. Weiss (2006) supported Suydam and Higgins (1977) by proposing that the incorporation of appropriate mathematical manipulatives and other visual aids into the teaching and learning process may rectify the fear of mathematics by enhancing the teaching of efficient mathematical concepts. Therefore, Weiss (2006) urged mathematics researchers and teachers to improve and design their teaching techniques and approaches to help learners to master mathematical concepts and symbols, by calling for greater use of concrete and visual objects in their lesson delivery.

All three researchers above emphasized the use of visual aids through the use of manipulatives and concrete objects in mathematics teaching and learning. According to Dzambara (2012), mathematics teaching and learning in Africa has been dominated by the inadequate use of visual aids. For example, in Nigeria, Aburime (2007, p. 14) argued that the lack of visual aids in mathematics teaching contributes to poor performance in examinations. He, therefore, advocated for "the uses of simple, cheap and improvised manipulatives" (p. 14) in mathematics lessons to destroy the stereotype of mathematics being a difficult subject among the learners. Yara and Otieno (2010, p. 126) claimed that Kenya also has inadequate teaching and learning resources for mathematics at all levels of schooling. They claimed that teaching and learning materials were missing in mathematics lessons even though the schools were equipped with well-trained and qualified educators.

Afolabi and Adeleke (2010) found that learners better understand what they have been taught when visual aids are used and visuals stimulate their interest in learning mathematics. Theuse of visual aids provides the learners with an opportunity to get actively involved in lesson activities, which in turn enhances their learning experience (van der Merwe & van Rooyen,2004). In the same vein, Ndafenongo (2011) from Namibia emphasized that the use of visual aids in mathematics lessons increases the learners' motivation through the use of materials that are challenging, attractive, and interesting. I thus argue that positive attitudes towards teaching and learning mathematics can be fostered by using visuals. This could also possibly enhance learning and motivation towards mathematics in learners, and in return decrease their MA.

My intervention in this study advocates the use of visual aids that are available in the immediate community and can be brought to school by the teachers and the learners. The challenge however will be to see whether a VTA can address issues of MA or not.

2.3.4 A visual teaching approach (VTA)

Hayatu, Mohammed, and Badau (2016) defined a visual approach to teaching as an instructional process where the learning process is supported by visualization techniques. Their findings stated that it is one of the best approaches to teaching and learning. They stressed that learners are viewed as important contributors to their learning, with proper guidance from their teachers. In other words, learners should be actively engaged in learning, through visualizing things in their environment (Hayatu et al., 2016).

In agreement with Hayatu et al. (2016), I argue that a VTA classroom is a busy one in which learners are encouraged to talk freely in small groups and make use of various objects and resources made available to them by their teachers, or ones that they have brought to class. The teacher walks around the class, talking with individual learners and small groups, asking questions, and making suggestions (Hayatu et al., 2016). That type of classroom should be equipped with visual materials such as "diagrams, posters, graph boards, chalkboard instruments, charts, mathematical sets, geometric models, graph papers, improvised visuals made using available resources as well as other physical artefacts that facilitate this kind of teaching and learning" (Dzambara, 2012, p. 11). In my case study, the classroom is set up as described and shown in Figure 2.1 below.

Figure 2.1: Some of the visuals in the after-school club mathematics class at my school

Encouraging learners to use visual aids in mathematics facilitates an environment that makes use of a multitude of senses (Weiss, 2006). Weiss (2006) cautioned that visuals alone cannot have an isolated impact on the overall academic achievements of learners. They (visuals) need to be used appropriately and effectively. In my experience, time is required to use visuals effectively in lessons. Therefore, this study is located in an after-school club where our teaching is not restricted by time as in the mainstream lessons. The teaching skills identified by Debes (1969) below are fundamental to a VTA. I will use the following teaching framework which contains observable teaching skills with indicators, in my analysis (see page 42 in Chapter 3) to classify my participating teachers' visual teaching approach.

(a) Designing visuals – lesson planning

This refers to the teacher's ability to identify, design, and make visual aids for teaching mathematics. The teacher prepares and develops appropriate visual aids before the lesson starts. The designed materials look attractive and appeal to the learners. The materials are topic-specific and appropriate for a particular grade level.

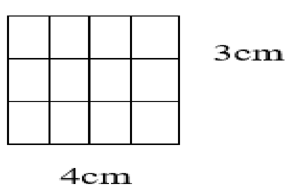
(b) The visual language of mathematics – lesson presentation

Mathematics is a language on its own, just as letters and words are a written language that should be learned. This skill refers to the teacher's ability to use the visual to articulate mathematical concepts – from the very basics to the more advanced. The teaching skills in this area of language teaching involve: knowing and using the relevant symbols, diagrams, and their labels to communicate mathematics; understanding the concepts represented by various visuals, and knowing how to communicate these. The teacher could code-switch where needed. He/she would also use body language (gestures) to communicate visually.

(c) Manipulating visuals in mathematics – lesson presentation

This skill refers to how the teacher uses and manipulates visuals to explain the concepts to be taught in the lesson. For example, if the lesson concept is 'finding the area of a 4cm x 3cm rectangle, the teacher might seek to take the explanation beyond the simple rule of '*l* x *b = area,'* as this alone does not show the outcome or concept. The teacher might do this by dividing the rectangle into smaller squares to clearly show how the area of 12 square units can be seen visually as consisting of sides that are 4cm and 3cm long respectively.

E.g.



The teacher would demonstrate the use of visual representations that connect the lesson concepts to the learners' prior knowledge. For instance, if the concept is 'a rectangle's perimeter,' he/she may refer learners to the soccer field that they use for athletics. One complete round of running around the field is 400m; he/she would then extend that knowledge to the 4cm + 3cm + 4cm + 3cm on a rectangle to get the correct perimeter.

(d) Assessing visuals – lesson presentation

This skill refers to the ability of a teacher to test or assess the learners when they do tasks visually. The teacher would assess learners' skills on naming diagrams, drawing diagrams (roughly sketched diagrams and accurately measured diagrams), accurate measuring, and labeling. He/she would also assess them on identifying the appropriate materials and tools to use in doing a task (e.g. ruler, set-square, and pencil to find the centre of a circle). Some other tasks in which the use of visuals can be assessed are calculating areas of different shapes, calculating the volume/capacity of unlabelled 3-D shapes for the grade level, (viz. cubes, cuboids, cylinders), constructing charts from a set of data, using and measuring angles.

The teacher would assess solutions used by learners when they perform the tasks visually, even when it was not the standard process presented in the lesson. For example, if the learners are asked to find the area of a right-angled triangle of a 3cm base and 6cm height, instead of using the standard formula *(½bh = area),* a child recognizes that it is a half of a rectangle, then draws a complete rectangle and gets its area which is 18 square cm; finally dividing that by 2 to get the final answer of 9 square cm.

The above framework will form the basis of my analytical framework when I analyze the participating teachers' lessons. The empirical field of the study is an after-school programme, which is explained in the following section.

2.4 AFTER-SCHOOL CLUB (ASC)

2.4.1 Definitions

My study and its intervention programme in an after-school club link well with the Namibia learner support programme (LSP) (Namibia. NIED, 2007). The LSP was initially established to implement the Namibian policy of inclusive education. According to the Namibian Learning Support Teachers' Manual for 2010, the LSP should help learners to catch up on the concepts that they did not understand well in the mainstream classrooms (Namibia: NIED, 2010).

In my experience, the term 'learning support' is however a stigma to many teachers and learners because it has a connotation of slow learners who need special learning support. Therefore, for this study, I changed the name to an after-school club. The term 'after-school club' accommodates any learner in my school in afternoon mathematics activities, not only those who have learning difficulties as stressed in the LSP. The teaching of mathematics to primary learners in an after-school club was researched by Graven (2011). She found that in after-school clubs, teaching involves the deliberate creation of more engaging, confidence-building, and participatory forms of teaching. She further stressed that these teaching practices provide learners with an opportunity to “re-author themselves” (p. 1) as mathematical producers, questioners, and explorers. In my study, the dominant teaching approach in the after-school club is a VTA – one where hopefully the mathematics is fun and meaningful to learn.

2.4.2 Originality of the After School Club

Many challenges force teachers to provide extra time to teach learners. According to Newton (2015), the main challenges that mathematics teachers experience in the classrooms at the primary phase are learners’ different mathematics abilities, lack of teaching resources, overcrowded classes, and time constraints. But in fact, those obstacles contribute to the fear of mathematics that Newton (2015) termed “mathematics phobia” (p. 1). He further argued that mathematics phobia affects learners’ behavioural problems; it contributes to a lack of learners’ engagement in lessons; poor performance and learner anxiety. All the challenges stated above can potentially prevent teachers from reaching every learner during the allocated 40-minute period (as is common in Namibia). Researchers have confirmed that mathematics anxiety is linked to poor mathematics performance, and could make teaching the subject a daily struggle (Newton, 2015). As a result, most of the committed teachers in Namibia have started making use of afternoon studies and some weekend days to supplement the mainstream’s time. The same problem was identified in early grades. Anhalt and Cortez (2015) from Tucson and New Orleans respectively, proposed the establishment of mathematics projects in Egypt to do mathematics activities with learners in the afternoons through playing games and making mathematics fun and enjoyable. Their proposal led to the formation of the project called: Science, Technology, Engineering and Mathematics (STEM) Project in Egypt (STEAM & STEM, 2019).

Graven (2011) started a mathematics club in South Africa in February 2009. Her club involved 22 Grade 10 and 11 mathematics learners from three ‘traditionally disadvantaged’ schools. She implemented her programme with Saturday classes accommodating learners from three schools. Her procedures and findings are very significant to my study because my research has a similar context to hers. Graven and Stott (2012) researched the context of after-school clubs. They found that after-school lessons can instill a love of a subject that so many learners, teachers, and parents find intimidating. These clubs provide additional time for devoting to mathematical activities, games, puzzles, and different free interventions.

2.4.3 Benefits of an After School Club

Newton (2015) identified the following benefits of an ASC, which I have classified into four steps.

Step 1: Confidence building

An ASC provides enough time for the teachers to prepare and present their activities that can build confidence. Some of the confidence-building exercises should challenge the gifted learners while others could encourage average and slow learners to do well. If these exercises boost learners' self-esteem and self-efficacy, mathematics anxiety and fear can be reduced because the learners feel motivated and capable of dealing with different concepts.

Step 2: Strengthening numerical skills

An ASC provides time for the learners to practice and master basic mathematical skills. The teacher has an opportunity to give special attention to the needy learners without being restricted to the period's time. The learners have an opportunity to learn numeracy through touching, playing games, and participating in warm-up activities which are in most cases accessible in ASC teaching and learning.

Step 3: Mindset development

Newton (2015) defined a growth mindset as: "the belief that a human's ability can be developed" (p. 2). He advised teachers to set and design appropriately challenging mathematics tasks to stimulate a growth mindset of hard work and frequent practice in the learners.

Step 4: Step-by-step approach

In the mainstream classroom, often too much information is presented within the limited time of the period. This is not the case in an ASC environment as time is not a limiting constraint. There is evidence from Mangi (2018) that even smart learners can feel overwhelmed by too much to do within a limited time, leaving little time for practice. So a step-by-step approach is designed to split the presentations of concepts and skills into manageable stages for the learners to have time to try out and practice each step. In the ASC, learners are encouraged to master each step before moving on to the next one and to maintain a good understanding across these steps.

One of the benefits that Graven (2011) identified was that an ASC provides learners with a free and safe platform where they can ask questions, produce their mathematics, talk mathematics, explain mathematics and enjoy mathematics. Another advantage she pointed out was that the ASC does not require lesson plans or homework plans that have to be monitored by senior officials. The lesson deliveries and all sessions depend on the learners' needs and demands. She further alluded to the benefits in terms of resources that are normally used in the ASC, which in my ASC include manipulatives and visual materials.

2.4.4 Exploring opportunities within the After School Club

According to my experience with the learning support programme and regional mathematics quizzes held at my school in the northern part of Namibia, participating learners seem to be very active, willing, and free to talk and play in afternoon activities organized at the school. In the planned ASC it is thus anticipated that the participating teachers experience the excitement of the learners. This encourages the participating teachers to create a positive and active learning environment that is non-threatening, safe, and inspiring. If the teachers demonstrate enjoyment and appreciation of mathematics, they can create a good relationship between their learners and mathematics as a subject. This in turn hopefully contributes to the reduction of mathematics anxiety in the learners.

Sfard and Prusak (2005) argued that mathematics clubs are very important because they provide a space for learners to develop an understanding of their mathematical abilities. Graven (2011) highlighted that an ASC also can become a space for negotiating future possible mathematical opportunities through discussing and investigating career options with the learners.

2.5 THEORETICAL FRAMEWORK

2.5.1 Introduction

The heart of my study is the intervention in the ASC which adopted a constructivist teaching approach, based on Jean Piaget's (1967) early studies and theories around cognitive constructivism and Vygotsky's (1962) social constructivism (Cohen et al., 2010). They (Piaget and Vygotsky) believed that a typical constructive classroom environment is practically-oriented and designed to enhance hands-on and mind-on learning for all learners (Cohen et al., 2010).

The following model describes how these constructivist theories supported and framed my study.

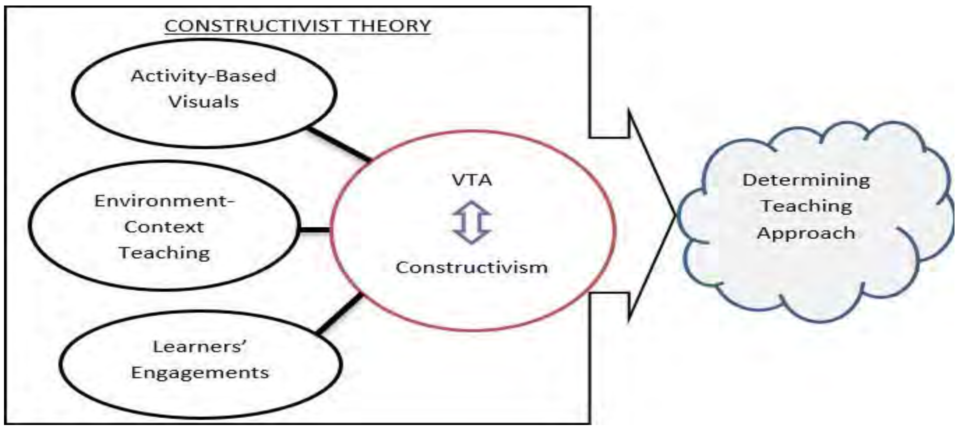


Figure 2.2: How constructivism frames a VTA

The model illustrated in Figure 2.2 above shows how the three constructivist elements of learners' engagement, environment-context teaching, and activity-based visuals feed in into a VTA. The VTA is a constructivist one because while using visuals, it is activity-based, it encourages learners' engagement developing their sense of responsibility and confidence, and it has an environment-context oriented focus, viz. materials to be used are obtained from the learners' local surroundings.

In support of the above model, Lemke (2001) suggested that knowledge construction should be rooted in the cultural contexts of the learners. Thus, mathematics should not be taught in isolation (ibid.). Similarly, Cobb (1988) reiterated that teachers should devise teaching approaches that lead the learners to make appropriate and meaningful constructions. These approaches should include the use of contextually appropriate visuals such as diagrams, drawings, and physical manipulatives that relate directly to the immediate environment.

A VTA requires teachers to facilitate and create teaching and learning environments that transform learners' basic information into deep and meaningful forms of knowledge (Ernest, 1991). He further elaborated that the environment (in my case the ASC) should support and encourage the active construction of concepts rather than receiving them as a finished product from the textbook.

The primary aim of a VTA in this study is to implement it strategically to try to address issues of MA in selected learners. It has been planned that this will be done by using visual teaching aids (visual aids in a VTA) and hands-on activities to potentially build and promote confidence (Dzambara, 2012). Dzambara (ibid.) also stressed that visual aids also have the potential to encourage learners' active cooperation, participation, and excitement during mathematics classes and thus reduce MA.

2.5.2 Cognitive constructivism – Learners' engagements

The cognitive constructivist theory framed this study, as one of the fundamental requirements of a VTA is learners' engagement in the lessons. According to Piaget (1968), cognitive constructivism emphasizes that knowledge is acquired through an adaptive process and results from the active engagement of the learners in their learning. McInerney and McInerney (2006) concurred with Piaget's cognitive constructivism, by emphasizing that learners should be actively engaged in the content to be learned. They also added that learning content should have an optimal match between the development stage of the learner and the logical properties of the material to be learned.

It is thus very important for the learners to be motivated to participate seriously in the lesson activities. For the learners to be actively engaged in the lessons' content, teachers have to motivate them well. Van-Riel and Fombrun (2007) divided the motivation of learners' engagement into two different types. They referred to the first one as behavioural motivation which is external and is observed as the reactions to positive and negative reinforcements from outside. The second type is cognitive motivation which is based on the learners' internal initiative. Van-Riel and Fombrun (2007) found that learners are motivated first by parents at home, and then by teachers at school through rewards and words of congratulation on and encouragement towards their best achievement. Therefore, they urged teachers to identify the dominant type of motivation that makes an individual learner achieve his/her best. This is because knowledge is actively constructed by a learner, so the learning also depends on the learner's internal initiative to understand and simplify his/her learning process. Learners are in many cases good at initiating new ideas and they need to be encouraged to bring about change in the world as far as mathematics teaching and learning are concerned (Maddox & Markman, 2010).

My argument here is that designing visual aids and planning lessons for the good implementation of a VTA will make mathematics fun and it requires the development of different initiatives. This on its own may result in the reduction of MA.

2.5.3 Social constructivism – Environment-context teaching

My case study is designed to align with a social constructivist approach because it is fundamentally hands-on and activity-based. Vygotsky (1978) reinforced the significant role that the culture of the classroom plays in influencing how learners think and learn. His social constructivist theory is the key in this study because it emphasizes that learners' thinking and learning in a classroom (in my case the ASC) are shaped and influenced by the situated nature of that classroom. The situation in this study is a classroom that is framed by a visual teaching approach. Vygotsky's (1962) theory is called a social constructivist theory because, in his opinion, the learning process is based on social interactions, language usage, and other cultural settings peculiar to a particular learning environment. This theory shows that learners learn from each other and can assist one another to construct knowledge within a socio-cultural context (Gergen, 2001).

A key element of this theory is scaffolding, which is about providing the learner with appropriate assistance at an appropriate time. In the ASC, the maximum time of one session is 1 hour and 30 minutes. This is a generous time to develop mathematical ideas and concepts. The teacher can attend to an individual learner with a specific problem while others are busy with some other tasks in groups. The scaffolding part of the theory is relevant to learners' knowledge development because if learners work in pairs or groups, they are interacting with others and therefore can learn different ideas from one another within the generously provided time in an ASC.

The social constructivist theory aligns well with a VTA because this approach can be applied in the classroom in several ways. The learners can be assembled into small groups so that those who understand the content work with those who do not. For example, if two learners in a group do not understand ratio simplifications, the group can have another learner explain the concept to them. The more knowledgeable peer might make it clearer to others than a teacher could. Nuttall (2003) added that knowledge is not simply constructed but co-constructed. To her, co-construction is a concept that learners can use to help them learn from others and expand their capabilities. She elaborated on the importance of co-construction in terms of developing creative partnerships within the classroom. I know from experience that cooperation and teamwork in a mathematics classroom are very important because they can teach learners how to effectively communicate with others to attend to mathematical problems. According to Garcia and Pacheco (2013), co-construction of learning allows learners to have social interactions within the classroom and makes the learning more creative.

Barkley, Cross, and Major (2005) claimed that collaborative learning methods require learners to develop teamwork skills. Individual learning can also be enhanced through the success of group learning. The manageable size for group learning is four to five learners when carrying out an investigation. They also highlighted that collaborative learning methods often require the teacher to break learners into smaller groups, although discussions are essentially collaborative learning environments. For example, during our mathematics investigations, learners may be split into groups that are then required to choose and research a topic from a certain concept. The learners are then held responsible for researching that topic and presenting their findings to the class. More generally, collaborative learning should be seen as a process of peer interaction that is structured by the teacher. Discussion can be promoted by the presentation of a specific concept or scenario and it should be guided using directed questions, the introduction and clarification of concepts, and information (Barkley et al., 2005). I also argue that learning from the local environment is very important.

The above deliberations indicate that learners learn through social interactions. That simply means that they learn from parents, from teachers, from each other, and all other creatures available in their surroundings. Learning occurs through acquiring knowledge which is transformed through language and all other cultural norms. These interactions are fundamental to my ASC. Thus my study is framed by a social constructivist perspective.

2.6 CONCLUSION

In this literature review, the main focus was firstly on MA. The MA discussion was split into subtopics: the definition of MA, concepts of MA, causes and reasons for MA, parent and teacher involvement in MA, and the classroom experience around MA.

Secondly, I discussed visualization. This included deliberations on visual aids and visual thinking. The discussion on a VTA focused on the required teaching skills and their observable indicators. The third part of this chapter looked at the context of this interventionist study which is an ASC in my school in the Oshikoto Region in Namibia.

I then presented an overview of how cognitive and social constructivism was the underpinning theory of this study.

In the next chapter, I focus on the research methodology, particularly highlighting the qualitative and quantitative methods that were used for collecting and analyzing the data of this study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter presents the research design and methodology that I adopted and used for this case study. I further discuss the procedures followed while conducting my research. The chapter further discusses all the data sources, including the interview process and how it unfolded after the 12 lessons were observed and video recorded. Thereafter, I conclude this chapter with comments on issues related to validity, reliability, and research ethics.

As previously discussed, this Namibian case study aims to explore how a VTA used by three selected senior primary teachers (Grade 5-7) could possibly address issues of MA in their learners. This VTA is implemented in the mathematics ASC at my school in the northern part of Namibia. I designed the ASC for this case study to coincide with the existing learning support programme as articulated in the Ministry of education Arts and Culture circular: FORM ED. 4/2004. According to the learning support policy, compensatory teaching has become compulsory in all Namibian schools (Namibia: NIED, 2007). The Learning Support Programme (LSP) is an extra-curricular programme that runs in the afternoons. The LSP, run by teachers of the respective schools, provides extra support for learners with learning difficulties or for those who have, for various reasons, experienced delays in reaching essential basic competencies in the different subjects and skills as required by the National Curriculum for Basic Education (NIED, 2014).

In my school, the LSP is arranged in subject clubs that offer support to below-average learners to master the content taught in the normal inclusive lessons, and also provide enrichmentactivities to above-average learners. Attendance is voluntary, but below-average learners are vigorously encouraged to join. During the LSP classes, the teachers present the content in a manner that below-average learners can follow. They mostly use visuals, manipulatives, and concrete materials to facilitate learning and to accommodate different learning styles. The teachers strive to make learning mathematics fun. They also involve learners in the continuous the practice of basic mathematical skills and include revision work of basic mathematics covered in previous grades. This enhances learners' confidence as they are given an additional chance to solve familiar problems and practice their skills. According to Graham and Pegg (2008), below-average learners in mathematics are often associated with learners who have low self-esteem, lack confidence, and experience MA. This often leads to slow progress and low achievement in mathematics. The particular focus of my study is thus to interrogate whether a visual teaching approach can combat MA in Grade 5-7 learners, in the context of my intervention programme during the LSP sessions at my school.

3.2 RESEARCH GOALS AND QUESTIONS

The aims and objectives of this case study are twofold:

(a) To critically investigate how the three selected Grade 5-7 teachers use a visual teaching approach to address issues of mathematics anxiety when teaching during after-school sessions, as a result of participating in an intervention programme.
(b) To explore the enabling and constraining factors when teaching with a VTA in an ASC.

This study attempts to answer the following three research questions:

(a) How do three selected Grade 5-7 teachers use a visual teaching approach in the context of an after-school club, as a result of participating in an intervention programme?
(b) How does the adoption of a VTA result in a change in MA amongst the learners of the participating teachers?
(c) What are the enabling and constraining factors when teaching with a visual teaching approach in an ASC?

3.3 RESEARCH ORIENTATION

The research design and methodology of my study are oriented within an interpretative paradigm. This paradigm is described by Patton (2002) as a world view that helps the researcher to break down the complexity of the real world. As my study intends to analyze and interpret ways in how a VTA can be used in mathematics teaching, I find the interpretive paradigm to be appropriate for my study. This is because according to Bertram and Christiansen (2014) the interpretive paradigm is guided by the basic assumption of understanding human behaviours in a given situation. Thus, this paradigm will enable me to observe how teachers use a VTA to facilitate learners' mathematical engagements in their lessons in the context of an ASC.

3.4 RESEARCH METHODOLOGY

3.4.1 Mixed method case study

The research method that uses both qualitative and quantitative methods is known as a mixed-methods study (Mohapatra & Hembram, 2009). The mixed-method research design helps the researcher to go for inductive and deductive reasoning techniques to accurately answer the study's research questions that cannot be completely answered through qualitative or quantitative research alone (Denzin & Lincoln, 2005). Denzin and Lincoln (2005) stated that a mixed research design emphasizes the explanation and application of factors through which the process of the research is advanced. Qualitative methods are enhanced through the incorporation of quantitative methods, sometimes referred to as triangulation. My study entails a mix of qualitative and quantitative methods because it employs video-recorded observations, stimulated recall and focus group interviews, and tests, as the means of collecting data. The learners who attended the intervention programme completed a series of pre and post-tests to determine their levels of MA as the teaching programme unfolded. A case study is an appropriate method to use because the researcher tries to understand the participants' experiences and views of doing something in-depth (Merriam, 2002). The case in this particular study is the lessons taught by three selected Grade 5-7 mathematics teachers implementing a VTA while teaching in an after-school programme.

My unit of analysis is the teachers' use of the VTA in the after-school programme. To answer my three research questions, I did the following:

- I determined the level of MA of the Grade 5-7 learners at Okankolo CS before the planned intervention programme. This was determined quantitatively.
- I analyzed how the three selected Grade 5-7 mathematics teachers use a VTA (to ultimately address MA) when teaching in the context of an ASC as a result of participating in an intervention programme. This was determined qualitatively.

- I analyzed the teachers' enabling and constraining factors when teaching with visuals in an after-school environment. This was determined qualitatively.
- I compared the learners' levels of MA after participating in an intervention programme, with their MA before the intervention. This was determined quantitatively.

3.4.2 Sampling

This research study took place at the school where I am the principal. I selected this school because it had an existing and up-and-running LSP which I could use to locate my after-school learning club and my research project. The participants in this study were selected purposively. According to Creswell and Plano (2011), purposive sampling involves identifying and selecting individuals or groups of individuals that are especially knowledgeable about, or experienced in, a phenomenon of interest. In addition to knowledge and experience, Bernard (2002) and Spradley (1979) noted the importance of availability and willingness to participate, and the ability to communicate experiences and opinions in an articulate, expressive, and reflective manner. One of the participants is a new head of department (HOD) of the mathematics and science department at my school. I was confident that with their teaching experience, the teachers I selected would hopefully generate rich data for my study. According to Mertens (2005), the broad aim of selecting appropriate participants is their ability to provide cases with rich information which can allow the researcher to study the project in-depth when working within the interpretive paradigm. The three teachers in this study were selected purposively according to the following criteria:

a) teachers that are currently teaching mathematics in the LSP from Grade 5-7;

b) teachers who showed their willingness to participate in the ASC; and

c) teachers with at least three years of teaching experience at this phase and are fully qualified mathematics teachers.

The learners that formed part of this LSP/ASC were learners with learning difficulties and needed extra support in certain areas. In this study, these learners are referred to as below-average learners. Eighteen learners were sampled for each class group. The number was determined by the usual attendance of LSP that fluctuated from 18 to 22 in the afternoon classes. I opted to restrict the number to the minimum of 18 per class to be able to compare the changes in MA in the tests' results per grade. That gave a total number of 54 learners from Grade 5 to Grade 7 to provide data for analysis in this study, but all other learners were allowed to attend ASC lessons.

3.5 RESEARCH DESIGN

Research design is defined as "the plan and procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis" (Creswell 2009, p. 3). Considering Creswell's view of what research design is – it is simply the framework of how research data is collected and analyzed in the study. The research design of this study unfolded in three phases:

Phase 1: Awareness workshop and a programme design

In this phase, I organized a two-afternoon workshop with the participating teachers of this study. The workshop was conducted in the afternoons to avoid interfering with the morning teaching sessions of the participants. During this workshop, the VTA was discussed and explored, and it was explained what it entailed and the values of this approach. We also discussed the issue of MA and how that impacts mathematics teaching and learning. In this workshop, the visuals that are appropriate and suitable for incorporating in teaching and learning were discussed. My role at this stage was to facilitate this workshop, spearhead ideas on making visual materials to use, and lead discussions on MA and VTA.

In the workshop, I promoted an attitude of sharing the materials between the grades once they were designed and made available. We also discussed ways of planning the VTA lessons together as mathematics teachers. During the workshop, we discussed how the participants would join each other and the researcher to design visual aids, activities, and tasks for the lessons.The planning and the designing of visuals were then agreed upon so that they could be prepared the day before the lesson observations took place. The reading of learners' test questions and invigilation processes were also considered at the workshop.

In this phase, we looked at the timetable and identified the topics to be covered in the intervention programme, per grade. The topics that were chosen were:

- ***Grade 5***: three-dimensional shapes, comparing common fractions, mathematics rules, andplace value;

- ***Grade 6***: square numbers and cube numbers, rounding off, primes and composite numbers, and perimeter and area of a rectangle; and
- ***Grade 7***: two terminologies and their basic operations, multiplying fractions, directed numbers, and percentage profit and loss

Table 3.1 below shows the names of the three participating teachers, including their LSP/ASC codes (numbers) which were used for timetabling purposes.

Table 3.1: Research names of the participants and their timetable codes

Participants' names used in this research	Timetabling code	Subject and Grades taught	No. of lessons observed
Ms. Tuuda (T1)	7	Mathematics Gr 5B	4
Sir Kukuta (T2)	8	Mathematics Gr 6	4
Ms Uukunde (T3)	18	Mathematics Gr 7	4
		Total # of lessons	12

The participants permitted me as a researcher to use the names reflected in this table. Ms. Tuuda is her real first name and she is referred to as teacher one (T1) in this study. Sir Kukuta is a nickname and he is referred to as teacher two (T2) in this study. Ms. Uukunde preferred her real surname to be used in this research and she is referred to as teacher three (T3). Therefore, my participating teachers were coded as T1; T2; and T3. Both codes and names would be used in this research.

The teaching of ASC lessons took place in the afternoons. Table 3.2 below shows the LSP/ASC timetable for the whole school. Other subjects and the codes of the teachers are also shown.

Table 3.2: The master timetable for the first three weeks of the after-school programme lessons for senior primary at Okankolo CS

	Week 1				Week 2				Week 3			
Day/Gr	4	5	6	7	4	5	6	7	4	5	6	7
Fri			*Plan*			*Plan*						*Plan*
Mon	NSHE 2	Eng 4	Maths 8 (T2)	Eng 3	Eng 6	Maths 7(T1)	Eng 3	Sc St 5	Maths 15	NSHE 2	NSHE 5	Maths 18(T3)
		Plan						Plan			Plan	
Tue	Eng 6	Maths 7(T1)	Eng 3	NSHE 5	Math 15	Eng 4	Sc St 5	Maths 18(T3)	NSHE 2	Eng 4	Maths 8 (T2)	Eng 3
Weds				*Plan*			*Plan*			*Plan*		
Thurs	Maths 15	NSHE 2	NSHE 5	Maths 18(T3)	Sc St 2	Sc St 5	Maths 8 (T2)	Eng 3	Eng 6	Maths 7(T1)	Eng 3	NSHE 5

The teaching of LSP/ASC took place for three afternoons every week (Monday, Tuesday, and Thursday). In Table 3.2 above, the emboldened lessons are the ones that were taught by the three participating teachers of my research study. The planning and visual design for each lesson was done on the previous working day. For instance, Monday lessons had to be planned on Fridays, and Thursday lessons were planned on Wednesdays. The challenge was planning Tuesday lessons because on Monday afternoons I had to observe another lesson. So, we arranged the planning during Monday's break time and finalized it in the late afternoon. The challengewas for each participant to be observed once per week. But because of the slow pace of the below-average learners and the use of visuals, some participants ended up being observed twice, with the lesson continuing the following week. The programme, therefore, took six weeks to complete. Each participant/teacher's lesson presentations I observed were video-recorded.

The teacher responsible for Grade 4 and Grade 5A mathematics was the one who unfortunately withdrew. However, she agreed to give her class to the Grade 5B mathematics teacher who is one of my participants, so that her learners could also be part of this research's intervention programme.

During this phase, we also discussed when to administer the MA tests to the learners.

Phase 2: Implementing the intervention programme

Big MA pre-test

The participating teachers administered the big MA pre-test (see details of this test below). The duration of the test was one hour long. The participants were the ones who invigilated the MA pre-tests. These pre-test questions (see Appendix H) were all the same in all grades and the learners wrote them at the same time. The teachers explained to the learners what the MA tests were all about and that they wanted the learners' true feelings and honest thoughts about mathematics. Teachers made it clear to the learners that the intention of the MA tests was not for assessment and grading purposes.

Implementing a VTA

After the big MA pre-test was administered, the three selected teachers were observed presenting their lessons using a VTA in the after-school programme. This was done in four cycles. Each cycle focused on one topic per grade. Each cycle took one to two weeks and consisted of the following components:

(a) Planning of the VTA lessons and developing the visual materials by the participating teachers and me. This was done the day before the teaching of the planned lessons. No data was collected here.

(b) The teachers then taught the lesson using a VTA. I observed while another person did the video recording. These formed my second data set after the first data set which was generated from the big pre-test.

(c) After each lesson, we then collaboratively reflected on the lesson with a stimulus recall interview. The resulting data were used to triangulate with the second data set. I audio-recorded these interviews.

(d) After each cycle, the learners then completed a small MA test. The 4th small test after the fourth cycle would then mark the end of implementing a VTA.

(e) After implementing a VTA, I administered a big MA post-test to all the learners of the participating teachers. This big MA post-test was the same as the big MA pre-test I gave to learners before the implementation. These two big tests enabled me to compare the MA before and after the VTA intervention programme.

Figure 3.1 below shows the research model of the implementation of the intervention as described above. The model indicates the design of how the activities were done around the cycles. Only the first two cycles are shown in the model below.

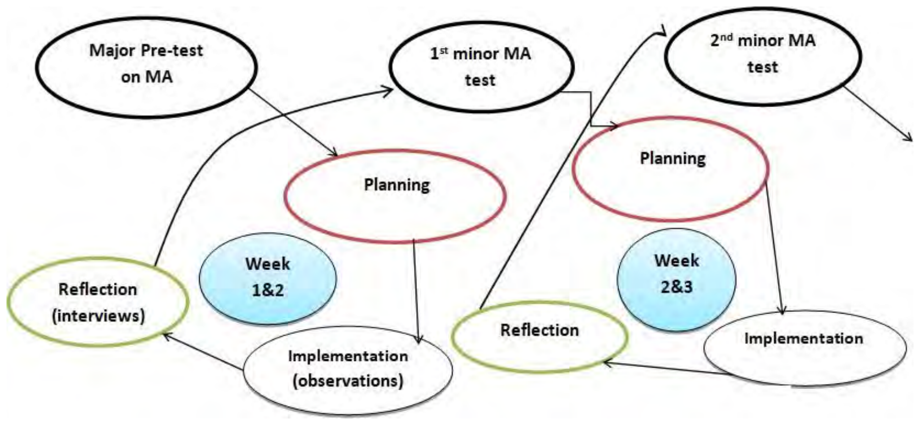


Figure 3.1: The research model of the implementation of the intervention.

Phase 3: The focus group interviews (FGI)

At the end of the 4th cycle, I conducted a focus group interview with all my research participants to reflect on the entire intervention process. According to Denscombe (2007, p. 115), a "focus group consists of a small group of people, who are brought together by a trained moderator (the researcher) to explore attitudes and perceptions, feelings and ideas about a topic". He further added that a focus group interview provides a setting for a relatively homogeneous group to reflect on the questions asked by the interviewer. The data collected from this phase of the research study, are meant to give answers to the third research question which seeks the enabling and constraining factors in this case study.

3.6 RESEARCH INSTRUMENTS AND ANALYTICAL FRAMEWORK

To gather data for this research study, the instruments I used were *observations, MA tests,* and *interviews.*

Observations: Observation was one of my primary data collection instruments. Observation is defined by Kumari (1996) as a "purposeful and selective way of watching and listening to an interaction at the time it takes place" (p. 105). The purpose of my observations was to look at how the participating teachers used their prepared visual materials in the lessons when they implemented a VTA. I would then look for the skills used during the lesson presentations by using the observable indicators in my observation tool. Each participant was observed once a week in each topic cycle. The observed lessons were video-recorded by my school secretary, while I observed to make initial sense of what was going on. The video recorder was placed at the back corner of the class where the after-school session was taking place, to avoid recording the faces of the learners. A total of 12 lessons were observed and recorded (four per participating teacher). The lesson observation took six weeks to be completed. The analytical template in Table 3.3 below was used during the lesson observations for all my participants. The analytical tool used in this study was adapted from Debes (1969).

Table 3.3: Analytical template A: Skills and observable indicators of a VTA. Adapted from Debes, (1969)

		Coding				Remarks or e.g.
Types of teaching skills	Teachers' activity in the classroom (Observable indicators)	1	2	3	4	
Designing visuals This is the ability to identify visual aids for mathematics and making them available for teaching.	A teacher prepares and designs visual aids to use before the lesson starts.					
	Visual materials used in a class are related to the topic taught.					
	Visual materials look attractive and appeal to the learners.					
	Appropriate materials for a grade level.					
Visual language This skill refers to the teacher's ability to teach the elements of the visual language of mathematics.	Naming and labeling of visuals and concepts					
	The language used is leveled to the grade taught.					
	Spelling and grammar adhered to.					
	The teacher uses body language (gestures) to visualize orders, directions, and rules.					
	Learners are allowed to speak, read or write.					
Manipulating visuals This skill refers to how the teacher uses the visuals to explain and interpret the concepts to be taught in the lesson.	Clear explanations of concepts about their visual materials.					
	Visual representations (diagrams or pictures) used in the lesson.					
	Any physical materials (manipulatives) e.g. a box used in the lesson presentation.					
	Any sign of advanced visual style in solving a problem came in a lesson.					
Assessing visuals This skill refers to an ability of a teacher to assess or test if the learners can do tasks visually.	Rough sketching and accurate measuring of diagrams of manipulatives.					
	Labeling and naming of figures/shapes.					
	Identifying appropriate tools to use for a task (e.g. a ruler, a set square, and pencil to find the center of a circle).					
	Visual solutions performed by the learners while doing a task.					

Table 3.4: Analytical template B: The coding categories and their descriptions. Adapted fromDebes, (1969)

Codes	Categories	Descriptions
1	No evidence	Only 1 or no visuals used or demonstrated
2	Weak evidence	Few visual representations are seen, e.g. 2 incidences only
3	Medium evidence	More visuals used up to 3 times
4	Strong evidence	Abundant visuals used up to 4 times or more and related well to the topic taught.

I also used the above framework in the stimulus-recall interviews with the teachers. Thus, this framework formed the basis for my conversations with each observed participating teacher.

MA tests: I administered two types of MA tests to learners. The first type were the big pre and post-tests. The big pre-test would be written before the programme started and the big post-test would be written after the intervention. The big pre and post-tests aimed to gather data toanswer the second research question which seeks to establish whether the adoption of the VTA imposed any changes in mathematics anxiety in the learners as a result of participating in the programme. I then compared the results of these big tests during the analysis. The questions of these pre and post-tests are the same and they are shown in Table 3.5 below. I analyzed the big MA tests quantitatively, using descriptive statistics to illustrate the results.

The second type of MA test was the small MA test (refer to Table 3.6). These tests were administered after each cycle and they were also meant to provide analytical data for this study. The rationale of this test was to continuously monitor change in the learners' MA after each cycle. The results from the small MA tests gave me an indication of how the lesson presentation helped in addressing the learners' MA. Additionally, they (small tests) were good indicators of progress for the teachers as they prepared their subsequent lessons for each cycle.

For anonymity purposes, the learners were not expected to write their names on either of their test papers. They could simply indicate their grades. Table 3.5 below shows the big pre and post-test questions on learners' MA.

Table 3.5: Big Pre and post-test on learners' MA - adapted from Ellen (2006)

#	Statement	Never	Few times	Some-times	Many times	Always
1.	I feel nervous in mathematics class.	1	2	3	4	5
2.	I am shy to go to the chalkboard in mathematics class.	1	2	3	4	5
3.	I am afraid to ask questions in mathematics class.	1	2	3	4	5
4.	I am worried about being mentioned in mathematics.	1	2	3	4	5
5.	I understand mathematics now, but I worry that it will get harder soon.	1	2	3	4	5
6.	I develop the feeling of hiding from mathematics class.	1	2	3	4	5
7.	I fear mathematics tests more than other subjects.	1	2	3	4	5
8.	I don't know how to study for mathematics tests.	1	2	3	4	5
9.	It's clear when I am in mathematics class, but when I go home it's like I wasn't in class.	1	2	3	4	5
10.	I am afraid that the majority of my classmates are better than me at mathematics.	1	2	3	4	5

Table 3.6 below shows the learners' small MA test questions and the coding criteria used: 1-strongly disagree, 2-disagree, 3-neutral, 4-agree, and 5-strongly agree.

Table 3.6: Small test on learners' MA - adapted from Ellen (2006).

Statement	Coding Scores				
(a) I can handle difficult mathematics.	1	2	3	4	5
(b) Mathematics scares me.	1	2	3	4	5
(c) Mathematics is a good subject.	1	2	3	4	5
(d) I wish to carry on with mathematics.	1	2	3	4	5
(e) I think clearly when working with mathematics tasks.	1	2	3	4	5
(f) I am confident to do mathematics	1	2	3	4	5

Interviews: In this study, I used two types of interviews to collect data, namely the stimulus recall interview (SRI) and focus group interview (FGI). The data collected from SRI was triangulatedwith the data from classroom observations and video recordings to answer the first question of this research study. The data collected from the FGI answered the third research question of this study. The interviews were conducted in the following way:

a) In the first instance, I held a one-on-one stimulus recall interview with each teacher after his/her video-recorded lesson. This type of interview is a conversation between the researcher (me) and the respondent (teacher) (Bertram & Christiansen, 2014). This was used to reflect on the observed lesson. During this stimulus recall interview, I played the recorded video for the lesson that the teacher had presented, and together we watched the video. The watching of the video with the participant was to verify my initial analysis of their VTA's observable indicators. In the interview, we also looked at the results of the previous small MA tests. The teachers were also granted an opportunity to elaborate their choice of any of the visuals used. I audio-taped and transcribed each of these conversations. The SRI data was used to answer the first question.
b) In the second instance, I conducted a focus group interview (FGI) with all the teacher participants together, after the final intervention cycle. Bertram and Christiansen (2014) state that FGIs aim to "explore and describe people's perceptions and understandings that might be unique to them" (p. 82). The FGIs were also audio-recorded. This data I used to

answer the third question of my study which has to do with enabling and constraining factors. Some of the teachers wished to respond in writing. If teachers opted to answer the FGI questions in writing before our discussions, I could have allowed them that freedom because some people prefer providing written data as opposed to verbal data. However, my participants were all comfortable with responding verbally. The FGI questions were as follows:

Focus group interview questions

1. What are your experiences of teaching in the after-school programme using a visual teaching approach (VTA)?
    a. ……………………………………………………………………………………
2. Have you detected any differences between your usual teaching approach (mainstream) and a VTA? If so, elaborate more:

    ……………………………………………………………………………………
3. What impacts do you think a VTA can have on learners' participation and motivation toward mathematics?

    ....
4. Do you think a VTA can reduce learners' mathematics anxiety? Motivate your answer.

    ……………………………………………………………………………………
5. How could this approach (a VTA) be made a desirable one to all mathematics teachers?

    ……………………………………………………………………………………
6. Could you please highlight some of the challenges experienced during the interventionprogramme and how these could be overcome?

    ……………………………………………………………………………………
7. Any other suggestions or comments?

    ……………………………………………………………………………………

3.7 VALIDITY

Validation is viewed as an important way of ruling out the possibility of misinterpreting the meaning of what participants do and say, and the perspectives they have concerning what is going on (Maxwell, 2009). According to Cohen et al. (2010), validity is the extent to which interpretations of data are warranted by the theories and evidence used. They further argue that researchers must indicate the grounds and the evidence that they will use to connect their data with the claims made from, or conclusions drawn from the data.

To ensure validity in my research study I triangulated my data. Triangulation is explained by Cohen et al. (2010) as the use of two or more methods of data collection in the study of some aspect of human behaviour. This study used three research instruments to gather data that is valid for the research study. In my study, I dealt with the interpretations of the teachers' use of visualization materials by using stimulus recall interviews, observations, and focus group interviews.

To determine whether my MA test questions would generate the desired data, I piloted the MA tests with a sample of five Grade 4 learners and ten Grade 7 learners at my school. According to Bertram and Christiansen (2014), piloting the research tool enables the researcher to identify the areas that need improvement or correction in that specific tool. They further add that piloting also helps the researcher to make amendments where necessary, to minimize possible errors in the answers to the questions. After I piloted the MA tests I observed that the language used was too formal and some questions were not clear. I later used appropriate language that the learners could understand and made the MA test questions clear and understandable to the learners.

I also member-checked the data by providing the participants with their interview transcripts so that they could confirm whether what was captured was a true reflection of their responses. The member checking was done on all the participants. Mayoh and Onwuegbuzie (2015) asserted that member-checking is a process in which a researcher asks participants to check and verify the accuracy of their recordings. I, therefore, replayed each video-recorded lesson to the presenters in the SRIs to validate whether what was recorded was indeed what happened in the classrooms.

3.8 ETHICS

According to Cavan (1977) ethics in research has to do with sensitivity to the rights of others and maintaining respect for human dignity. To adhere to the rules and standards of the Rhodes University ethics guidelines, I incorporated the following ethical principles in my study:

3.8.1 Respect and dignity

Consent (See Appendix E and F) was sought from the regional director of the Oshikoto educational region and the inspector of education for the Onyuulaye circuit where my school is situated. I wrote letters requesting their consent, to my three participants in this study. I communicated the purpose of this research study and made it clear to them, without withholding any information, that the data collected would only be used for this study. I made it explicitly clear to the participants that taking part in this study was voluntary and they have the right to withdraw at any stage of the research. I guaranteed their anonymity by using pseudonyms T1; T2 and T3. The collected data were kept confidential and were only shared between me and my supervisor.

In addition to this, I also assured the school board members, school management, and the entire staff at the school that this research would not disrupt any morning lessons, because it targeted the after-school intervention programme.

The parents (on behalf of the learners) agreed by signing their specific consent letters as well. The letters to parents were written in English and Oshindonga (local language) – see Appendix G. The letter informed parents about the aim of the intervention. Three parents did not return the consent letters, but fortunately, they called me telephonically to include their children in this investigation. As well as their parents' consent, learners were asked in advance about their willingness to write the MA tests. They were assured that they could withdraw at any time.

Furthermore, I clearly explained all the aspects of my study to all my participating teachers before we commenced. By signing the consent letters in appendix F, the participating teachers agreed to be observed, video-recorded, and audio-recorded throughout the intervention programme. I was aware that even though all these aspects were clarified, it could be possible that the participating teachers chose to volunteer to partake in my study out of obligation because I was their professional superior (Anderson, 2003). This means that teachers might have found it difficult to decline and say no due to my authority and position as their principal. I, therefore, emphasized to the participating teachers that their participation in this study has no link to the authorities or any of our occupation's power relations. For confidentiality reasons, learners were not required to write their names on the answer scripts for any MA tests.

3.8.2 Transparency and honesty

To demonstrate honesty in this study, I explained the main purpose of the research to my participating teachers and their learners as well as the parents of those learners. I further assured that their input would be utilized for this study only. I assured the participants that the data collected in this study would be shared only between me and my supervisor and thereafter it would be archived. I tried to fulfill all trustworthy expectations of every participant to ensure the utmost transparency.

3.8.3 Accountability and responsibility

I can be held accountable for keeping the collected data safe, during and after the research study. In every conversation with my participants, I always tried to be democratic, trusting them and avoiding threatening statements throughout our interactions. My participants were aware that I am committed to keeping the data safe for five years on my computer and at Rhodes University`s Education department only. My computer will have a very sensitive password to ensure that safety. I fully encouraged my participating teachers and learners to give their opinions and answers honestly without having to be afraid of any power relations that may compromise their responses.

3.8.4 Integrity and academic professionalism

I upheld the professional and academic standards and integrity expected by Rhodes University by adhering to the rules and standards as laid down by the institution. My findings were based on authentic data which I collected. My analysis was based on my empirical work and not on my assumptions and opinions.

3.8.5 Researcher position

I was entirely aware that my position as a principal could influence my participants' actions and responses. Thus, from the beginning of planning the intervention programme, I tried to make it clear to the participants that we would-be colleagues and that I should be seen as a student, and not their principal. I also informed them that we would team up together to initiate a new mathematics teaching approach called a VTA. I emphasized that my participants should consider themselves as knowledgeable mathematics educators at the senior primary level and that I was a student trying to understand their expertise and practices, to design and strengthen a VTA. In this way, I was explicit that I hoped to learn from them. I was interested in working with them to investigate the use of a VTA in the context of an after-school club to possibly address the issues of mathematics anxiety among our learners at the senior primary phase.

3.9 CONCLUSION

This chapter placed my research study within the interpretive paradigm. Furthermore, the chapter described the mixed-method approach and justified it more specifically. The research instruments used to collect the data were explained. The research design was thoroughly discussed in its different phases. It then set out how data was collected for qualitative and quantitative analysis. Lastly, I addressed issues of validity and ethical considerations.

The next chapter describes the qualitative and quantitative analysis of the data collected.

CHAPTER 4

DATA ANALYSIS AND PRESENTATION

4.1 INTRODUCTION

In this chapter, I report on the findings of the data that I collected from my investigations. These findings were aimed to give information and arguments that would help me as a researcher to answer the following three main research questions:

(a) How do three selected Grade 5-7 teachers use a visual teaching approach in the context of an ASC, as a result of participating in an intervention programme?
(b) How does the adoption of a VTA result in a change in MA amongst the learners of the participating teachers?
(c) What are the enabling and constraining factors when teaching with a visual teaching approach in an ASC?

My decision to carry out this investigation was inspired by my hope to create awareness amongst teachers and education researchers about the explicit use of a visual teaching approach (VTA) in the teaching and learning of mathematics to possibly address issues of MA among the learners. Therefore, the goals of the research were to try to find out: firstly, how the three selected Grade 5-7 teachers use a visual teaching approach when teaching in the context of an ASC, as a result of participating in an intervention programme; and secondly, to establish any change in MA among the learners of the participating teachers; and thirdly, to explore the enabling and constraining factors when teaching with a VTA in an after-school club.

In the first part of this analysis chapter:

- I first present a brief profile of the teacher concerned.
- Then, for each lesson, a brief overview of the observed lesson is given.
- This is followed by a bar chart that illustrates the frequency of the four specific types of teaching skills that were observed, according to my analytical tool. These are Designing visuals (**DV**), Visual language (**VL**), Manipulating visuals (**MV**), and Assessing visuals (**AV**).

The narrative of each lesson is based on my observations and one-on-one interviews with each teacher.

The second part of this analysis chapter consists of the results of the learners' pre and post-tests. These are presented to answer the second research question that has to do with detecting a possible change in MA amongst the learners of the participating teachers. This data is presented quantitatively in the form of tally marks, small tables, and pie charts. Thereafter, the FGI analytical tool is used to answer the third question about enabling and constraining factors in teaching with a VTA.

4.2 ANALYSIS OF LESSONS

4.2.1 TEACHER ONE (T1): MS TUUDA

4.2.1.1 Profile of T1

Ms. Tuuda is a Grade 5 mathematics teacher with six years of teaching experience. She holds a BEd-Hons from the University of Namibia. She specialized in mathematics and integrated natural science (INS) subjects in the senior primary phase (i.e. Grade 4-7). She has been teaching mathematics since the start of her career. Data for Ms. Tuuda in this research are coded as follows: Teacher one (**T1**), Grade 5 (**Gr 5**), Lesson one for Grade 5 (**L1 – Gr 5**), Lesson two for Grade 5 (**L2 – Gr 5**), Lesson three for Grade 5 (**L3 – Gr 5**), Lesson four for Grade 5 (**L4 – Gr 5**), Videos for Ms. Tuuda (**T1V1, 2, 3 & 4**), Stimulus Recall Interview (**T1 SRI**) and Focus Group Interviews (**T1 FGI**). Ms. Tuuda is the only respondent responsible for Grade 5 mathematics teaching in this intervention. She taught four lessons that were video-recorded and analysed.

4.2.1.2 Lesson 1

(a) A brief overview of the lesson

In this lesson, T1 introduced the topic of three-dimensional (3-D) shapes. The objective of the lesson was to teach learners the meaning of the term 'three-dimensional shapes' in comparison with 'two-dimensional shapes' and to explore their differences. The teacher entered the class with some hand-made materials such as cubes, cuboids, and prisms that represented the use of a VTA in this lesson. Some of these materials can be seen in Figure 4.1 below.

Figure 4.1: Hand-made 3-D manipulatives used in L1 of T1

Ms. Tuuda also sketched diagrams of a rectangle and a square on the chalkboard immediately after greeting the learners. She used the sketches shown in Figure 4.2 below to introduce this lesson.

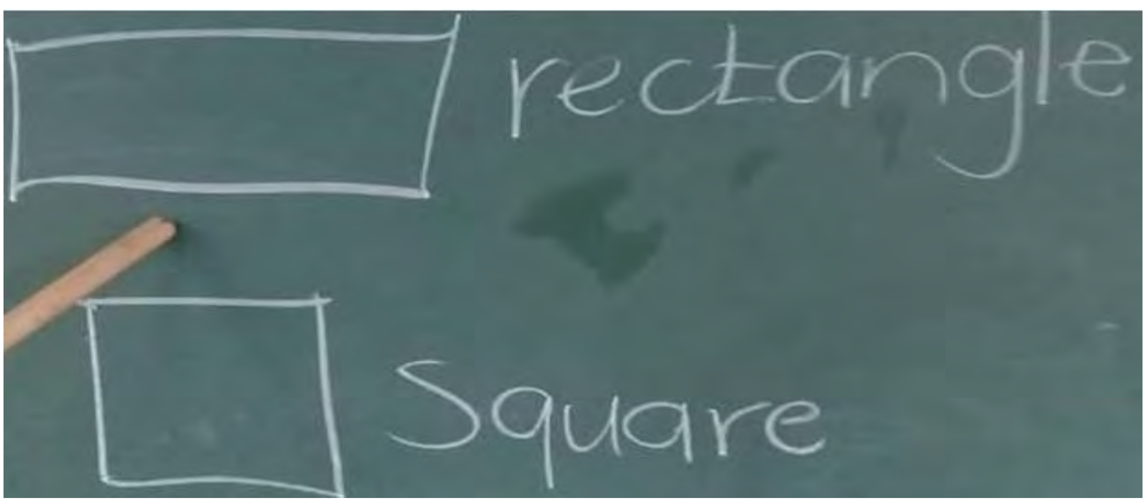


Figure 4.2: Rough chalkboard sketches used in the introduction of L1 for T1

(b) VTA types of skills in L1

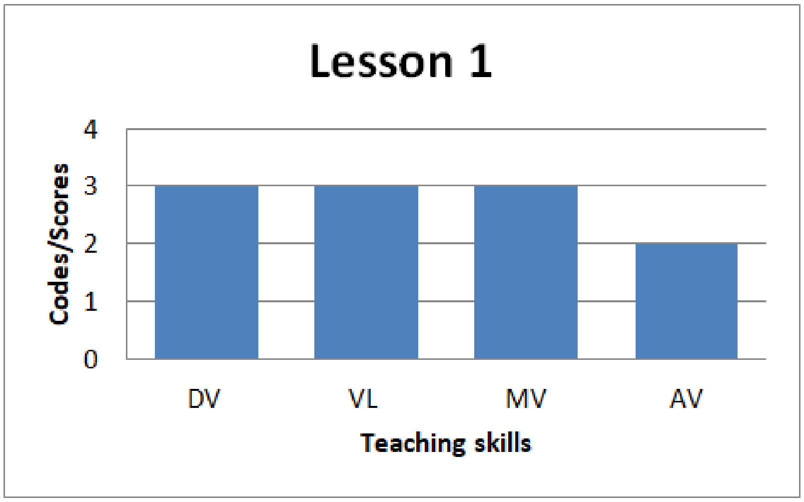


Figure 4.3: Numerical scores of T1's skills on three-dimensional shapes

Figure 4.3 above presents the frequency scores of the skills observed in the first lesson of T1 when she taught three-dimensional shapes. The first three bars in the above figure show that there was medium evidence that T1 used the skills of *DV, VL,* and *MV* about three times each in this lesson. The bar chart also shows that the teaching skills of *AV* were used to a slightly lesser extent by T1 in her first lesson.

Designing visuals: T1 entered the class with a box containing some hand-made cubes, cuboids, and other pyramids as shown in Figure 4.1. This, on its own, indicated that she had prepared the visuals before entering the class. Those 3-D materials looked attractive and appealed to the learners. She also sketched a rectangle and a square on the chalkboard. The sketches were not straight, because she did not use a ruler (refer to Figure 4.2). The teacher did not explain in more detail some of the shapes she brought into the class, like cylinders and pyramids, but merely introduced them by their names. However, when I asked her during the stimulus recall interview, why she had done this, she stated: "*According to the Gr 5 mathematics scheme of work, the harder shapes like pyramids are not supposed to be interpreted in detail to the learners in the first lesson of three-dimensional shapes*" (T1 SRI-L1). She further reasoned that: "*Maybe that was done to prevent the learners from getting too much information at the beginning which can confuse. These types of confusions may also cause the MA"* (T1 SRI-L1).

Visual language: The teacher spelled the names of all shapes correctly and she labeled the drawn shapes with their correct geometrical names like ‘rectangle’, ‘cuboid’, ‘cube’, etc. Ms. Tuuda repeated the new and unfamiliar words to the learners like ‘cuboid’ and ‘cube’ for them to be able to pronounce them. T1 code-switched two to three times when she was helping one learner at the back of the class. She was showing that particular learner that a cuboid has eight vertices and they are called ‘oongotsa’ in Oshindonga vernacular. During the interview, she said that “*I always take some time to help that Thomas (a learner). He is one of the vulnerable learners because he is over-aged and he only started schooling the previous year*” (T1 SRI-L1). She further explained that Thomas does not fully understand her presentations in English. Another observed feature of visual language was how Ms. Tuuda made use of her body language by pointing to the chalkboard with her hands or with a pointing stick, and by holding the three-dimensional shapes high up for all learners to see and identify components of the shape, like the vertices (refer to the Figure 4.4 below).

Figure 4.4: T1 holding a cuboid asking learners to count the number of vertices

Manipulating visuals: When she introduced the lesson by using a rectangle on the chalkboard, she asked the learners what it was. The learners said it was a rectangle. She pulled out a cuboid from the box and also asked them what it was. She was impressed when one learner said it was a box made with many rectangles. *“Very good boy! Who else can see rectangles on this and how* *many are they"?* She asked the class loudly and happily. The teacher and learners started counting the rectangles on the box before even mentioning even the name 'cuboid'. When I asked her why she looked impressed by the answer of the boy in SRI she stressed that: *"I was so happy because my cuboid showed the link between the rectangle on the chalkboard and the ones on it. The boy detected the rectangles on the box so quickly. His answer simplified my explanations of those rectangles to the rest of the class"* (T1 SRI-L1). From there she stated that the mathematical name of the box is 'cuboid'. Ms. Tuuda continued explaining the properties of cuboids and cubes, like the number of faces (rectangles/squares), edges (straight lines), and vertices (points). She also stressed that the cuboids' six rectangles are called faces. She further elaborated on the differences between the rectangle and the cuboid as well as between the square and the cube. The manipulatives of cubes and cuboids were physical and concrete, and most of the learners wanted to touch them.

Assessing visuals: T1 introduced the lesson by testing the prior knowledge of the learners using sketches as her visuals. She did this by asking the learners the names of the shapes. By doing that, she was assessing and at the same time linking the learners' new understanding of cuboids to their previous knowledge of rectangles. Immediately after continuous questioning throughout the lesson's delivery, the bell rang before any tasks were given by T1. During the one-on-one interview, T1 reflected that: "*Our planning included too many concepts to teach without considering the 60 minutes long lessons and the Grade 5 pace. The other problem that affected the lesson was that some of the learners were absent as they went for cultural performance preparations while others went for singing practice that same afternoon. It is a bit safe that we didn't go that far"* (T1 SRI-L1).

4.2.1.3 Lesson 2

(a) A brief overview of the lesson

The second lesson of Ms. Tuuda was on comparing common fractions. The objective of the lesson was to teach learners how equivalent fractions are said to be equal and to compare some other fractions using visuals. T1 entered the class with some cardboard cutout fractions and some Bostik glue. Most of these fractions pieces were in the form of circular and triangular shapes (see Figure 4.6).

(b) VTA types of skills in L2

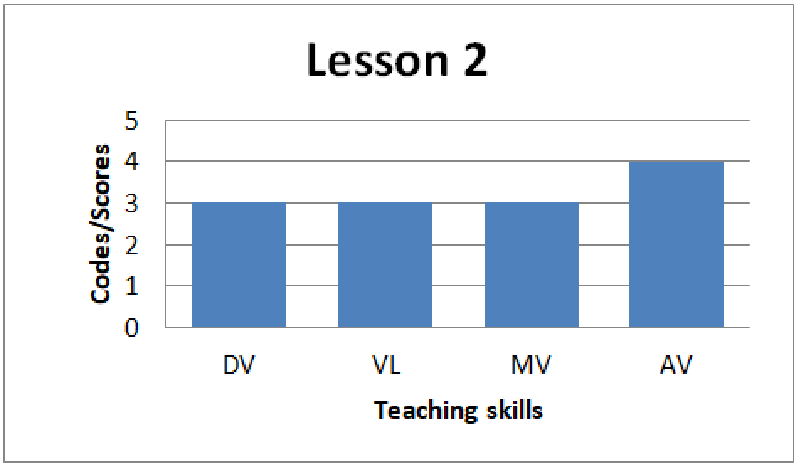


Figure 4.5: Numerical scores of T1's skills on comparing common fractions

Figure 4.5 above presents the frequency scores of the skills observed in the second lesson of T1 when she taught comparing common fractions. The first three bars in the above chart show that the average of all the observable indicators in all those three skills (*DV, LV,* and *MV*) rounded off to a score of three. This is thus medium evidence, revealing that T1 used her visuals about three times in this lesson. The bar chart also shows that the teaching skills of *AV* were used abundantly by T1 in her second lesson.

Designing visuals: T1 prepared some fraction pieces made from cards and paper. The pieces looked new and attractive because they were in different colors (blue, yellow, and white) – see Figure 4.6 below.

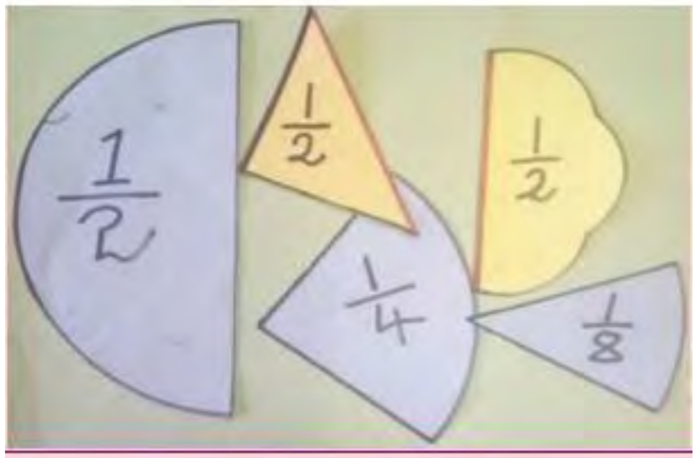


Figure 4.6: A picture of some fraction pieces used in L2 of T1

The used fraction materials were appropriate for Grade 5 because they only contained fractions with numerators 1 like ½, ⅓, ⅙, ⅛, ⅒, which the learners could compare easily.

Visual language: Most of the learners understood T1 despite her advanced English. When she asked a question, the majority of the learners raised their hands and gave the correct answers. She also gave the learners opportunities to ask questions. A surprising incident happened in this lesson when one learner wanted to ask the teacher why some pictures of halves were bigger than others. The learner could not ask this in words but decided to draw them on the chalkboard. He drew two triangles of different sizes and labeled ½ on each and then asked why they are all halves but they are not equal in size. The boy said he saw this in a textbook at home. Figure 4.7 below shows the pictures that the boy used to ask his question visually on the chalkboard.

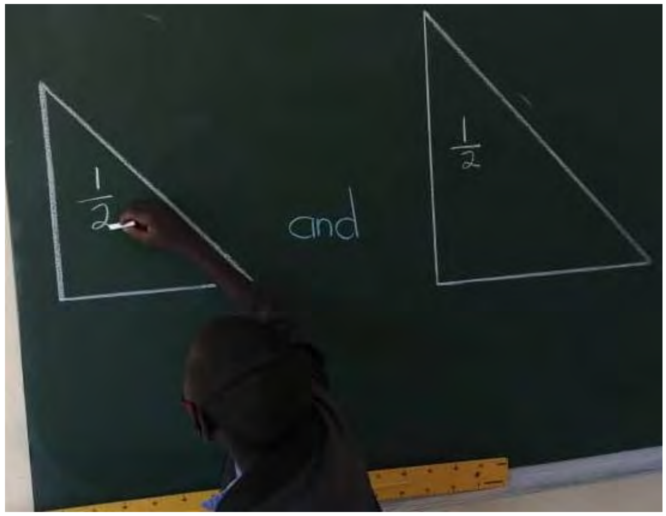


Figure 4.7: The learner's question on why these halves are not equal in size

T1 answered the question by completing all the triangles to form complete quadrilaterals and informed the class that all the specific triangles are halves of their different-sized shapes. She also elaborated further by saying: *"Half of a chicken is smaller than a half of a goat when they are slaughtered, but they are all halves"* (T1-L1). The move of this boy proved how diagrams can assist learners to present their questions visually. The participating learners in my study were expected to express their ideas and thoughts through images and sketches. She once again used abundant body language to attract the learners' attention when she answered this learner's question. She did this by comparing half of her body with half of the small boy's body.

Manipulating visuals: T1 explained that if the numerators of two or more fractions are the same, the one with the smallest denominator (bottom number) is the biggest fraction. She visualized this point by using the fraction pieces of the half, quarter, and eighth. She stuck them on the chalkboard in the way they are shown in Figure 4.8 below.

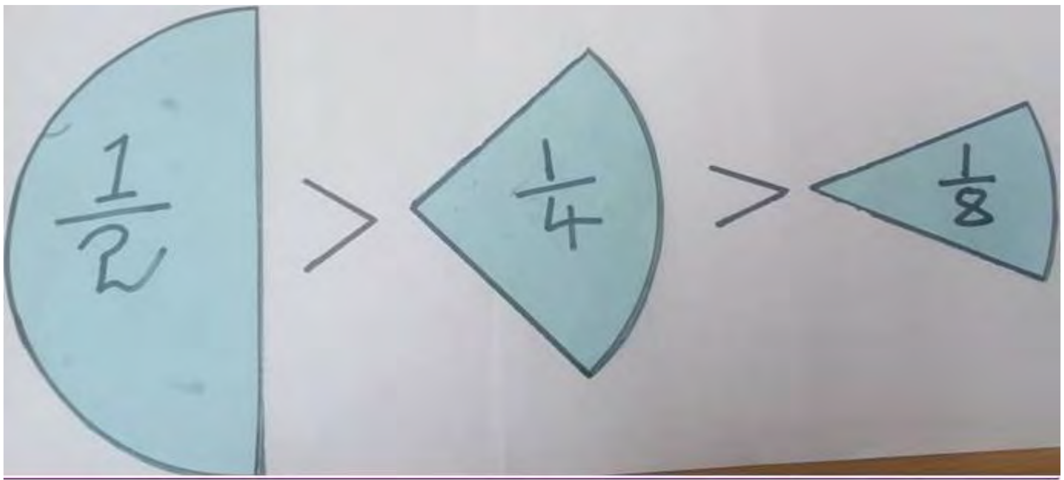


Figure 4.8: Comparing fractions of the same numerators

The teacher reinforced that the denominator two in the above fractions is smaller than four and eight of the other fractions. But its fraction, which is ½ in this case, is the biggest one as shown in the picture. T1, during SRI, said: *"Sir, you see the magic those fraction pieces are showing the learners there? Even if the learner does not understand my explanations on denominators and so forth, she/he can see with his/her eyes, the bigger piece. It is not even a matter of using those greater than signs"* (T1 SRI-L2).

In this same lesson, T1 also demonstrated visually how the fractions are said to be equivalent. She did this by matching the four pieces of eighths with one piece of the half. To me, this was also a clear use of visuals to compare fractions, as shown in Figure 4.9 below. It was a practical and visual 'proof' of why $\frac{1}{2} = \frac{4}{8}$

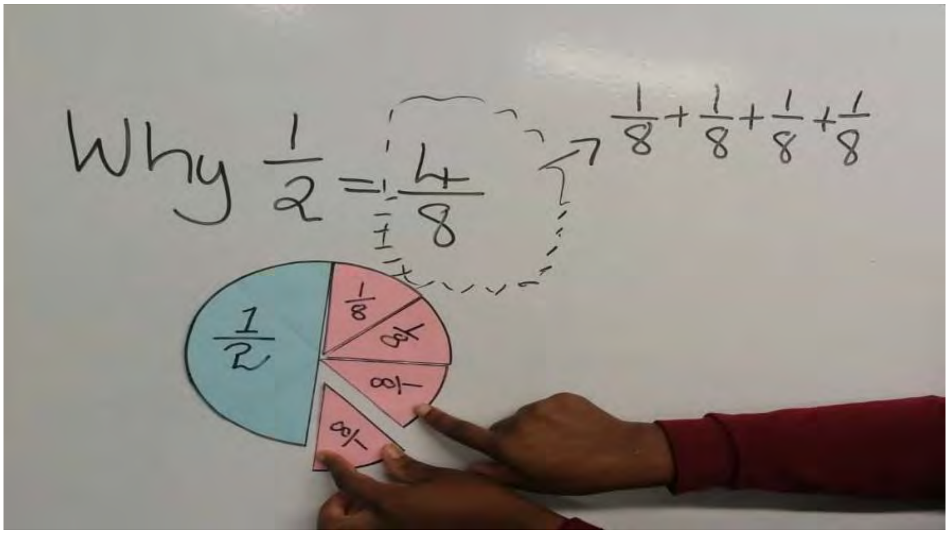


Figure 4.9: T1 matching the eighths to form a half

Assessing visuals: T1 gave an activity to the class, to match halves with quarters, sixths, and tenths in different groups. This class activity was given to learners in groups of four to five. Each group was given a bigger piece for ½, like the one in Figure 4.9 above, and smaller pieces like three quarters, four sixths, and seven-tenths. The task was then to see how many of the small fractions could form ½. This activity encouraged the learners to use visuals to practice equivalent fractions in this lesson. During her reflection on this lesson, Ms. Tuuda expressed: *"This fractions lesson was fun. Fractions were not as difficult as some learners label them. Those colourful materials made the learning of fractions more interesting to my learners. It was amazing to see many learners wanted to touch, feel, see, and listen to all that I planned to present"* (T1 SRI-L2).

4.2.1.4 Lesson 3

(a) A brief overview of the lesson

The third lesson of T1 was on mathematics rules in Grade 5. The objective of the lesson was to teach learners the hierarchy of operations that are used in calculations, and why. The teacher entered the class with a poster of some unsolved problems (see the poster in Figure 4.10 below).

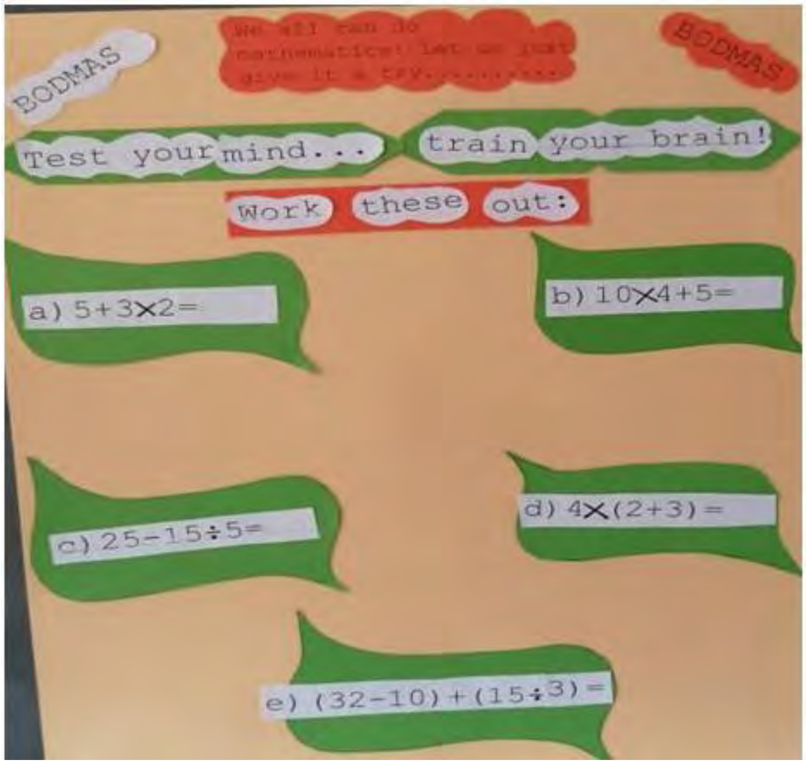


Figure 4.10: A poster of unsolved mathematics problems

Some of the problems included 5+3×2 and 25-15÷5. Ms. Tuuda also had some differently coloured marker pens and some coloured chalks including two white ones. She also had an envelope containing printed words on strips of paper.

(b) VTA types of skills of L3

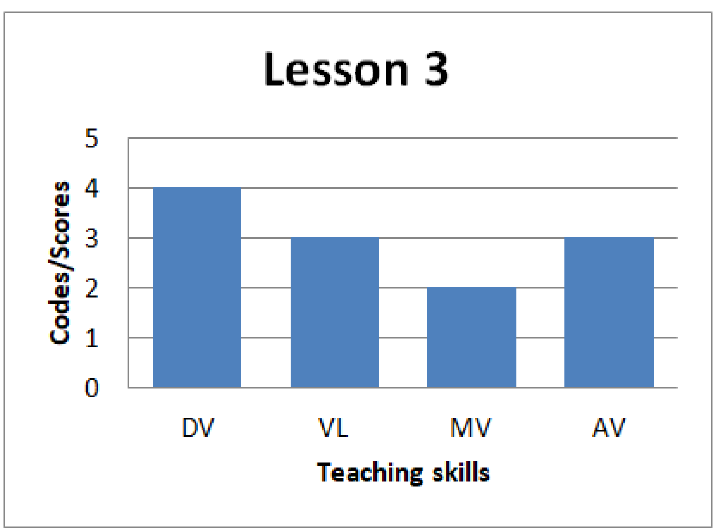


Figure 4.11: Numerical scores of T1's skills on mathematics rules

Figure 4.11 above presents the frequency scores of the skills observed in the third lesson of T1 when she taught mathematics rules. The data shows that the *DV* skills were observed most in this third lesson of T1. The *VL* and *AV* skills were used to an extent of a score of three. The *MV* skills were demonstrated the least.

Designing visuals: The visuals of this lesson were prepared before the lesson but the poster was completed in the class during the teaching. The teacher prepared a poster that had unsolved problems. She also designed some flashcards to stick onto the poster as the teaching unfolded. The coloured marker pens were purposefully used to highlight all the steps to follow when calculating, like multiplication first before adding. The completed poster was attractive and colorful by the end of this lesson (refer to the picture in Figure 4.12). Much of the production of the poster was done by the learners through the teacher's guidance.

Visual language: In the introduction, T1 asked the learners to mention the four basic operations. The learners mentioned them while the teacher was jotting them onto the chalkboard. The operations were mentioned and recorded as +, -, ×, and ÷. The other visual language skill observed was how she guided the learners to calculate and complete the poster. To avoid different handwriting on the poster, she asked learners first to write their suggestions on the chalkboard. She then copied their products onto the poster when the final answer to the problem was agreed upon by the whole class. When she allowed learners to ask questions, one girl asked why they have to multiply first before adding if there are no brackets in a problem. Ms. Tuuda answered that it was a mathematics rule, which was agreed upon globally. The poster was clear and complete by the end of this lesson (see Figure 4.12 below).

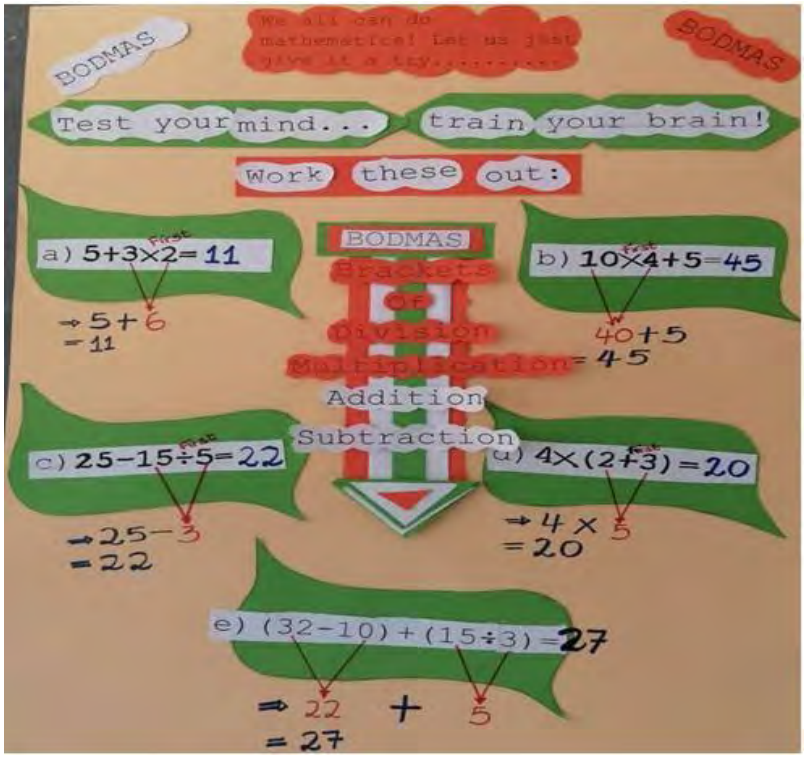


Figure 4.12: The poster of the solved problems by the lesson's end

Manipulating visuals: Immediately after the introduction, the teacher put up the poster with the unsolved problems on the chalkboard and asked learners to quickly answer (a) 5+3×2 and (b) 10×4+5 individually. She promised to give sweets to the first two learners that could get them all right. The first four learners that finished got their answers as (a) 16 and (b) 45. That is an indication that these learners did not use the brackets of division multiplication, addition, and subtraction (BODMAS) rule in the first problem, and they only got the second problem correct because the multiplication sign was written first in (b). The fifth and seventh learners were the ones who got sweets as they got all the answers correct. Ms. Tuuda asked the seventh one to show how she solved number (a) on the chalkboard. In the interview, I asked T1 why she focused more on the seventh learner, and her response was: *"That girl is good at mathematics in comparison with the rest of the group. She always gives me the right answers. But maybe she gets afraid of me. She is too quiet mostly in my lesson. I now try by all means to give her some work in my lessons to see if that can reduce her fear. I also try to train that girl to stand in front of others to present something. This would reduce her shyness in my lessons"* (T1 SRI-L3). The teacher continued explaining the BODMAS rules by making use of other problems from (c) to (e). She was giving turns to the learners to write their solutions on the chalkboard while she was copying them into the poster.

Assessing visuals: In this lesson, T1 first asked learners to mention the four basic operations. She also tasked them to solve the first two problems in the poster. It was very interesting to observe the learners getting opportunities to practice the 'BODMAS' rules on the chalkboard. The teacher used the 'question and answer' teaching method for most of this lesson. She told the learners to use coloured chalk to show the steps they followed when solving these problems.

4.2.1.5 Lesson 4

(a) A brief overview of the lesson

The last observed lesson of T1 was about place value. The objectives of the lesson were: to teach learners to identify units, tens, hundreds, and thousands in given whole numbers; to investigate what is meant by the word 'digits', and to form large numbers using single-digit cards. The teacher entered the class with some laminated cards of single digits. The illustration below in Figure 4.13 shows some of the cards she brought to this lesson.

Figure 4.13: The single-digit cards used in this lesson

(b) VTA types of skills of L4

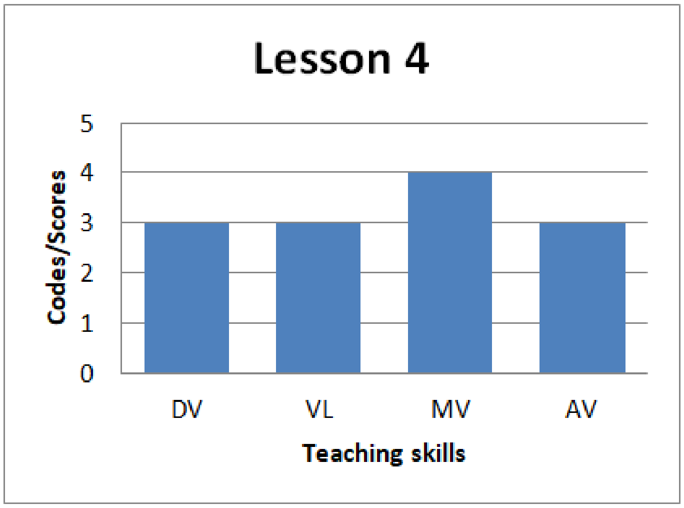


Figure 4.14: Numerical scores of T1's skills on place values

Figure 4.14 above presents the frequency scores of the skills observed in the fourth lesson of T1 when she taught place value. The skills of *MV* were most frequently evident, compared to the other three types of skills (*DV, VL,* and *AV*) which were moderately used by T1 in this lesson.

Designing visuals: A variety of single- digit cards in different colours were prepared by T1 before this lesson. The prepared cards were then stuck onto the chalkboard with glue to form numbers. The teacher sketched a table of place values on the chalkboard.

Visual language: The spellings of 'tens', 'hundreds', 'thousands', etc. were correct and they were elaborated on by the teacher after she had written them on the place values she sketched on the chalkboard. The learners were then given opportunities to state the number of digits in the big numbers dealt with and to indicate which digit was in the place value holder for hundreds, units, etc. For instance, she verbally asked one learner to mention how many digits formed the number 'five thousand, seven hundred and thirty-four (5 734)'. She asked another learner to say what those digits are and another learner to form that number using the cards in the place value order. These were all mathematics visual language skills being practiced. As I stated in Chapter 2, a VTA would enable the teachers to actively engage with learners during the lesson presentations.

Manipulating visuals: These were the most observed skills as shown in the bar graph in Figure

4.14. T1 boosted up these skills by making use of the cards that were more attractive and in different colours. The learners were using these single-digit cards directly by touching them physically to construct numbers and position them in the right place value holders. This exercise was very lively for the learners. They appeared to be confident and happy. When I was going out of this class, I heard one learner telling a friend that she enjoyed the lesson. A VTA advocates that teachers should plan and present lessons that accommodate the use of confidence-building methods in their mathematics teaching. Many learners drew visual representations of number-building styles using single digits cards on the chalkboard as they were asked by the teacher. In the one-on-one interviews, T1 said, '*It made it more logical that each group of the same color for the cards was placed separately from others. That helped my learners to form each number with the cards of the same color'* (T1 SRI-L4).

Assessing visuals: The tasks for this lesson were dominated mostly by the learners pasting digits on the chalkboard, to form the numbers that were read out loudly by the teacher. The teacher was also evaluating whether the learners could write the whole numbers. Homework was given after this lesson. It was almost the same as the class activity but the last two problems included the ten-thousand place value. To my question of whether she detected any progress in her learners as a result of participating in this programme, this is what T1 said: *"This programme imposed positive mindsets in my learners. My learners tend to perform quite well in this subject now. They are even becoming confident to participate in these afternoon lessons. The majorities are attending now and they are willing to touch and play with my teaching materials"* (T1 SRI-L4).

4.2.1.6 Summary of visuals used in the four lessons for T1

- In L1: The teacher made this less visual by using concrete materials, such as hand-made three-dimensional teaching aids. The materials used were obtained from the local environment (e.g empty milk boxes).
- In L2: She used fraction pieces to help the learners to compare fractions. A boy who asked the question while drawing triangles on a chalkboard also demonstrated a visual presentation in terms of the picture's language.
- In L3: T1 created a poster of unsolved problems that were all BODMAS based. She guided learners to solve all the problems in the lesson for them to produce their notes together.

- In L4: Ms. Tuuda used single-digit cards that the class used to learn about place value andwriting big whole numbers.

4.2.2 TEACHER TWO (T2): SIR KUKUTA

4.2.2.1 Profile of T2

Sir Kukuta teaches mathematics to Grades 4 and 6. He has been teaching mathematics for eight years now. Besides his Bed Hons from the University of Namibia, he obtained an Advanced Certificate in Education (ACE) from the North-West University. He majored in mathematics and integrated natural science (INS) in the Senior Primary phase (i.e. Grades 4-7). Data for Sir Kukuta in this research are coded as follows: Teacher two (**T2**), Grade 6 (**Gr 6**), Lesson one for Grade 6 (**L1 – Gr 6**), Lesson two for Grade 6 (**L2 – Gr 6**), Lesson three for Grade 6 (**L3 – Gr 6**), Lesson four for Grade 6 (**L4 – Gr 6**), Videos for Sir Kukuta (**T2V1, 2, 3 & 4**), Stimulus Recall Interviews (**T2 SRI**) and Focus Group Interviews (**T2 FGI**). Sir Kukuta is the only respondent responsible for **Grade 6** mathematics teaching in this intervention.

4.2.2.2 Lesson 1

(a) A brief overview of the lesson

Sir Kukuta presented four video-recorded lessons in Grade 6. His first lesson focused on square numbers and cube numbers. The lesson aimed at revising square numbers and introducing cube numbers. He designed a poster showing square and cube numbers in parallel columns. Figure 4.15 below shows the poster that Sir Kukuta used in his lesson.

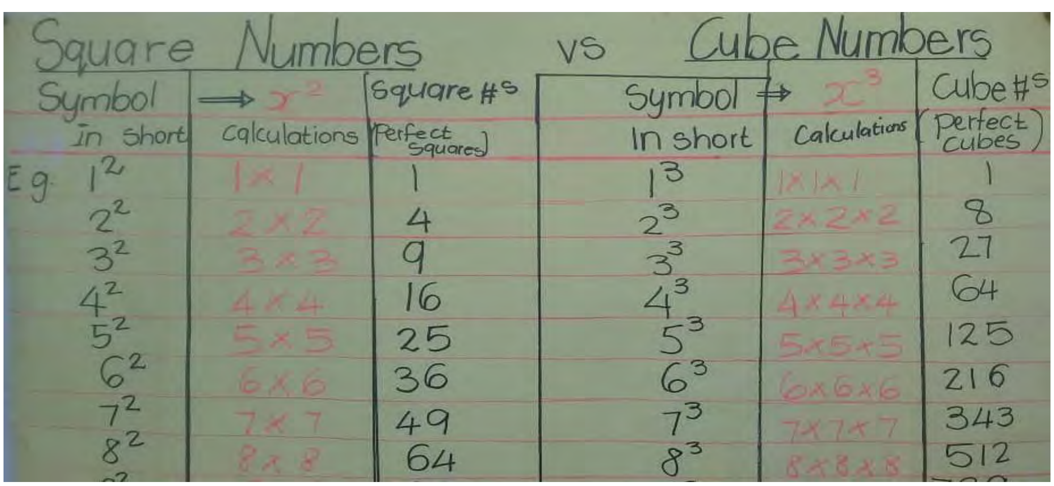


Figure 4.15: The poster of square numbers and cube numbers used in L1 of T2

In addition to the poster used, he provided five flashcards that contained different types of numbers written in different forms as shown in Figure 4.16 below.

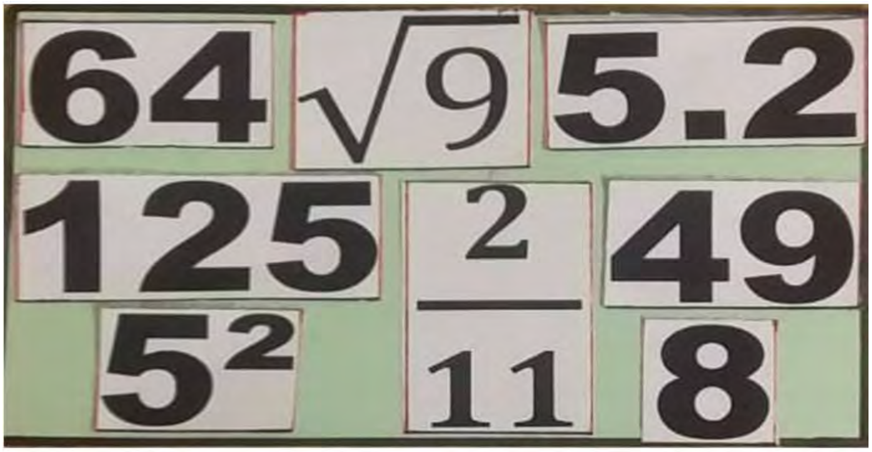


Figure 4.16: Some of the flashcards used in L1 of T2

Sir Kukuta further divided his learners into groups consisting of three to four learners per group. Each group was provided with a flashcard.

(b) VTA types of skills

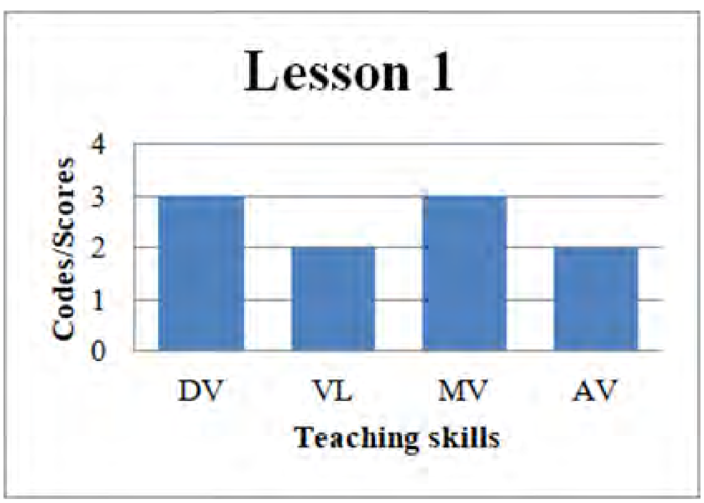


Figure 4.17: Numerical scores of T2's skills on square numbers and cube numbers

Figure 4.17 above represents the frequency scores of the skills observed in the first lesson of T2 when he taught square numbers and cube numbers. The scores of *DV* and *MV* skills outperformed the *VL* and *AV* skills, indicating that more aspects of the two skills (*DV* and *MV*) were observed than for the other two (*i.e. VL* and *AV*).

Designing visuals: T2 prepared a poster showing square and cube numbers before the lesson. He also designed the flashcards that he distributed to the groups. Each flashcard contained a range of different numbers arranged randomly. The square numbers and cube numbers in the teaching poster were appropriate for the Grade 6 level, because the greatest square was 100, while the biggest cube was 1000. The poster looked attractive as it was written in different colours such as blue, black, and red. The flashcards the teacher brought to the class contained the numbers mixed up as even and odd numbers, perfect squares, cubes, powers with the exponents of two and three, as well as some fractions. They were written on both sides of the flashcard. T2 had three marker pens as well.

Visual language: The teacher used grade-level language in the poster. He titled it 'square numbers vs cube numbers' which was the topic at hand. T2 indicated the symbols (x^2 and x^3) of these two concepts (squares and cubes) in the appropriate blocks in the poster. The poster contained tables with subtitles on top as shown in Figure 4.15. When the teacher stuck the poster on the chalkboard, it contained some empty rows –the third, fourth, sixth, seventh, and ninth rows. So, at the beginning of this lesson, the poster looked like Table 4.1 below.

Table 4.1: Example of the poster of T2 at the introduction of L1

Square numbers			**Cube numbers**		
In short = x^2	Calculations	Square numbers	In short = x^3	Calculations	Cube numbers
1^2	1×1	1	1^3	1×1×1	1
2^2	2×2	4	2^3	2×2×2	8
5^2	5×5	25	5^3	5×5×5	125
8^2	8×8	64	8^3	8×8×8	512

During the SRI, I asked T2 why he left some rows blank on the poster. His response was; *"Sir, the blank space or a gap in a table is a visual language on its own. The gap is visually informing the learners that there is work left for them. You see those gaps communicated directly to my learners without any single word from me. Thus some learners started calculating while I was busy with the introduction"* (T2 SRI-L1). "The other reason is," he continued, *"... my learners like to use the posters that they produced or participated in their production. When these posters are displayed in the class, they like pointing at them saying: that's my work or that's our group's* *work. This to me shows that my learners are developing the will of producing their visuals in my subject"* (T2 SRI-L1).

The teacher gave the learners opportunities to speak and write when he asked them to calculate and complete the empty rows in the poster. The learners discussed in their groups and provided the answers for the teacher to write on the poster with the marker pens. The learners also spoke when they were identifying numbers as squares, cubes, fractions, etc. from the flashcards.

Manipulating visuals: The teacher asked the learners to suggest some examples of square numbers they had learned the previous week. The learners mentioned '2', '4', and '25'. He rejected the '2' and pasted the poster on the chalkboard. T2 asked the learners to fill in the rows of the squares for '3' and '4' as they were blank in the poster. While he was getting answers from learners, he detected that two groups at the back were making a noise and they seemed to be writing something else. He quickly rushed there and looked at what they writing.He did not say anything but his stern face gave the message that they should stop making a noise.In the one-on-one interview, I asked him to tell me why. He said, *"I wanted to stop them if they were writing different things. Fortunately, I found them calculating cubes. They were in a lesson but just ahead of the class. You know, that's a problem with designing a poster containing some problems solved. Some learners get the ways of working out the rest of the problems. So, to me, they were doing well. I just had to warn them to stop making noise and of course to wait for the rest of the class. I warned them with the facial expression which is also visual I guess"* (T2 SRI-L1). From there he distributed the flashcards per group. He told the learners to finish filling the gaps in the poster first so that they could move on to the next activity. T3 said that the activity would require them to use the flashcards.

Assessing visuals: After completing the poster of squares and cubes, the teacher instructed the learners on what to do with the flashcards. He sketched a table titled 'squares, cubes, and fractions' on the chalkboard. He told the learners to copy that sketch into their group workbooks. He further asked them to identify those types of numbers from the flashcards and write them in the tables. When the learners were busy working, two girls called him. I did not hear what they asked him but I could observe him helping them with the squaring of $(\frac{2}{11})$. During SRI he clarified this by saying: *"I realized that those two girls started working on that problem immediately after getting the flashcards without any instruction. One thing I detected in using* *visuals is that number cards can give instructions without words. I think the girls hoped that every number in the flashcard was to be squared or cubed you see. Those visuals can also make learners guess the task they are expected to do as well. These girls might have guessed that the fraction would be squared. Anyway, I found them done with squaring the numerator 2. They were just struggling with 11. I just helped them to get 121 and to form the new fraction of as* $\frac{4}{121}$*"* (T2 SRI-L1).

I also observed a debate that arose in one group. The debate was about whether the group could write '64' as a square number or a cube number. The feeling of some was that '64' could not be written twice in the exercise. The girl that won the debate convinced all her group members by saying, *'You guys don't even need to ask Sir! The question is not telling us to use the number only once from the card and 64 appeared twice in the poster also. Let's put it in two lists of our answers also'.* That girl convinced others by suggesting that 64 can appear in both lists in the poster. To me, the learners could visually identify that 64 is a square number and a cube number. The study of Allen and Fraser (2007) termed this as visual thinking and they referred to it as the sharing of information through pictures or diagrams.

4.2.2.3 Lesson 2

(a) A brief overview of the lesson

Sir Kukuta's second lesson was on rounding off. The lesson aimed at ensuring that learners can round off whole numbers to the nearest ten, hundred, and thousand as stipulated in the mathematics syllabus. T2 brought to class some physical materials such as arrows for rounding up and down, parallel bars for the equal sign, and wavy bars for the approximate sign. These materials were cut from a cardboard box and were all coloured white. The teacher also had glue, coloured chalk, and a one-metre chalkboard ruler. The video frame below (Figure 4.18) shows some of the materials and the number line the teacher used to introduce this lesson.

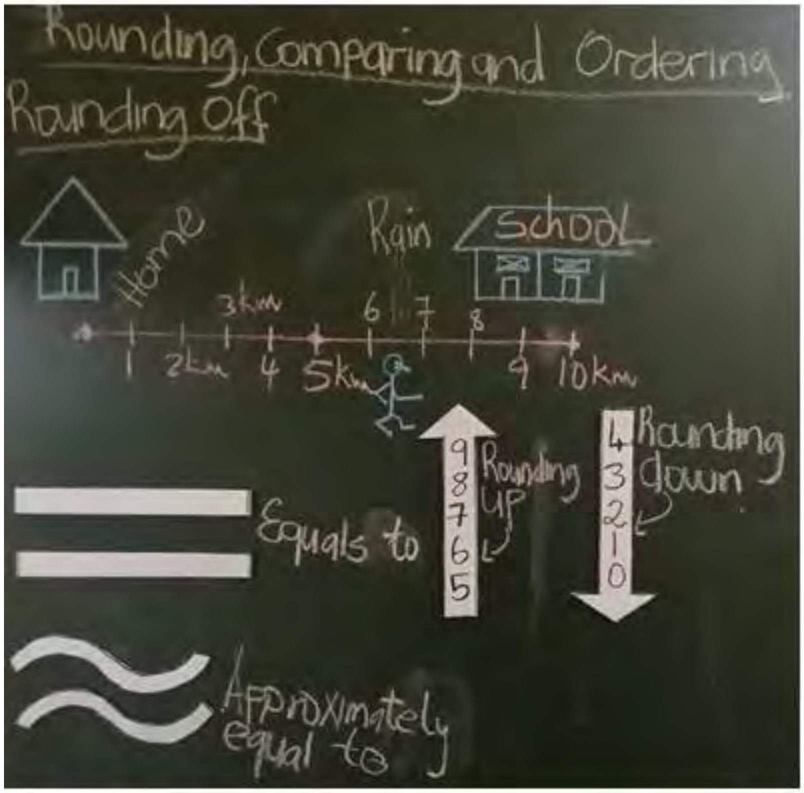


Figure 4.18: Some concrete materials assembled on the chalkboard close to the number line.

(b) VTA types of skills

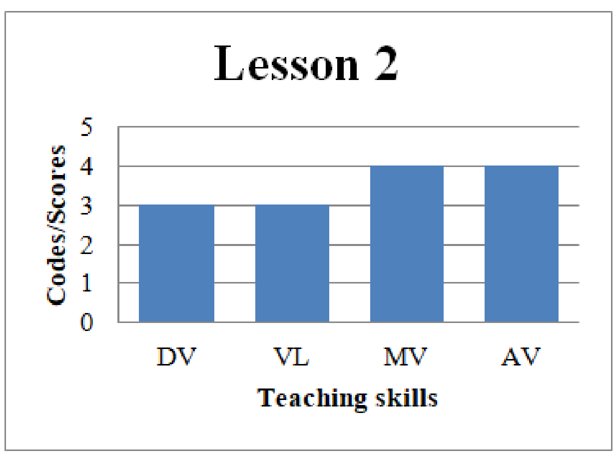


Figure 4.19: Numerical scores of T2's skills on rounding off

Figure 4.19 above presents the frequency scores of the skills observed in the second lesson of T2 when he taught rounding off. It is evident in the above graph that there was the abundant use of *MV* skills and *AV* skills compared to *DV* and *VL* which were employed moderately. Concisely, the chart shows that almost all the teaching skills were visible in the lesson presented and they kept increasing from the *DV* skills to the *AV* skills.

Designing visuals: T2 designed teaching materials as described and pictured in the brief overview of this lesson. He also introduced the lesson with some visuals. He sketched a house and a school that are ten km apart. He then drew a number line and a boy running to school in the rain. The sketch indicated many drawn visuals like the house, school, rain, and the boy. It simplified the rounding off to the nearest ten. The distance is ten km and the rain started when the boy was six km away from home. That means he was only four km away from school. The closest or nearest place of home and school was therefore the school. The above scenario was related and relevant to the topic, specifically in the introduction stage of rounding off. The sketch looked very attractive and appealed to the learners as he used different colours. I also noted other details on the number line (i.e. home, rain, and school) that were evidence for other skills like visual language and manipulating visual skills. The planning of visuals in this lesson linked the abstract to the concrete. The rounding off as an abstract concept was introduced with an example of a real-life situation. Beilock (2008) suggested that a teacher should plan lessons in a way that makes precise use of visuals to make his/her teaching more concrete and accessible.

Visual language: The language he used was simple enough to accommodate Grade 6 learners. He started with the sketch in which he gave the scenario of the boy traveling to school in the morning. After 6 km, it started raining. "*What would be the place to run to between home and school?"* he asked the learners. The learners could speak freely because they were all familiar with the situation and with the sketch, could visualize the scenario. They answered that it was school. *"Why?"* the teacher probed the learners. The learners answered that the boy was closer to aschool than home. They even mentioned the six km and four km to make comparisons. These were all indicators of visual language observed in this lesson. The other words he used frequently were; 'nearest = closest', 'greater than 5 = bigger than 5'. The classroom environment was learner-centered. Learners were involved by responding to the teacher's questions in this lesson. The other visual language indicator observed in this lesson was the use of arrows. The arrow with big numbers (5-9) pointed up and it was marked 'rounding up'. The arrow with small numbers (0-4) pointed down and was marked 'rounding down'. In one-on-one interviews, the teacher described the use of the arrows by saying: *"I used those arrows to explain a lot to the* *learners on my behalf. In other words, the arrows minimised my teaching load in terms of explanations. They show learners for instance the numbers that determine the rounding up, the arrow also points up and vice versa. So, my job there was only to write the problem on the chalkboard and the learners read on the arrows and solve"* (T2 SRI-L2).

Manipulating visuals: After the introduction that I explained in Designing Visuals above, the teacher pasted the arrows and the signs on the chalkboard. T2 started presenting the meanings and other information contained by the arrows. Many learners raised their hands when the teacher asked them the numbers that determine rounding up. He then mentioned the increase and decrease and explained why the increased answer is referred to as rounded-up. The answer gets bigger than the original number (before rounding) (e.g 38 becomes 40 to the nearest ten). He further stated that the answer can be written as $38 \approx 40$ but not $38 = 40$ because 38 is not equal to 40 as these numbers are approximately equal. He added that the decreased answer is referred to as 'rounded down' because the answer becomes smaller than the original or initial number (before rounding). He explained all these, making use of the visuals (arrows and signs) on the chalkboard. One learner asked him to repeat how the number 38 was rounded to 40. This question made him draw the following number line on the chalkboard. In responding to the learner's question, he used the small number (27) as seen in Figure 4.20 below.

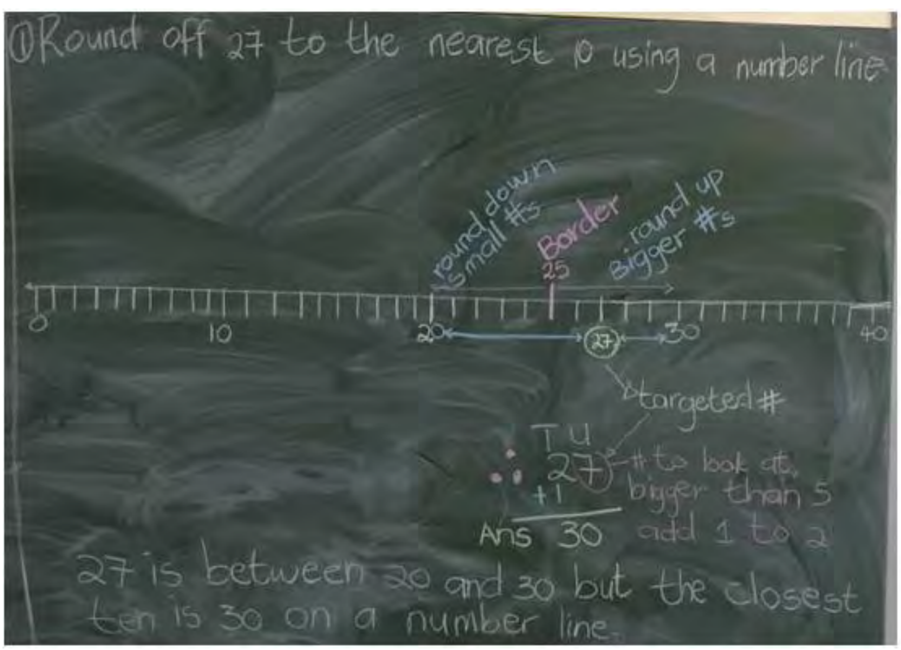


Figure 4.20: The closest ten of 27 between 20 and 30 shown on a number line

He clarified the concept of 'the nearest' by outlining 27 between 20 and 30. The learners could see how far 27 is from 20 when it crossed the border (5), and how close it was to 30. After the explanation on the number line, he wrote 27 below. This is where he indicated the unit digit as 7 and the tens digit is 2. After demonstrating all steps shown in Figure 4.20 above, T2 moved to the big numbers that required learners to round up to the nearest hundred. During SRI Sir Kukuta emphasized the use of number lines in rounding off by stating: *"I usually find the numberline as the best visual to introduce rounding off at primary level. I just assumed the learners understood it well in the introduction. But when that learner asked, I was forced to visualize the teaching by drawing a number line. I also decided to minimize the number from 38 to 27. That was because I wanted to draw the number line as from zero"* (T2 SRI-L2).

Assessing visuals: T2 tasked all the learners to individually round off 4 658 to the nearest hundred. He urged them to show their work until the final answer. He recommended that they carry out and indicate all the steps of rounding off such as: underlining the target number, focusing on the digit after the targeted digit, the digits to form the zero(s), and the ones to remain untouched / dropped down into the answer. He moved around the class marking the learners' work. Figure 4.21 below shows how he marked one learner's work.

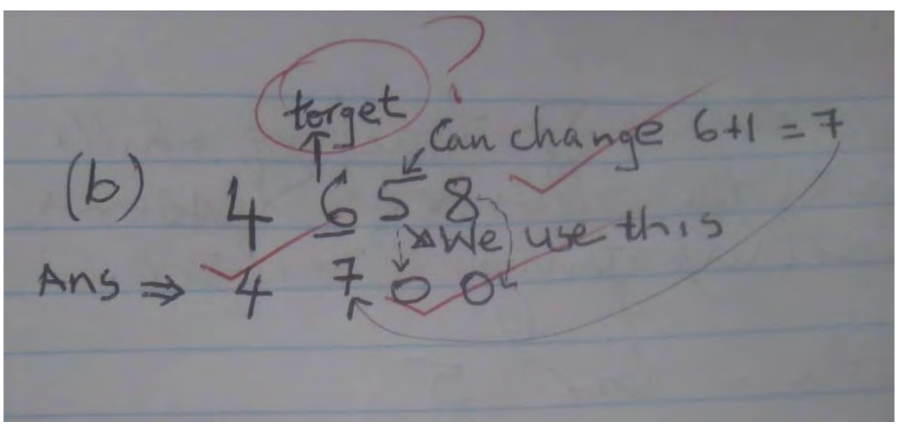


Figure 4.21: The marked solution of one learner to the given task

The learner did it correctly. However, he spelled the word 'target' wrong. The teacher put a question mark around it. That learner did what the teacher demonstrated and asked them to do: he showed the target was 6, the digit to look at was 5, the digit to form zero (8) and the answer was rounded up to become 700. During the one-on-one interview, T2 reasoned that *"I award more marks in class works to motivate all learners to show their work. It also helps me to see if* *they understanding"* (T2 SRI-L2). Dove and Dove (2015) claimed that exposing learners to the approach and strategies of solving the problems would decrease MA. In addition, Gresham (2007) supported them by clarifying that a remarkable reduction in MA can be brought about by the use of hands-on learning of mathematics concepts. T2 in this case gave the learners the chance to demonstrate and show all the steps in solving the problem.

4.2.2.4 Lesson 3

(a) A brief overview of the lesson

The third lesson of T2 was about prime numbers and composite numbers. The objective of this lesson was to teach the learners to be able to identify all primes and composites between 20 and 40. The teacher expected the Grade 6 learners to be able to define prime numbers and composite numbers and to differentiate between them. He, therefore, directed the class to construct two lists by the end of the lesson; one for prime numbers and the other for composite numbers, with their definitions in their notebooks. The teacher went into the class with a chalkboard ruler (one-metre ruler), coloured chalk, some handouts, and flashcards. As an introduction, the teacher reflected onthe previous lesson, which was on odd and even numbers. Figure 4.22 below shows one of the cards he brought into this lesson. Some numbers also appear on the other sides of the cards.

Figure 4.22: Some of the flashcards used

(b) VTA types of skills

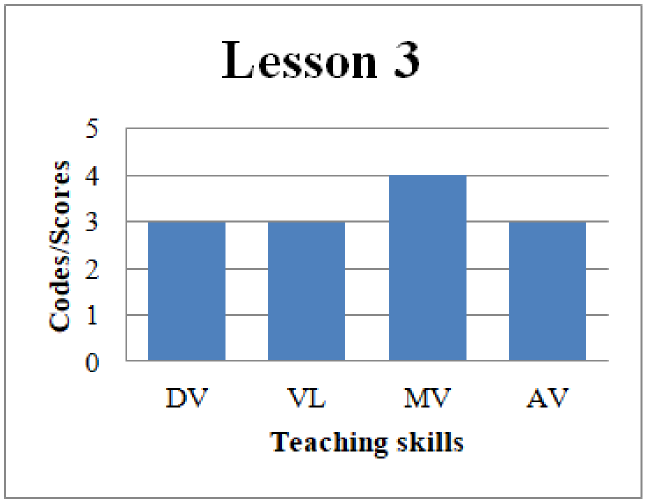


Figure 4.23: Numerical scores of T2's skills on prime and composite numbers

Figure 4.23 above presents the frequency scores of the skills observed in the third lesson of T2 when he taught prime and composite numbers. The skill of *MV* indicates that there was evidence observed. On the other hand, the use of the other three skills (*DV, VL,* and *AV*) was observed at a moderate level.

Designing visuals: The teacher prepared flashcards and handouts. The cards were laminated and the numbers were typed (refer to Figure 4.22). This implies that the teacher designed these physical materials before the lesson. I describe the handouts under the Assessing visuals heading for this lesson.

Visual language: The teacher sought for learners' prior knowledge first when he asked them to mention even numbers and odd numbers. He further asked them for any number that they could think of which can only be divided by one and itself. The learners mentioned: 3, 7, 13, and 15. Interestingly one learner corrected the last answer by shouting that "*fifteen can also be divided by five!"* T2 canceled 15 out immediately. Sir Kukuta probed further to define the numbers they had just listed. This engaged them in a productive discussion as one learner first called them odd numbers. The teacher asked the learner why number 15 was taken out if they were odd. The conversations here implied the use of visual language skills in this lesson because the teacher could ask the learners what the odd numbers were called in Oshindonga vernacular language.

One girl said: *'They are called, oonamba inadheelekana'*. Lastly, one learner announced the correct term 'prime numbers'.

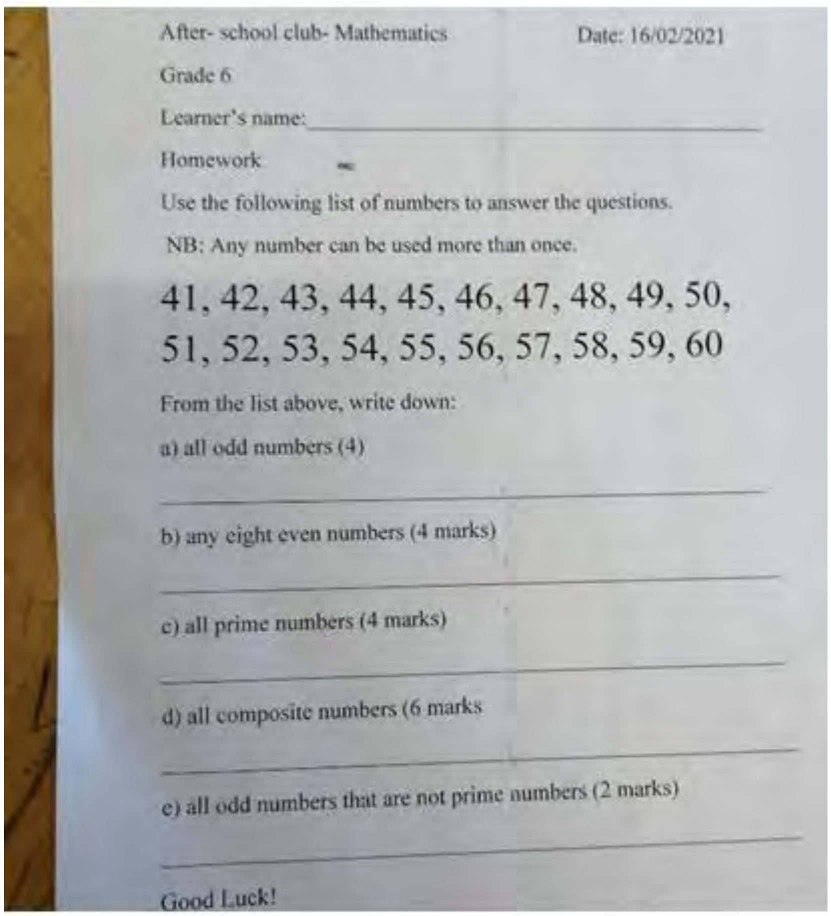
Manipulating visuals: Immediately after this, T2 defined the terms for prime numbers, composite numbers, and factors. He drew a table with these three headings on the chalkboard. He called the table's title "*primes and composites ladder*" because it looked like a ladder. The table had empty spaces which he asked learners to come and fill with the correct number of flashcards issued to each group. The way he differentiated the primes and composite numbers using the table on the chalkboard was clear, as shown in Table 4.2 below. I retyped this table because it was not in focus in the video.

Table 4.2: Primes and composites 'ladder' (20 – 40)

Prime numbers	**NO**	**Factors**
➢ Numbers with two factors only (1 and itself)	23	1 & 23
	37	1 & 37
Composite numbers	20	1, 2, 4, 5, 10, & 20
➢ Numbers with more than two factors	35	1, 5, 7, & 35
	28	1, 2, 4, 7, 14, & 28

Finding the factors for each number helped the learners to distinguish between these concepts. It served as the reason why that particular number was placed in the group of primes, and not in composites. Clear explanations of the numbers in the two tables showed signs of visual strategy. The findings of Geist (2010) emphasized that unsuitable teaching is a cause of MA. My intervention programme aims at promoting a VTA that makes use of visual materials to generate motivation and inspiration amongst learners. The teaching in this lesson was characterized by using flashcards and activity-based tasks that made primes and composite numbers visible.

Assessing visuals: The teacher assessed learners by asking them to identify different types of numbers from the flashcards and put them in the tables they copied into their group workbooks. It was also noticeable that this whole lesson was task-oriented. The teacher guided the learners to complete the poster first. The homework was prepared as handouts, which were distributed at the end of the lesson. This was self-explanatory to the learners and the parents at home. The range of numbers used for homework was from 41 to 60 which were bigger numbers than those in the flashcards they had used in class. The questions in the handout included the revision of the previous lesson about odd and even numbers. The teacher adhered to the Grade 6 syllabus that instructed teachers to teach prime numbers up to 60. The homework handouts are shown in Figure 4.24 below.


After- school club- Mathematics Date: 16/02/2021

Grade 6

Learner's name:______________________

Homework

Use the following list of numbers to answer the questions.

NB: Any number can be used more than once.

41, 42, 43, 44, 45, 46, 47, 48, 49, 50,
51, 52, 53, 54, 55, 56, 57, 58, 59, 60

From the list above, write down:

a) all odd numbers (4)

b) any eight even numbers (4 marks)

c) all prime numbers (4 marks)

d) all composite numbers (6 marks

e) all odd numbers that are not prime numbers (2 marks)

Good Luck!

Figure 4.24: The homework handouts given to learners in L3 of T2

During SRI, T2 reflected on the above homework by saying, *"I made the homework a little bit harder because I like my learners getting help from parents to do mathematics home*" (T2 SRI-

L3). This homework linked to the literature I reviewed that stressed that learners should go to their parents for mathematics help. This confirms that teachers may ask parents to work on homework with their children (Beilock & Maloney, 2015).

4.2.2.5 Lesson 4

(a) A brief overview of the lesson

T2 was teaching about the perimeter and area of a rectangle in L4. The objective of the lesson stipulated that the learners should be able to differentiate between the perimeter and area of a rectangle and to calculate them. The teacher came to class with a tile. There was already a one-metre ruler in the class. He also brought with him two pieces of A4 paper. These big rectangles were all marked as four cm long and three cm wide. The teacher also brought some small pink squares of paper. These squares were marked with one cm sides. T2 used all those physical materials during the presentations with the learners. Figure 4.25 below shows how T2 used the prepared small squares to teach the area of a rectangle.

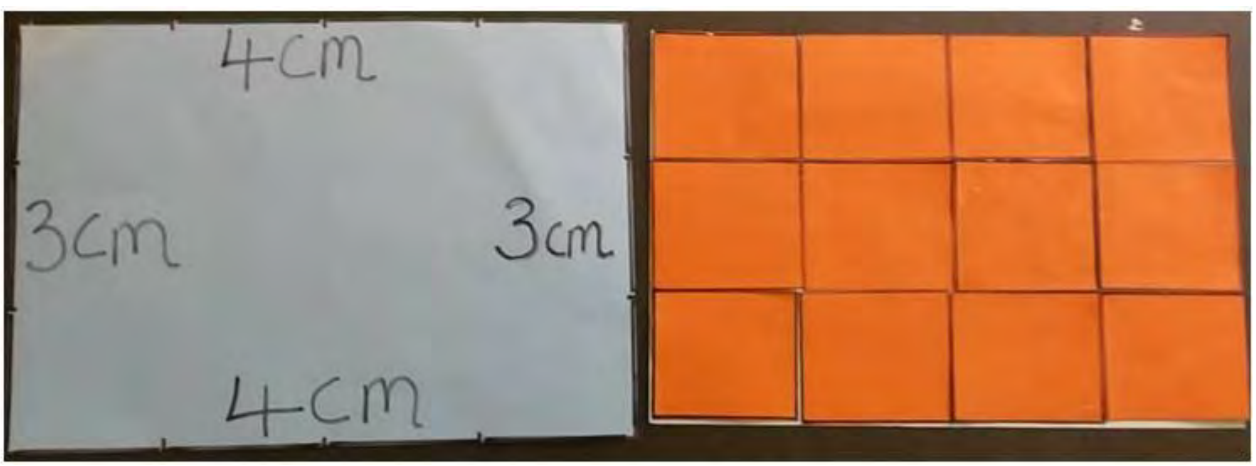


Figure 4.25: The small squares used to indicate the area of a rectangle.

(b) VTA types of skills

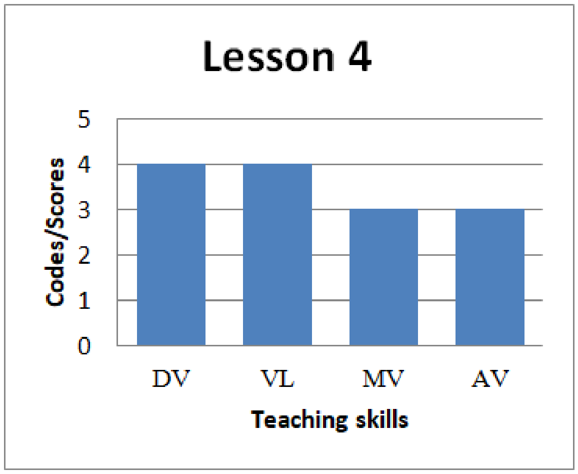


Figure 4.26: Numerical scores of T2's skills on perimeter and area of a rectangle

Figure 4.26 above presents the frequency scores of the skills observed in the fourth lesson of T2 when he taught the perimeter and area of a rectangle. The chart graphs the abundant use of *DV* and *VL* skills. The other two skills of *MV* and *AV* scored moderately (i.e. observed about three times per lesson). Thus, T2's Lesson four can be rated as one of the better-prepared lessons in VTA methods in Grade 6, however, there was not much evidence of presentation and assessment skills.

Designing visuals: The teacher came to the lesson with some prepared visuals: small squares (which he pasted into one of the big rectangles of four cm × three cm, with twelve of them fitting) and two big pieces of coloured A4 paper (labeled four cm long and three cm wide) in. One of the pieces of A4 paper had measurements indicated around its edges. T2 also had a one - metre ruler and a tile as manipulatives. The square tile with 50 cm sides was made from a cardboard box.

Visual Language: Sir Kukuta explained and wrote the definitions of 'perimeter' and 'area' on the chalkboard. He incorporated visual language when he made use of shapes and colours during his presentation. The learners grasped the difference between the perimeter and area of a rectangle by looking at the shapes used along with the definitions on the chalkboard. In a VTA, that is referred to as visual perception. The language used by the teacher suited the level of Grade 6 learners. The teacher allowed learners to speak in this lesson. I observed this when one learner surprisingly mentioned that ‘finding the area is like tiling the floor of the room’. T2 thanked that learner very vociferously and consequently he introduced the lesson, by laying tiles on the classroom floor as described in the next section on Manipulating visuals.

Manipulating visuals: The teacher asked the learners to stand up and move back. This afforded a big space in the front of the classroom. He measured and marked space of three m by two m on the floor with a one-metre ruler and chalk. The marking formed a rectangle. He asked the class, *"How many of these tiles can we cover this space with? Let us get the way quickly with this one tile"*. One girl murmured: *"Boys work"*. One boy came and used the tile to mark the length and width. The learners physically counted until they reached 15 tiles when the teacher stopped them and requested them to sit down. Nevertheless, the space was not yet fully tiled. The diagram below shows the learners were drawing the tiles.

Figure 4.27: Learners finding the area of a rectangle visually

This introduction was related to finding the area of a rectangle which was the topic for the day. The teacher planned this activity to be short so that it did not take up much time for the lesson. Tome as a researcher, this introduction led the learners to understand what was going to happen in this lesson. In support of this point is Mesaros (2012) who suggested that visuals allow the learners to better see and understand the problem with the assistance of physical resources like manipulatives or concrete objects.

T2 continued by explaining the difference between the perimeter and area of the rectangle. He made use of the blue A4 paper and small pink squares. He showed the learners the distance around the marked A4 paper as the perimeter, thus emphasizing that one has to add the measurements of all four sides of the rectangle together to get its perimeter. In this instance, the rectangle had a length of four cm and a breadth of three cm. The perimeter found was 4 cm + 3 cm + 4 cm +3 cm = 14 cm. He further explained that when finding the area of a rectangle, "*we are physically finding the number of small squares that can cover the rectangle*" (T2-L4). T2 demonstrated this precisely by pasting the prepared small squares into one of the A4 rectangles. The extract in Figure 4.28 below shows how the small squares looked on the chalkboard (although the photograph was captured from a distance).

Figure 4.28: Small pink squares pasted into an A4 rectangle

The 12 pink small squares covered the whole area. After that, he introduced the use of the formula ($A=l\times b$). T2 told his learners that using a formula is the fastest way of finding the area and it is easy to use if you know the formula by heart. He started with the same example and said, *"In our rectangle, the area is 4cm × 3cm = 12cm². That answer means the same as 12 small squares that I used to cover the rectangle above"* (T2-L4).

Assessing visuals: The visual aids used by this teacher during the lesson were of good quality and they addressed learners' interests (manipulating physical objects) and needs (learning by seeing). These visuals helped learners who had little understanding about finding the perimeter and area of the rectangle. All of these are evident as most of the learners managed to calculate the areas and perimeters of rectangles in the given task. The teacher tasked learners to accurately draw a rectangle of five cm by four cm in their exercise books and calculate its perimeter and the area. The boy in the picture below worked it out as follows:

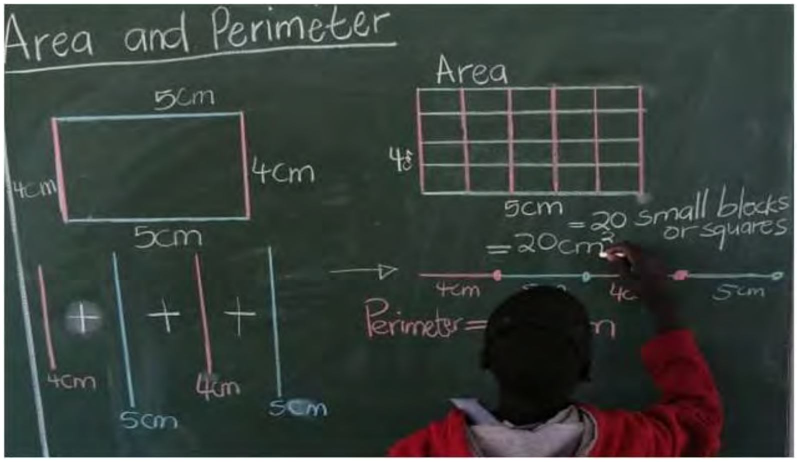


Figure 4.29: The learner solving the perimeter and area visually

The teacher asked this boy to present the class work on the chalkboard (calculating the perimeter and the area of the rectangle). He worked out the perimeter more visually by dismantling all the sides and adding them together separately. To get the area, he used the same method with which this lesson was introduced. This shows that he was using the understanding he gained during the lesson. In response to whether the use of visuals can bring any change in learners' MA, at the SRI, T2 said: *"I argue that these visuals could help in reducing learners' anxiety towards this topic Mr. Ngonga. These visuals could also enhance the learners' comprehension of finding the perimeter and area of the rectangle. During planning yesterday, I was guided by the visual methods termed as concrete-based in the syllabus. It stated that concretes can ease the mastery of finding areas and perimeters of two-dimensional shapes in general. So, they are required even in the basic competencies in the syllabus on page 29"* (T2 SRI-L4).

4.2.2.6 Summary of visuals used in the four lessons for T2

- In L1: The flashcards provided different instructions to learners and made them think out of the box (i.e. by squaring a fraction). The gaps left in the poster visually showed the learners where to start working out the unsolved problems.
- In L2: T2 introduced the lesson of rounding off with the real-life situation relating to the nearest ten. He made this visual by using the example of a boy running to school and encountering rain on the way. The teacher used rounding off arrows to facilitate his teaching. Well-designed visuals can teach on behalf of a teacher.

- In L3: The teacher made use of flashcards to motivate and inspire the learners. The use of flashcards made the prime and composite numbers visible. T2 provided homework as part of the activity-based task that parents could assist with at home, as advocated by Beilock and Maloney (2015).
- In L4: The teacher linked concrete to abstract concepts with the use of tiles and small squares to calculate the perimeter and area of a rectangle.

4.2.3 TEACHER THREE (T3): MS UUKUNDE

4.2.3.1 Profile of T3

Ms. Uukunde is a Grade 7 mathematics teacher with 11 years of teaching experience. She possesses a Basic Education Teacher Diploma (BETD), obtained from Rundu College of Education, now the University of Namibia. She specialized in mathematics and integrated natural science (INS) in the Senior Primary phase (i.e. Grade 4-7), but later she advanced her studies with UNAM and attained a Bed Hons in secondary school mathematics and physical science. Currently, she is the Head of Department (HOD) of the Mathematics and Science Department at my school. Since she started her teaching career nine years ago, she has been teaching mathematics in the senior primary (Grade 4-7). Data collected from Ms. Uukunde's video-recorded lessons are coded as follows in this research study: Teacher three (**T3**), Grade 7 (**Gr 7**), Lesson one for Grade 7 (**L1 – Gr 7**), Lesson two for Grade 7 (**L2 – Gr 7**), Lesson three for Grade 7 (**L3 – Gr 7**), Lesson four for Grade 7 (**L4 – Gr 7**), Videos for Ms. Uukunde (**T3V1, 2, 3 & 4**), Stimulus recall interviews (**T3 SRI**) and Focus group interviews (**T3 FGI**). Ms. Uukunde is the only respondent responsible for Grade 7 mathematics teaching in this intervention. As for other participants, I observed and video-recorded four lessons of T3.

4.2.3.2 Lesson 1

(a) A brief overview of the lesson

The first lesson Ms. Uukunde delivered was regarding terminologies of the two basic operations (- and ×) in algebra. The objective of the lesson was for learners to be able to transfer ordinary language terminologies into mathematical statements and solve problems visually. Before the lesson, she prepared 36 square tile manipulatives for the lesson. She made these hand-made tiles out of cardboard boxes and painted some of them in different colours. They were all squares of about 10 cm sides. The teacher also prepared the two problems she would present and write them on the poster shown in Figure 4.30 below. The first problem had to do with the decrease (-) in the temperature, and the second one was on tiling the room floor with prepared tiles (×). Figure 4.30 below shows the poster of the problems presented visually in this lesson.

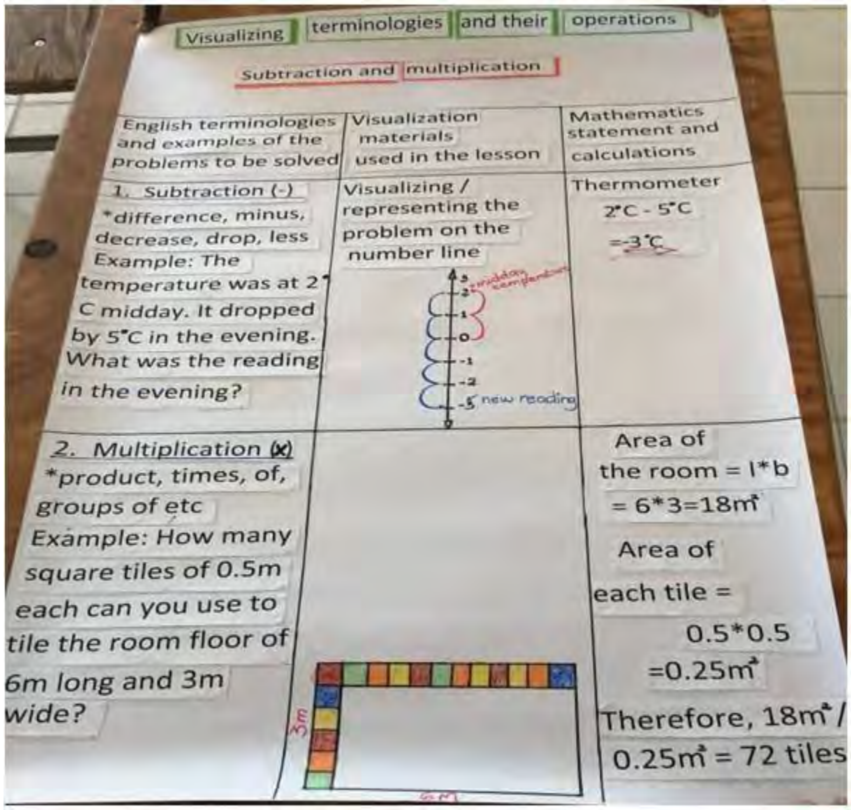


Figure 4.30: The poster on the problems to be solved visually in L1 of T3

(b) VTA types of skills

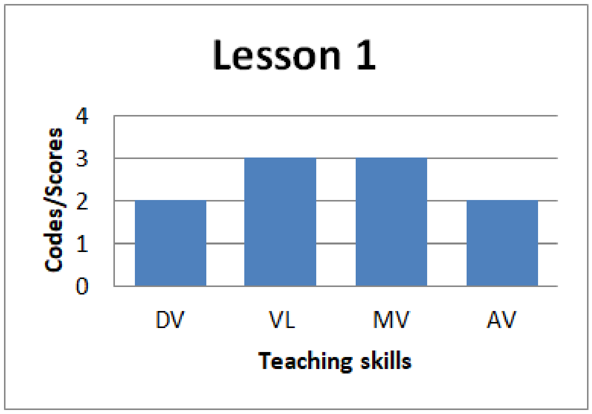


Figure 4.31: Numerical scores of T3's skills on terminologies and their basic operations

Figure 4.31 above represents the frequency scores of the skills observed in the first lesson of T3 when she taught terminologies and their basic operations. The graph indicates that there was a moderate use of *VL* and *MV* skills compared to the DV and *AV* skills which were least evident.

Designing visuals: In addition to the prepared tiles and the poster, the teacher also had some coloured chalk, two marker pens, and a pointing stick. The poster that T3 had prepared before L1 comprised of the words that have similar meanings to subtraction in mathematics such as *minus, difference, decrease, drop,* and *less*; and multiplication was shown to be associated with words such as *times, product*, and *of* as shown in Figure 4.30. The second problem referred to a floor area of 6 m by 3 m covered with tiles with 0.5 m sides. The teacher thus scaled the floor diagram and the tiles during the preparation of this lesson. In a one-on-one interview, she explained to me how she did it. *"You see Mr. Ngonga, I aimed to show the similar problem on the chalkboard using visuals i.e. tiles now. However, the story of 6m and 3m couldn't fit on the board. I decided to scale down the metres into centimetres but still keep my answer as 72 tiles. Anyway, I solved the problem first and got 72. Then I just started with the 6m side. I played around with it until I got the idea of making it 120cm and the width 60cm, which gave me the scale of 1:20. I scaled tiles to 0.5×20=10cm, meaning that each square tile I made was 10cm sides"* (T3 SRI-L1).

Visual language: The language used by T3 was grade-level appropriate (Grade 7). Instead of mentioning terms like 'algebraic expressions'', T3 used words such as 'decrease', 'drop', 'product', and 'times', and the operations they represent in mathematics (- and ×) to solve the twoproblems. She was skillful in simplifying the words like 'product', 'difference', etc. and replacing them with more familiar words such as 'multiplication' or 'of' (×) and 'subtractions' or 'minus' (-). T3 also ensured that below-average learners participated in the lesson. They were mostly asked to recall the words referring to subtraction or multiplication. Many learners were observed raising their hands and suggesting words. This shows that the learners were engaged in this lesson.

Manipulating visuals: After guiding learners through recalling words for subtraction, the teacher matched the following ordinary language terminologies with their mathematics statements on the chalkboard: *three subtracted from seven as 7-3*. I observed how she emphasized seven as the number to start the mathematics statement with because it is the number that three is subtracted from. She then proceeded by reading aloud the temperature problem from the poster (i.e. *a 2ºc temperature in the midday decreased by 5ºc in the evening. What was the new temperature reading?*). She asked the learners the basic operation or sign of the word 'drop', to which the learners answered *"minus* (-)*"*. She sketched a vertical number line on the chalkboard and further asked learners to state some more words describing the change in temperature apart from dropping. The learners suggested, *"down, cold and decrease"*. T3 asked the learners to point on the number line where the temperature was in the morning, according to the problem. The first learner pointed at zero and the second one pointed at two on a number line. The discussion to visualize the change of the temperature went on. The teacher indicated the dropping movement of the temperature from two (+2) until negative three (-3) on the number line (refer to Figure 4.30). She pointed at -3 and told the class that it was the answer to the problem. T3's visual facilitation of the problem-solving processes aligns with Mesaros (2012), who indicated that the main purpose of visualization in teaching mathematics is to facilitate and support the learners' mathematical problem-solving processes.

To visualize the second problem about finding the number of tiles needed to cover a given space, T3 requested one learner to read it from the poster. She drew a scaled rectangle of 120 cm by 60 cm on the chalkboard and marked it 6 m long and 3 m wide. Next to the figure, she wrote the scale as (1:20) and told the learners not to worry about that because it would be taught at secondary school. T3 picked up one tile and said to the learners: *"That's a room floor on the chalkboard. How many of these tiles can we use to tile that floor?"* (T3-L1) This question attracted the attention of many learners. In this video, I heard three different learners shouting: *1.*

"Ups, some hundreds! 2. No ways, maybe 40 to 50 there, and 3. Yes, I think we can get it Ms, let us glue them in that diagram and count! But they are too many hey, we may not go home". The teacher encouraged the third learner loudly by saying: *"That's a brilliant idea! But don't worry about going home; mathematicians have to be confident and positive towards solving the problems"* (T3-L1). The pasting of tiles started. Figure 4.32 below shows how the learners started.

Figure 4.32: The learners pasting tiles to solve the second problem in L1 of T3

The teacher gave the learners two to three minutes to paste the square tiles while she was watching and looking at some learners who were doing it in their books. "*The tiles will be 72 in total*"! One learner shouted. By then, the learners had pasted more than 20 tiles onto the rectangular floor and they detected that the remaining tiles on the table would not finish the floor area. In SRI, she informed me *"I did not bring enough tiles because I wanted to stimulate the learners to employ calculation modalities by even using the patterns. This was even the way used by the learner who got the answer first*. *You see when I moved close to her there,* pointing at a video. *She showed me that she counted the top layout tiles and got 12 and the vertical tiles were 6, she multiplied to get 72"* (T3 SRI-L1).

In this lesson, many learners could touch the materials when they were pasting the tiles. When the teacher asked them to read the question again, some recognized that they were solving a pure multiplication problem of 12×6=72. The teacher engaged, motivated, and stimulated the learners during the presentation of this concept. According to Park and Brannon (2013), learning is supported when learners are involved in visual representations and constructed manipulatives. Durmus and Karakirik (2006) gave examples of manipulatives such as tiles, fraction pieces, and pattern blocks, and they further stressed that those visuals could make abstract ideas and symbols more meaningful to the learners.

Assessing visuals: Apart from verbal questions, T3 asked learners to write mathematics statements for the following ordinary language problems and work them out *(a) seven less than sixteen, (b) the shadow of a network tower decreased from nine hundred and seventeen centimetres to six hundred and sixty centimetres. By how many centimetres did it change? (c) The product of eight and thirty-two, and (d) the difference between ninety and the product of twelve and three.* The teacher instructed the learners to complete the assessment task in groups of four to five. All groups reported their solutions. However, two groups had difficulties in solving the last question (d), as they failed to multiply first and subtract the product from 90. One group in the back corner of the class got all the answers correct in this task. The teacher knew there was a smart girl in that group who was always speaking with her left hand covering her mouth or face. The teacher felt that the girl was nervous to respond to her questions. Therefore, Ms. Uukunde asked her to go to the chalkboard and show the class how their group did the (d) problem. The picture below shows how that nervous girl wrote on the chalkboard to answer 90-12×3. I observed the girl holding her mouth, face, and finally the back of her neck with her left arm as seen in this picture. She behaved like that from her seat to the chalkboard until she was finished writing. I could also see that she insisted on standing up when the teacher called her. The picture below shows how she was holding herself at one point.

Figure 4.33: The nervous girl motivated by T3 to solve the problem on the chalkboard

When the girl was writing, T3 was watching her and reassuring her by nodding from time to time. She was motivating the girl softly by mentioning words like *"very good, yes, wow, nice, brilliant"*. I observed how the girl was smiling at the teacher as she gained confidence. The girl did not explain anything but she wrote correctly until she got the answer. She ran very happily back to her seat and the teacher asked the class to clap hands for her. During SRI, T3 told me, *"I detected that Selma (that girl) is very nervous. She always hides her face, teeth, and looks down. I try in most cases to reduce that nervousness by allowing her to present what she understands well. I keep motivating her but she always gets the right answers. I think she is very good at mathematics"* (T3 SRI-L1). According to Dzambara (2012), the aim of using drawings as resources is to inspire learners, induce them and build self-reliance in them to lessen the fearof mathematics. He further argued that, apart from the materials and figures, teachers themselves are the first resource to motivate their learners to gain confidence.

4.2.3.2 Lesson 2

(a) A brief overview of the lesson

The second lesson I observed was on multiplying fractions. The teacher expected that by the end of this lesson, the learners would be able to multiply common fractions using visuals. She entered the class with a poster illustrated in Figure 4.34. The poster contained examples of some of the fractions she used in this lesson.

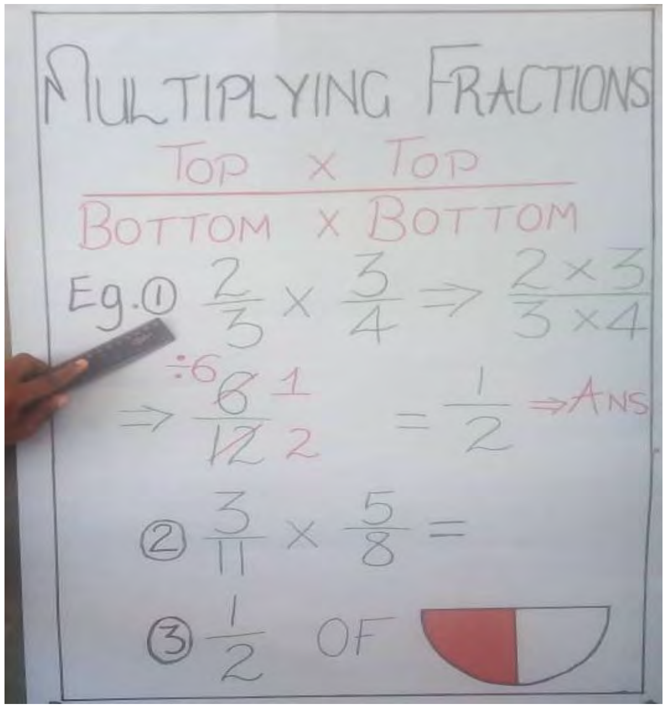
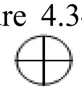


Figure 4.34: The poster displaying how fractions can be multiplied, prepared by T3.

The first example was done as displayed in Figure 4.34 above. However, it was also done visually on the chalkboard. It was displayed as $\frac{2}{3}$ of  .
The learners were expected to shade the appropriate part of the fraction. As in the third problem in Figure 4.34 above, they shaded $\frac{2}{4}$ as $\frac{2}{3}$ of $\frac{3}{4}$ which simplified to one half.

The steps used to get the final answer were shown in the examples on the chalkboard. A visual teaching approach reinforced this method. The learners assisted one another by shading the fraction visuals to answer the multiplications problems. This is how learners help a teacher to educate their friends. Afaneh (2007) termed this 'peer teaching'. In addition, Ms. Uukunde brought some fraction visuals prepared from pieces of coloured card hard. She utilized these hand-cut fraction materials in this lesson.

(b) VTA types of skills

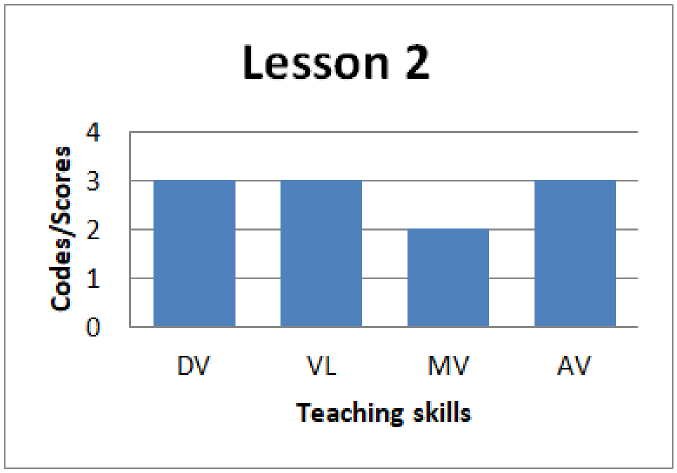


Figure 4.35: Numerical scores of T3's skills on multiplying fractions

Figure 4.35 above presents the frequency scores of the skills observed in the second lesson of T3 when she taught multiplication of fractions. It shows that *DV, LV,* and *AV* skills were used at a moderate level compared to *MV* skills, which indicates that only a few visual representations were observed. Only two such incidences occurred.

Designing visuals: Before the lesson started, Ms. Uukunde prepared the poster in Figure 4.34. She also cut the fraction visuals from coloured cards, as can be seen in Figure 4.36.

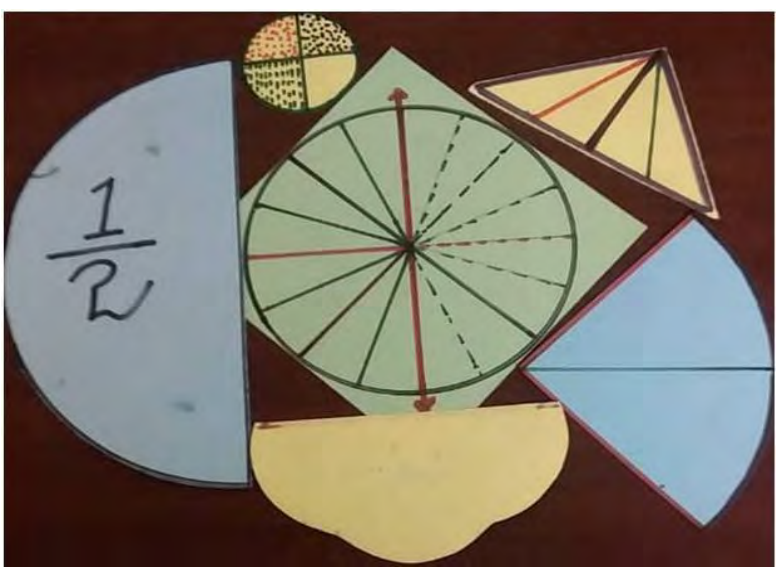


Figure 4.36: Some of the prepared visuals on multiplying fractions' lesson

Many of the visuals that T3 designed for this lesson appeared attractive and appealed to the learners in Grade 7, and they suited the topic at hand. According to Dzambara (2012) the MoE in Namibia unfortunately only supplies a few, inadequate teaching aids to schools. Therefore, Ms. Uukunde improvised and made her visual aids herself to use in Lesson 2. In the SRI, she indicated that a lack of visuals is a big challenge. In her own words, she said, *"Lack of visuals is a big problem because at a certain point when you are teaching you to want all your learners to beworking but because the visuals are not enough then you have to sit with this group before yougo to the next group. If the visuals could be enough for every learner in the problem then it will be nice because when you are teaching all learners are following and using these visuals to compute and get answers. So, I improvise and make visuals. I sometimes ask my learners to help me in creating visuals because many of them are very creative. My learners pay attention when they see me teaching with what they created"* (T3 SRI-L2).

Visual language: It appears that the learners understood the language used in this lesson. In the introduction, the teacher used *'top by top and bottom by bottom'* as a formula for multiplying fractions. She used words (i.e. top and bottom) the learners were familiar with instead of using big mathematical words like 'numerator by numerator and denominator by denominator. Another aspect noted regarding visual language skills, was when the teacher remarked that the word '*of*' means times (×) in mathematics. She did that when she was presenting the shadings of fractions in the problems like the one in Figure 4.37 below.

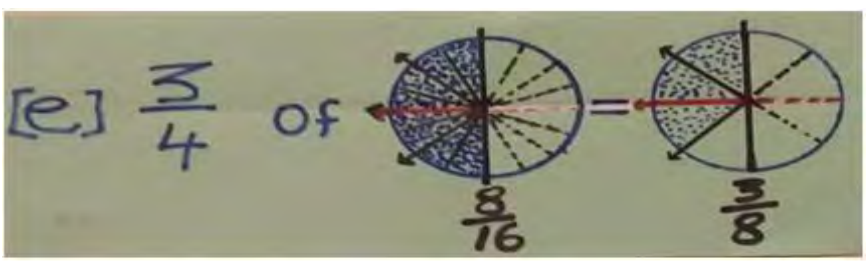


Figure 4.37: How T3 worked out $\frac{3}{4} \times \frac{8}{16}$ using visuals

In a one-on-one interview, she reinforced the use of the above visuals by saying: *"You see how the shading of that material answered* ($\frac{3}{8}$) *right away. Using visuals does not even require the simplification processes involved when you multiply like* $\frac{3}{4} \times \frac{8}{16}$ *you first get* $\frac{24}{64}$ *which simplifies* *to $\frac{12}{32}$ then go to $\frac{6}{16}$ till the answer $\frac{3}{8}$ If a learner wants to practice more on using visuals, she/he can try to draw some more similar diagrams and use that shading method at home"* T3 SRI-L2.

This approach encourages the use of familiar vocabulary that the learners can understand at their grade level.

Manipulating visuals: The explanations of multiplying the halves by fractions were emphasized with the use of prepared shapes in this lesson. This emphasis was to show learners why the halves of proper fractions resulted in a smaller fraction using shapes e.g. $^1/_2$ of $^1/_6$ is $^1/_{12}$ (the answer $^1/_{12}$ is smaller).

She first calculated $^1/_2 \times {}^1/_6 = {}^1/_{12}$ with the learners on the chalkboard in an abstract way. She asked the class if the answer is a big or a small fraction. The majority of the learners shouted: *"Big!"* T3 told the class to hang on. She then took the sixth fraction piece from the table and traced it onto the chalkboard. She asked one learner to go and shade half of that shape. The learner divided the shape nicely into two parts and then shaded one of those parts. When the teacher went back to the 'big fraction' answer, the learners were surprised. This scenario shows how the use of visuals helped the learners to detect that a sixth ($\frac{1}{6}$) is bigger than a twelfth ($\frac{1}{12}$).

The fraction visual used in the above exercise is pictured in Figure 4.38 below.

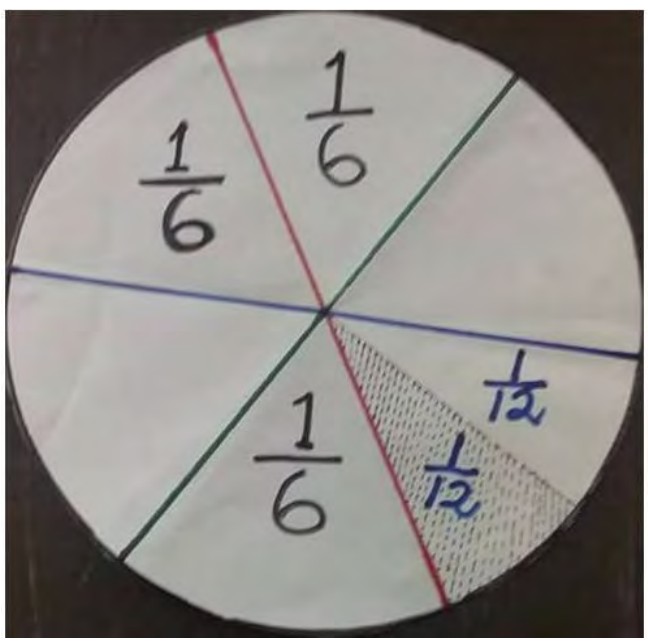


Figure 4.38: A visual showing the sixth and its half used in L2

The same Figure 4.38 above was also used by T3 to clarify visually that half ($\frac{1}{2}$) of a sixth ($\frac{1}{6}$) is a twelfth ($\frac{1}{12}$). This happened as a result of multiplying those two fractions further (i.e. $\frac{1}{2}\times\frac{1}{6}$). When I met with her during the one-on-one interviews immediately after this lesson, she reasoned that *"I could not use the prepared visuals because I forgot the Bostik glue for sticking them on the chalkboard. I just brought the magnet that I used for the poster. I felt I would waste too much time rushing to the office to get the glue. And that's the reason why I decided to sketch the fraction visuals on the chalkboard to show the shading"* (T3 SRI-L2). This brought the bar of the manipulating visuals skill to 2 as marked in the Figure 4.35 bar graph. Nevertheless, according to Afaneh (2007), the teacher is also expected to initiate any possible mechanism to teach if the originally planned one has failed. And that is what T3 did. In the conclusion, the teacher emphasized that shading in the diagrams would answer using visuals (refer to Figure 4.37).

Assessing visuals: This skill was observed through the homework she gave to the class. The handout sheets were distributed to all the learners. The teacher urged all the learners to use only pencils or coloured pencils to shade in the diagrams drawn for each question.

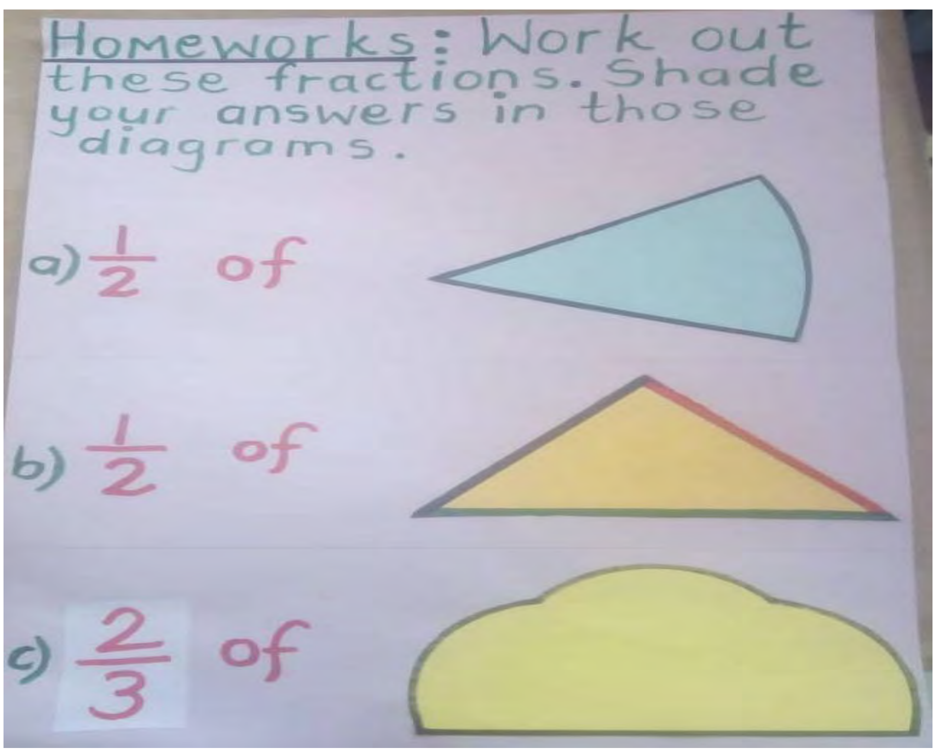


Figure 4.39: Assessment activity of L2 for T3 on shading parts of fractions (the first three)

When I stood up to leave the class with the teacher, I observed two girls discussing the (b) and (c) problems. One girl was telling her partner about getting the center of the base first in those problems. This is in line with peer teaching and learning strategies. It is in agreement with Dioso-Henson (2012), whose findings suggested that peer teaching is an effective intervention regardless of age, grade level, or disability status.

Those two diagrams prompted learners to discuss and agree upon a certain step before they started to solve the problems. In other words, the sample of the assessment activity in Figure 4.37 strives to assess the learners' skills in interpreting fractions with diagrams, which is a visualization effect. For instance, in question (c) above, the teacher expected the learners to shade two-thirds of that shape. Their first step is to determine the centre and then divide the shape accordingly before they start shading. During the one-on-one interview, T3 mentioned that: *"Those types of activities are required in the Gr 7 mathematics syllabus (p. 38), however, there is no sample availed in any of the prescribed mathematics textbooks, thus we had to design on our own. I wish this approach (a VTA) would be extended to the curriculum designers"* (T3 SRI-L2).

4.2.3.3 Lesson 3

(a) A brief overview of the lesson

The third lesson for T3 focused on directed numbers. The motive of this lesson was for learners to be able to add and subtract positive and negative numbers. T3 planned to achieve this objective by using number lines. The teacher did most of the presentations using PowerPoint slides and a projector that she quickly set up in the class during the first two minutes of the lesson. Ms. Uukunde further sketched some number lines on the chalkboard. They served as visuals in her teaching. Figure 4.40 shows the sketches and the number line on the slide.

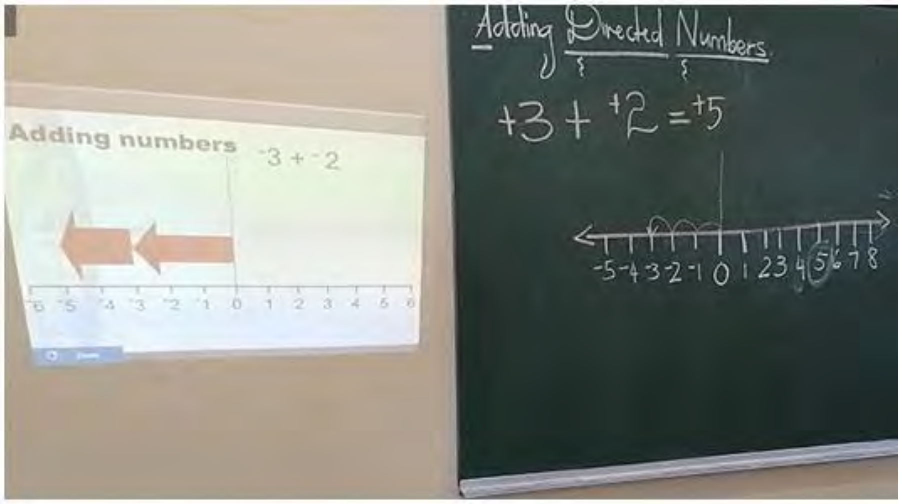


Figure 4.40: The projected and sketched number lines used in L3 of T3

(b) VTA types of skills

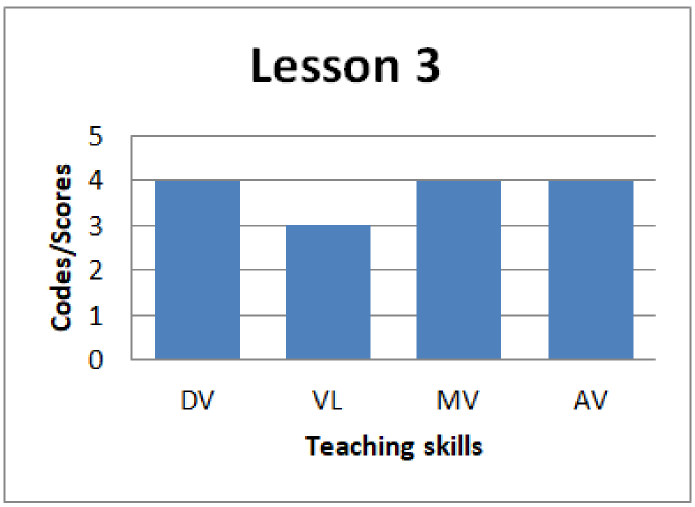


Figure 4.41: Numerical scores of T3's skills on directed numbers

Figure 4.41 above presents the frequency scores of the skills observed in the third lesson of T3 when she taught directed numbers. The bar graph shows that *DV, MV,* and *LV* skills were frequently employed in this lesson. The *VL* skills were moderately observed in this lesson.

Designing visuals: The designed visual aids were directly linked to the topic. The teacher designed her PowerPoint slides of the number line and she prepared the projector beforehand. Ms. Uukunde also made sketches of number lines (refer to Figure 4.40) on the chalkboard during the lesson presentation. These number lines were effective in teaching the addition of positive and negative numbers as the teacher's illustrations and elaborations made sense. In place of calculators – which are prohibited in Grade 7 in Namibia – the learners ought to master adding by utilizing number lines precisely. The teacher's explanations were clear and reinforced the use of number lines. This guaranteed the accuracy and effectiveness of the number lines. The learners' participation indicates that the usage of number lines is helpful to master adding positive and negative numbers. Their participation was boosted by the use of a projector. According to Abramovich, Grinshpan, and Milligan (2019), the progression from primary to secondary level can be facilitated by the use of digital technology. They further stated that mathematical ideas borne in the context of action learning with physical tools can be extended to a higher level through computational experiments, supported by digital tools. T3 administered this transition by using the projector in her Grade 7 classroom. Devices like this help the teachers to present much information in a short time. T3 used the projector to view many of the number lines slides compared to the chalkboard sketches.

Visual language: The teacher performed the naming and labeling of visuals and concepts throughout her lesson. This was evident as she clearly explained and pointed out the parts of the number line such as positive numbers on the right side, negative numbers on the left side, point zero, and the starting point (first number). She also referred to the number of moves, which side to move, and how the move is determined, plus where to stand or end for the answer. This way of explaining was evidence of visual language skills. Indeed, the teacher chose to use words like *'add, move, steps, right, left'* rather than using words like addends, the sum, center, etc. that are used at higher grades. Gestures such as lifting left and right arms when showing the sides of the number lines were observed in this lesson. The teacher also maintained good eye contact, which is essential to keep learners on task and ensure that they are paying attention.

Manipulating visuals: In this lesson, I noticed the teacher's clarification of concepts. She explained and showed the learners how to work out addition on the number line on the chalkboard. She carried out all the steps like drawing an empty number line and labeling it. She then identified the positive and negative sides, pinpointing the starting point of the sum. Lastly, she determined the direction of the jumps, moving and highlighting the endpoint, and thus jotted down the answer. She further worked out some problems on the whiteboard and illustrated each step of the procedure by viewing the slides using the PowerPoint projector. Moreover, this lesson was also learner-centered as some learners, like the one in Figure 4.42 below who were seen doing demonstrations when appointed by the teacher to work out problems on the chalkboard and to explain to their classmates.

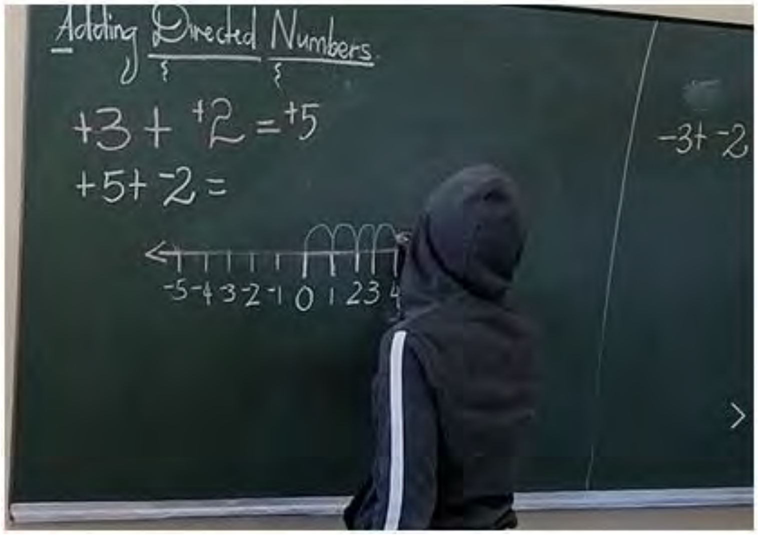


Figure 4.42: The learner working out a problem on the chalkboard

During the SRI, Ms. Uukunde paused the video on a particular boy and said; *“Look sir, when our primary teacher taught us that *5 ∓2, she referred those numbers to people. She said *5 were like males and ⁻2 were females. The two males from the five were ‘like’ married to the two ladies and then the left three (*3) males were the answer. Now I can challenge our former teacher if she was using visuals that way. Because I wonder how the couples disappeared. Nevertheless, I like using number lines to visualize directed numbers. Number lines are fast and easy to sketch and I can ask learners to work on them”* (T3 SRI-L3).

Assessing visuals: The teacher sketched several number lines on the chalkboard (e.g. as in Figure 4.42 above) and asked the learners to work them out and explain their workings to others. This shows that she was assessing them with visuals in her teaching. She also asked learners to tell the class about the starting point (the first number), which side to move to (the sign of the second number), and how many steps to take (the second number).

4.2.3.4 Lesson 4

(a) A brief overview of the lesson

The last lesson for Ms. Uukunde comprised the topic of money and finance. The specific objective of the lesson was for learners to be able to calculate percentage profit/loss. The formula she explained to learners required them to calculate the profit or loss first. As in her previous lesson, the teacher prepared and relied on the PowerPoint slides as her main physical materials. The slides were visible and clear as shown in Figure 4.43 below. However, she gave learners the option of ignoring the pounds symbol (£) and replacing it with Namibian dollars (N$) if they were not comfortable with it. She did not do it herself.

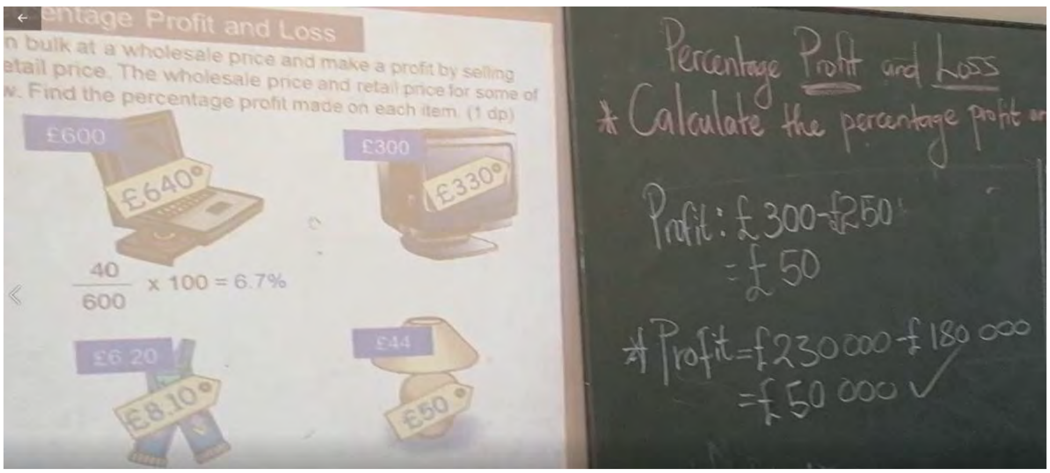


Figure 4.43: Slides and some calculations on percentage profit and loss

(b) VTA types of skills

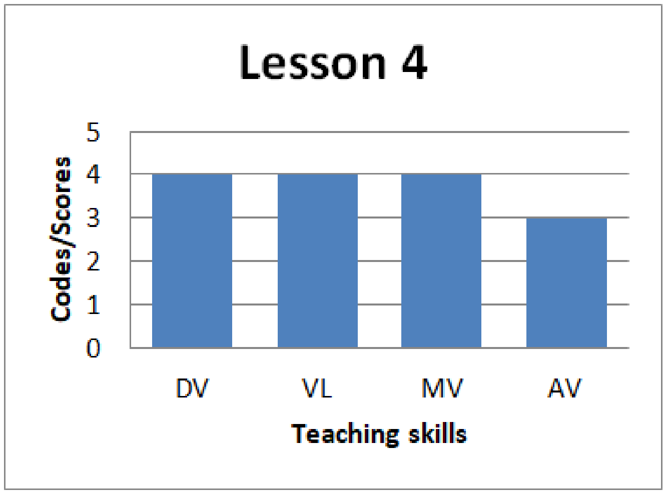


Figure 4.44: Numerical scores of T3's skills on percentage profit and loss

Figure 4.44 above presents the frequency scores of the skills observed in the fourth lesson of T3 when she taught percentage profit and loss. The bar chart shows that Ms. Uukunde used the first three skills abundantly (*i.e. DV, VL,* and *MV*) in her fourth lesson. However, the *AV* skills were moderately observed as the bar was averaged at three.

Designing visuals: The teacher once again used a projector in this lesson. The projector stimulated learners' interest in and attention to the presentation. It benefited the learners in the sense that they could interact with it to support their knowledge about the concept presented. The projected visual materials looked real and attractive. The materials made visual the concept of percentage profit. The teacher drafted a few points on the chalkboard during the introduction, related to the meanings of cost price, profit, loss, and selling price. She termed these as the key concepts of this lesson. She made the learners participate to construct concrete understanding via hands-on experiences, by asking them to do the calculations on the chalkboard. The teacher also displayed the calculations of percentage profit (already solved) on the projector immediately after the learner's solution. Examples of these calculations are in Figure 4.45 as follows:

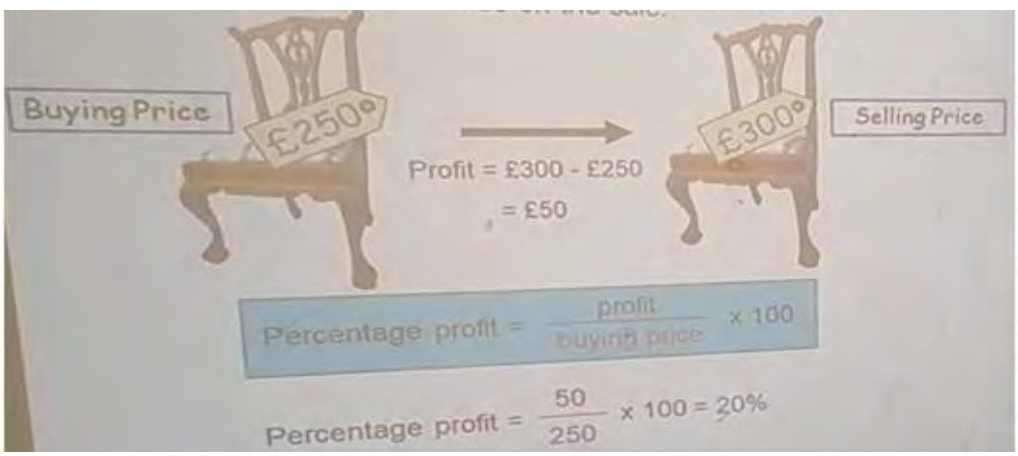


Figure 4.45: Calculations displayed in the slide show in L4 of T3

This lesson made use of many visuals for the learners. T3 showed many commodities with their buying and selling prices as in the above example. The learners did calculations of percentage profit/loss on the chalkboard. The teacher reinforced their learning by using systematic procedures and elaborated on them to the learners. T3's teaching approach is supported by Thornton (2008, p. 251) According to Thornton's view, using visuals provided by technology to view concrete objects allows the learners to reflect on what they have seen in life. Therefore, technology assists learners to generate and test hypotheses and then possibly provide proof. “In effect, technology doesn`t devalue visual thinking but rather increases the value of visual methods” (p. 251).

Visual language: Despite the symbol of pounds used in this lesson, some other language-related indicators observed were abundant. Indeed, the teacher could be heard mentioning that: *“A fraction calculating the percentage profit is written as the profit number over the cost price (i.e.* $\frac{profit\ num}{cost\ price}$*)”* (T3-L4). She stipulated what the profit was, how to calculate it, the cost price, and why to multiply by 100. I heard the learners answering questions correctly, and this was an indication that they understood. T3 used body gestures. She was pointing to the chalkboard and saying, *“The moment you get a profit, let that number jump up on top of the cost price to form a fraction. The fraction would then qualify to be multiplied by the boss (100)”* (T3-L4). The demonstration and language sounded humorous but it made sense to the learners.

Manipulating visuals: The teacher’s explanations were clear and they were supported by visual materials. She projected many diagrams while explaining the concepts. There were no other physical objects used in the lesson presentation apart from the projector. The displayed procedures of working out percentage profit were also useful. Afterward, T3 displayed the completed calculations and answers on the projector. She worked through these with the learners to check if their answers were correct. This showed me that the teacher had those solved problems prepared already as well. There was a deep emphasis on ‘looking back at the question’ for learners to refrain from common errors they usually make. For example, in the issue of acting out a business owner buying a laptop for $600 and selling it at $640: T3 warned the learners to avoid stopping at the profit made ($40) when they are asked for percentage profit.

Assessing visuals: The teacher assessed the learners by displaying problems on the screen and asking learners to solve them on the chalkboard. Just as the formula for calculating the percentage, profit was displayed on the slide, and this learner was observed trying to use it in the exercise on the chalkboard.

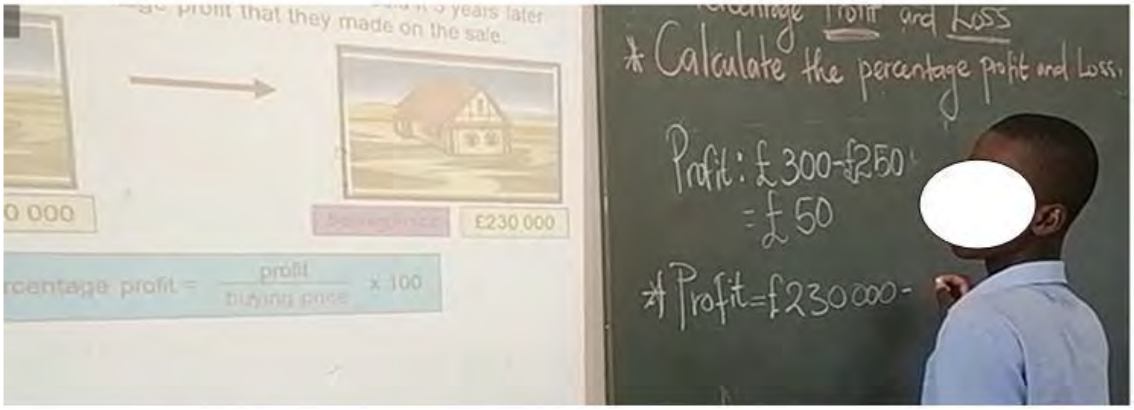


Figure 4.46: A learner using the formula displayed on the screen

The learner in Figure 4.46 got the correct answer. He was videoed copying the numbers from the display to put them into the formula. This was evidence that he made use of the described formula.

4.2.3.6 Summary of visuals used in the four lessons for T3

- In L1, T3 made visual the two given problems on subtraction and multiplication. She used the number line for the temperature problem and a set of tiles for the room floor problem.
- Lesson 2 of T3 looked at multiplying fractions. The teacher made this topic visual by using various fraction shapes to shade and obtain answers.
- In L3, the teacher presented the topic of directed numbers. She made visual this topic by projecting the number line and sketching some more number lines on the chalkboard.
- The fourth lesson of T3 was on money and finances. The teacher again used PowerPoint slides and a data projector to teach about percentage profit and loss.

4.3 ANALYSIS OF LEARNERS' MA TESTS RESULTS

This section of the chapter analyzes the results of the MA tests taken by the learners who participated in the intervention. The tests are compared to analyze whether there was any change in the participating learners' MA during the intervention. The differences or similarities between the learners' responses in the tests reveal whether the change has taken place. The big pre-tests were administered the day before lesson observations were carried out, while the big post-tests were administered at the end of all the cycles (at the end of intervention). The analysis of this section of the study aimed at answering my second research question. The intervention consisted of 54 learners in total, with 18 learners per class.

In this section, I first present the results as raw data (see Appendix J) in a comprehensive tally chart of all the big pre-test and big post-test results. The analytical tool in Appendix J consisted of the keywords indicating the theme of the question in the tests. The questions and coding are described in Appendix H. Additionally, to ease comparisons of data between both big MA tests, the learners' responses are graphed as bar graphs per category. The quantitative data gathered from these tests are analysed with descriptive statistics as they are presented in the section below.

Thereafter, I present the analysis of the small tests. I grouped all four tests in one bar chart. That helped me to see the trend of the changes as a result of the learners' participation in the intervention programme.

4.3.1 Descriptive data (statistics) of big MA pre and post-tests results

The key of the big MA pre-test and big MA post-test is indicated in each figure below. The percentages on top of the bars are equivalent to the frequency of responses for the particular coding in each figure. A short interpretive narrative for each theme is then presented after displaying the data in the figures.

4.3.1.1 Nervousness

Ruffins (2007) found that MA engenders psychological symptoms like panic, nervousness, and helpless feelings before participating in a mathematics lesson. Nervousness refers to the state of having or showing feelings of being worried and afraid about what might happen (Winkler, 2001). In mathematics, for example, the nervous learner would worry about what might happen if he/she provides an incorrect answer.

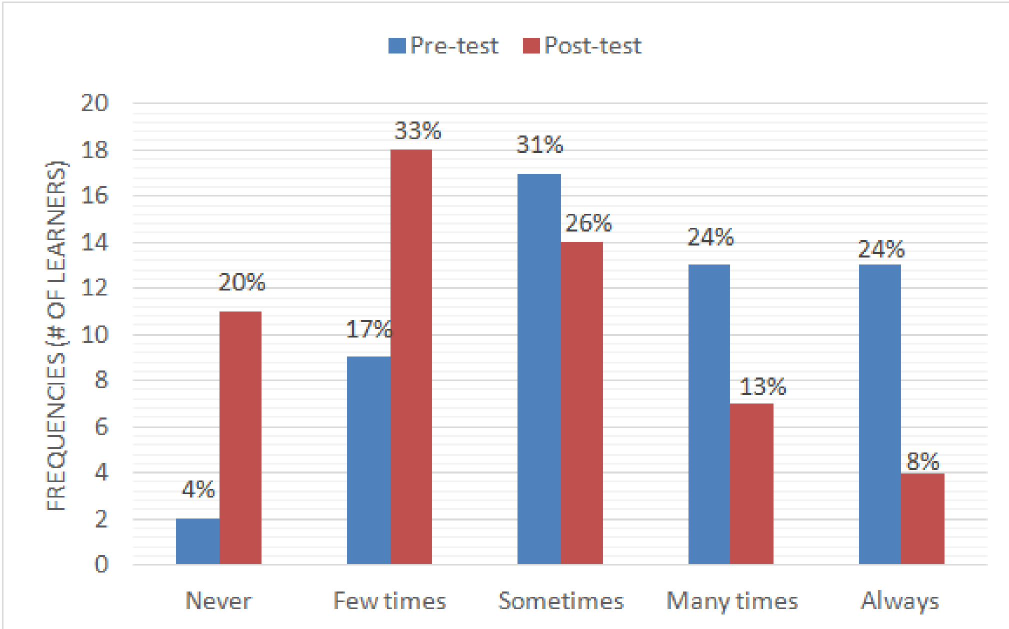


Figure 4.47: Nervous learners

As shown in Figure 4.47 above, two learners (4%) indicated on the pre-test that they *never* felt nervous in the mathematics class, but this number increased to eleven (20%) in the post-test. The data in Figure 4.47 reflects that nine learners (17%) who were nervous a *few times* in the pre-test had also increased to 18 (33%) in the post-test.

In Figure 4.47 during the pre-test, there were 24% of learners who are always nervous in mathematics but the number later decreased to 8% in the post-test. The results show that the learners who felt nervous before the intervention ceased being nervous. This is a positive change that could be ascribed to the intervention programme. The intervention thus reduced nervousness amongst the participated learners.

4.3.1.2 Shyness when writing on the chalkboard

According to Winkler (2001), shyness refers to low self-esteem and fear of judgment and rejection. Shyness is a common sign of learners' anxiety observed in mathematics lessons (Ruffins, 2007). According to Ruffins (2007), shy learners typically avoid being sent by the teachers to the chalkboard to write down their solutions or calculations.

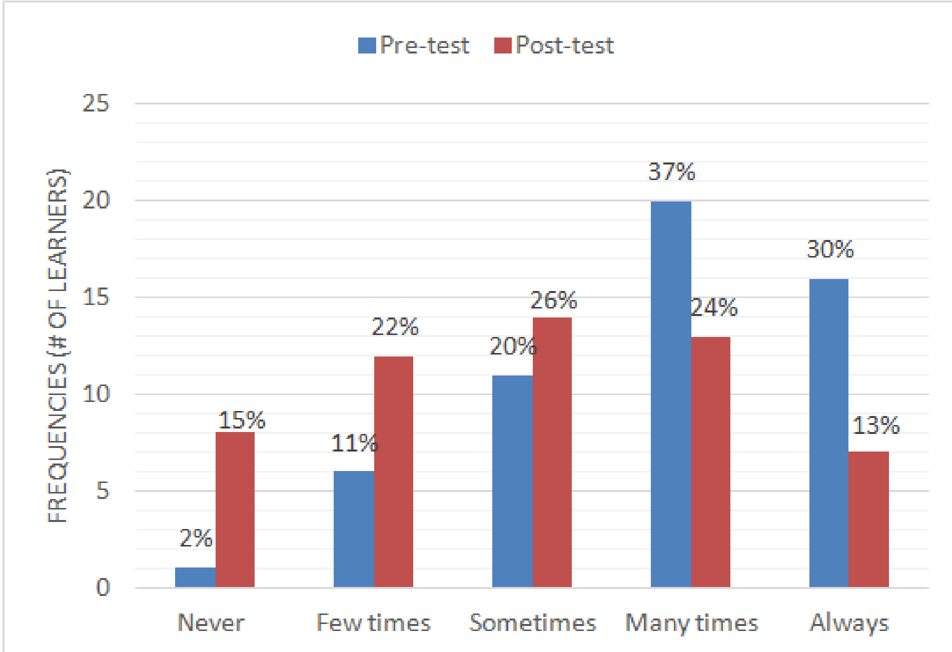


Figure 4.48: Shy learners

Figure 4.48 indicates how learners' shyness to write on the chalkboard lessened during the intervention. From the data provided in Figure 4.48 above, 37% of the learners who indicated *many times* in the pre-test, reduced to 24% in the post-test. Concurrently, the 16 learners (30%) at *always* in the pre-test also reduced to seven (13%) in the post-test. Only one learner (2%) indicated that she/he was *never* shy to write on the chalkboard before the intervention. By the end of the intervention, she/he was joined by seven learners who indicated that they are *never* shy to write on the chalkboard. From the data in Figure 4.48, it can be deduced that learners reduced their shyness as a result of participating in the intervention programme.

4.3.1.3 Afraid to ask questions

Wong (2005) emphasised that apart from the fear of any contact with mathematics, MA also includes avoiding direct communication with the mathematics teacher. He further gave an example of a learner that may encounter some difficulty in solving a mathematics task but is too afraid to ask for help from the teacher.

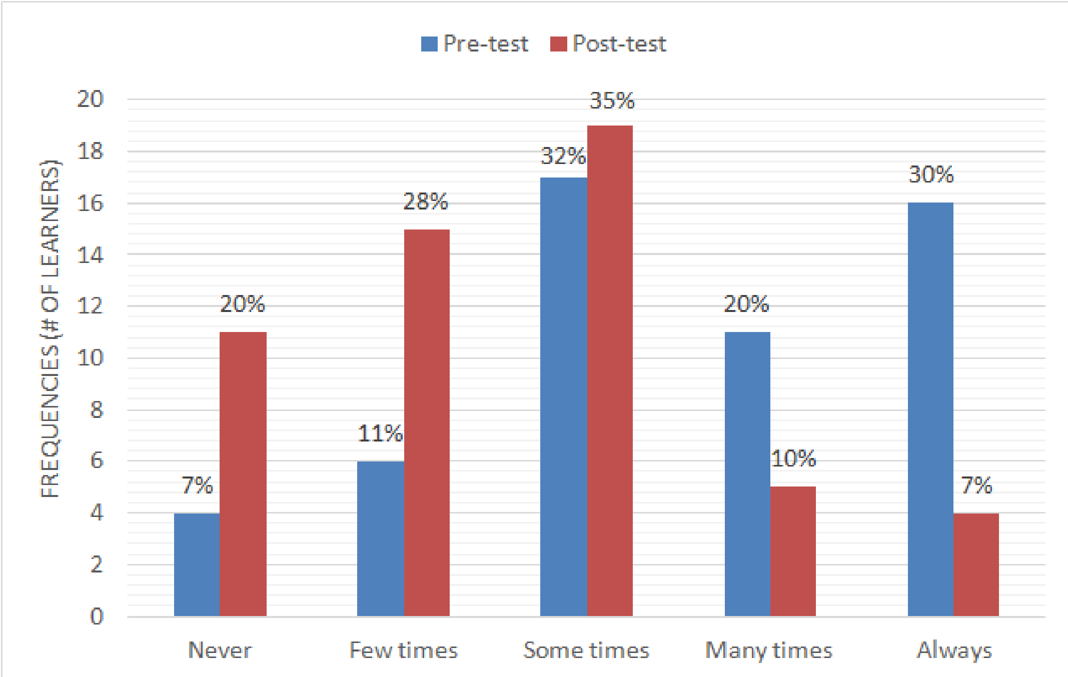


Figure 4.49: Learners with a fear of asking questions

As indicated in Figure 4.49 above, 17 (32%) learners were *sometimes* afraid of asking questions before the intervention. By the end of the intervention, the number of learners slightly increased by 2% to 19 (35%). The rise is a result of the indicated fall in the number of learners who were *always* afraid in the pre-test. Initially, 16 learners were *always* afraid of asking questions (30%) but this dropped to four (7%) in the post-test. This indicates the positive impact of the VTA intervention on the MA of the learners. With the presented data one can thus say the intervention programme reduced the fear of asking questions among these 54 learners.

4.3.1.4 Afraid of responding in class

Legg and Locker (2009) defined MA as “a general fear or tension associated with anxiety-provoking situations that involve interactions with mathematics” (p. 471). They believe that MA could lead to learners avoiding interactions in a mathematics class and being anxious about being called up or asked a question in class.

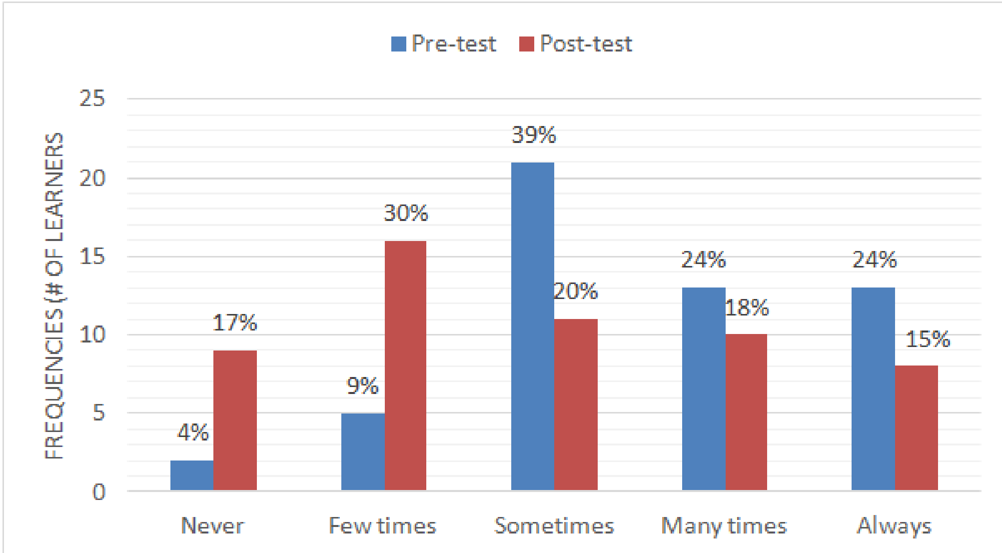


Figure 4.50: Learners worried about being mentioned in class

Figure 4.50 above shows a general decline in learners' fear of participation as the intervention unfolded. Learners who were *always* worried about being mentioned in class declined from 13 (24%) to eight (15%). It is encouraging to observe that those who *never* worried in the pre-test increased by seven learners from two (4%) to nine (17%) in the post-test. The programme influenced those seven learners to stop worrying. I thus argue that the use of visuals in the class reduced the fear of asking questions among the participating learners.

4.3.1.5 Afraid of mathematics becoming difficult

Sparks (2011) explained that MA creates fear for and discomfort in mathematics and can lead to fewer learners pursuing mathematics and science in school and tertiary institutions. This fear could lead to learners being worried about their future participation in mathematics and about mathematics becoming difficult.

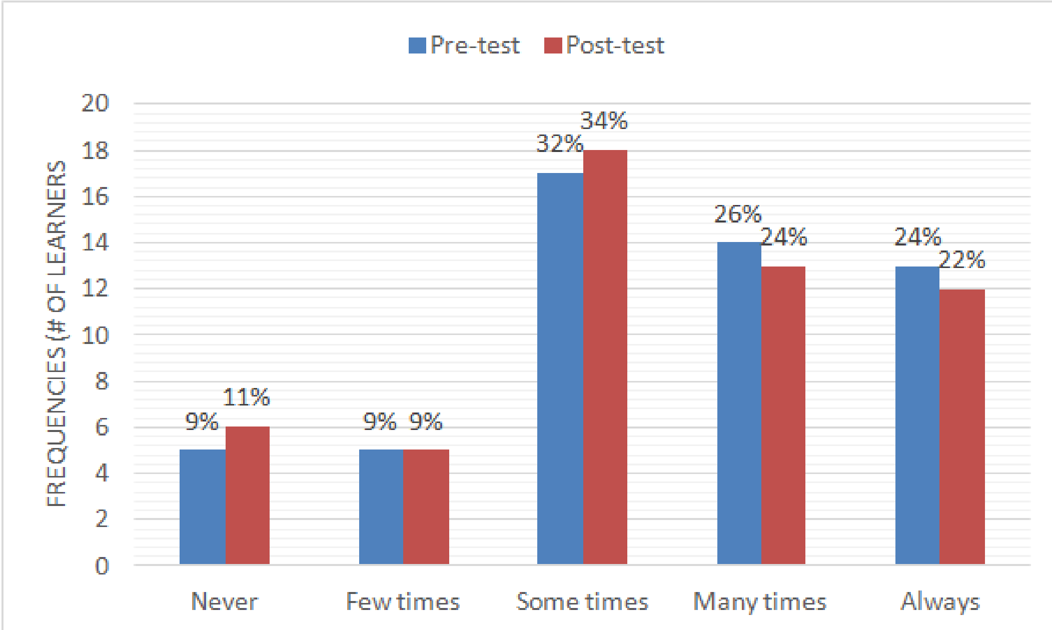


Figure 4.51: Learners who understand in class but think it will get harder soon

Figure 4.51 shows a slight difference in the pre-test and post-test results. This suggests that the intervention programme did not impact that much on the learners' perception that mathematics would get harder in the future. One of my teacher-participants suggested that the reason could be that the end of the intervention would be the end of using a VTA. However, it is positive that learners who indicated *never* and *sometimes worried* in the pre-test, increased by 2% each (e.g. at *never* from 9% in the pre-test to 11% in the post-test).

4.3.1.6 Wishing to hide away from class

Sparks (2011) described MA as a kind of negative emotional feeling created when engaging in activities requiring mathematical computations. In the same vein, Smith (1997) considered MA as a cause of fear of mathematics. He further elaborated that the fear could manifest itself as a feeling of discomfort while doing mathematics, and wishing to avoid any contact with a mathematics class. This can result in learners skipping mathematics classes and feeling sick when mathematics lessons start (as cited in Kumari, 2015).

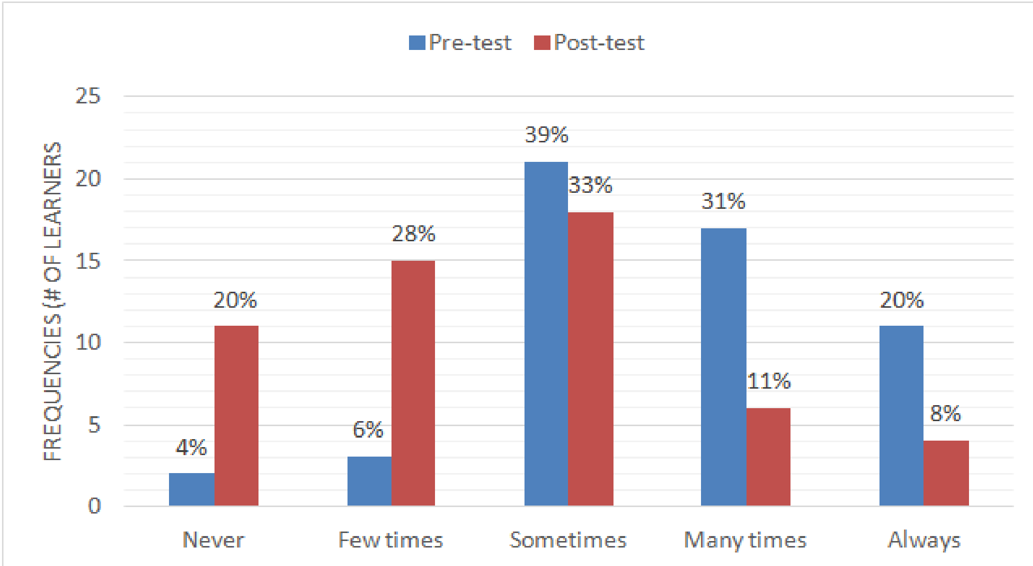


Figure 4.52: Learners who wish to hide away from mathematics class

Figure 4.52 above shows that 17 learners (31%) circled *many times* in the pre-test. At the end of the intervention, they dropped to six (11%). Another decline is observed in the *always* category, as there were 11 learners (20%) in the pre-test who were reduced to only four (8%) in the post-test. This is supported by the increase in the number of learners who *never* wished to hide, from two (4%) before the intervention programme, to 11 learners (20%) after the intervention. The programme made more nine learners stop thinking about hiding away from class. This confirms that the intervention with its VTA reduced the feeling of fear and desire to hide away from mathematics class among many of the participating learners.

4.3.1.7 Afraid of mathematics tests

Latterell (2005, p. 24) defined MA as "an intense fear of mathematics that prevents a person from being able to do mathematics freely". The learners with this fear are in some cases observed shivering or sweating when writing mathematics tests.

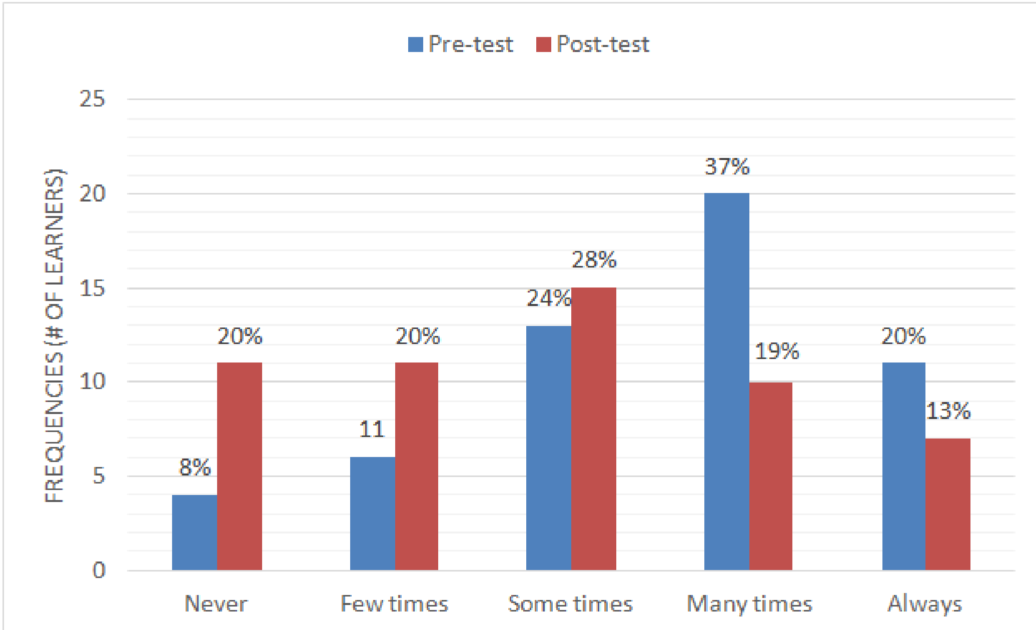


Figure 4.53: Mathematics fear than other subjects

With regard to Figure 4.53, there were 20 learners who frequently (*many times*) panicked and 11 learners who *always* panicked about mathematics tests in the pre-tests – 37% and 20% respectively. The number of learners in these categories reduced to ten (19%) and seven (13%) in the post-test. Figure 4.53 above also conveys the rise in the number of learners who *never* feared mathematics tests from four (8%) in the pre-test to eleven (20%) in the post-test. This means that the programme transformed the learners' fear of mathematics tests. I thus argue that it reduced the fear of mathematics tests.

4.3.1.8 Lack of study knowledge

Bower (2011) emphasised that learners' poor mathematics test marks in tests were often a result of a lack of study knowledge. This could be reflected in poor performance in mathematics tests.

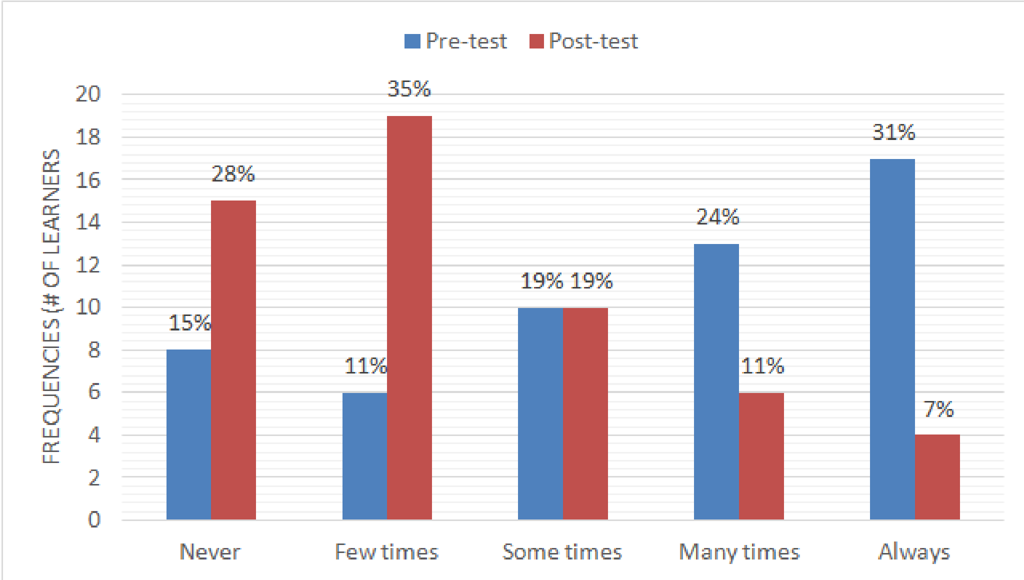


Figure 4.54: Poor knowledge of studying mathematics

The data in Figure 4.54 shows that before the intervention; many learners (31%) *always* struggled to study for mathematics tests. However, the number of learners reduced to 7% after the intervention. According to the data in Figure 4.54, learners that indicated a *few times* improved from 11% in the pre-test to 35% in the post-test. The category of *never* had 15% of learners in the pre-test but as a result of the intervention, the number of learners in the same category increased to 28% in the post-test. Looking at the data presented in Figure 4.54, it can then be argued that the intervention affected the learners' study knowledge positively. The intervention increased the number of learners able to study mathematics.

4.3.1.9 Mathematics is hard at home

Lucadamo (2016) argued that parents need to communicate with their children's teachers about their difficulty in helping their children at home. She further stressed that a parent can also ask his/her child to teach him/her an unfamiliar concept the learner was taught in the mathematics class at school. It is argued that the learners are finding mathematics hard at home because the parents are not helping them or the teachers do not have any proper channels of communication with the parents.

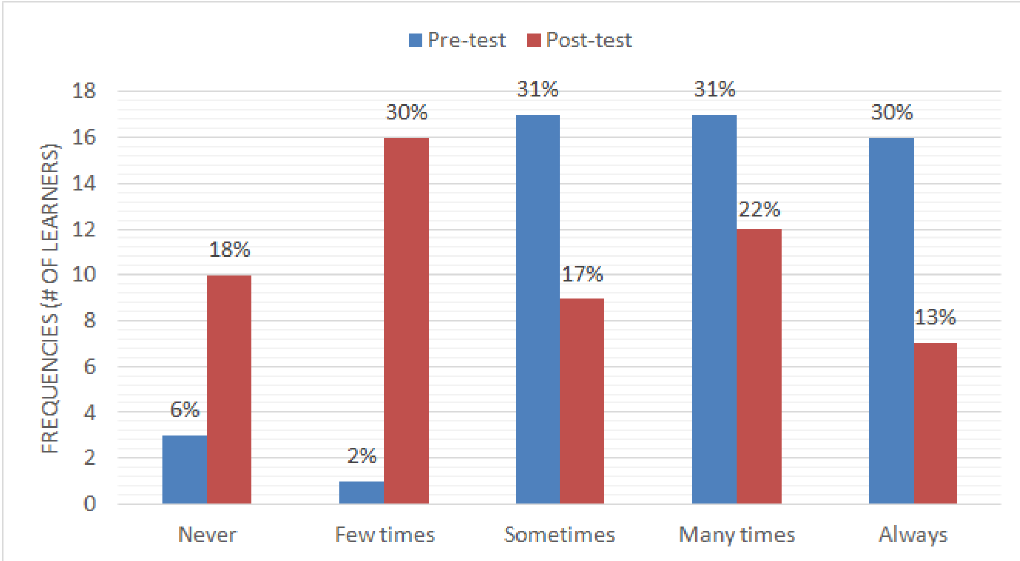


Figure 4.55: Mathematics easy in class but hard at home

Figure 4.55 depicts that a large number of learners tended to find mathematics easy in class but hard at home before the intervention programme. This can be observed in the pre-test in the last two categories (*many times* (31%) and *always* (30%)). The number of learners dropped to 22% and 13% in the post-test. Learners who indicated in between these two options (at *sometimes*) comprised a larger number in the pre-test at 17 (31%) but dropped to 9 (17%) in the post-test. I thus argue that the intervention increased the number of learners finding mathematics easy in class and also at home.

4.3.1.10 Many classmates are better than me

Smith (2004) identified the second cause of MA as the fear of public embarrassment. The fear of embarrassment refers to the shaming of low-performing learners in mathematics by other learners, teachers, and the public at large.

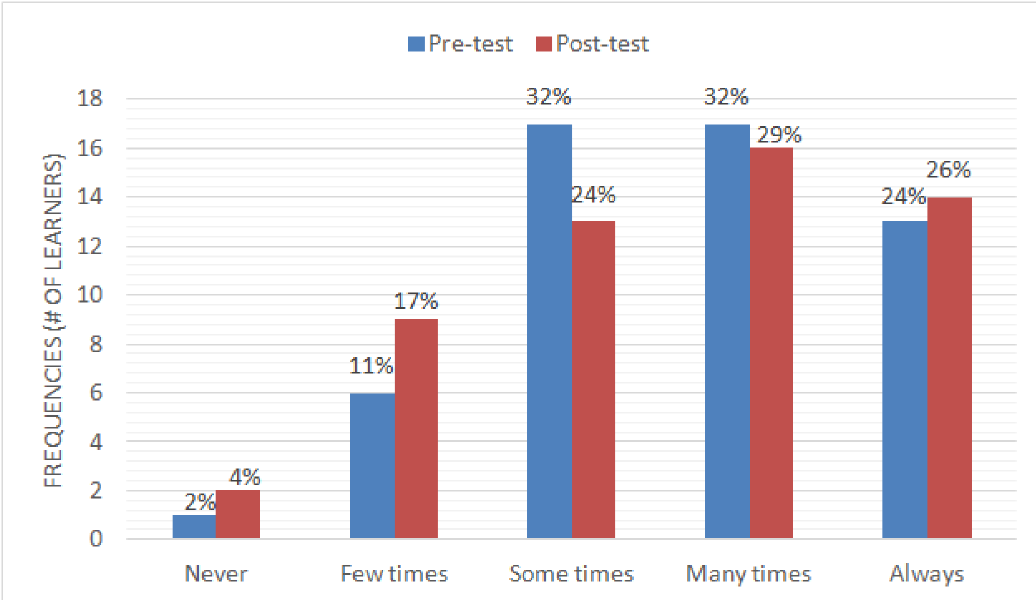


Figure 4.56: Learners afraid that many classmates are better than them at mathematics

Figure 4.56 above shows that the learners who *always* perceived that they were weaker than others increased from 13 (24%) in the pre-test to 14 (26%) in the post-test. The reason could be that the ASC consisted mostly of struggling learners. Perhaps they were answering this question, referring to their classmates in the ordinary morning classes. According to data in Figure 4.56, there are also no big differences in *sometimes* and *many times* when comparing the pre-test with post-test. However, there is a slight improvement seen in the first two categories (*never* and *few times*). This indicates that the intervention did not make a huge difference in the participating learners' minds about their fear that their classmates are better than them at mathematics.

4.3.1.11 Summary of how MA was addressed by adopting a VTA

- In Q 1: Nervousness: The use of visuals reduced nervousness among the participating learners.
- In Q 2: Shyness: The intervention programme of using visuals decreased the learners' shyness.
- In Q 3: Afraid of asking: The adoption of a VTA reduced the fear of asking questions among the learners.

- ❖ In Q 4: Afraid of being mentioned: The VTA intervention programme stopped some learners from worrying about being mentioned in mathematics class. Thus, it boosted the learners' participation.
- ❖ In Q 5: Mathematics gets harder: The intervention programme did not make a discernible difference in the learners' worry that mathematics would soon get harder.
- ❖ In Q 6: Hiding away from class: The intervention programme with the use of visuals reduced the feelings of hiding away from class among the participating learners.
- ❖ In Q 7: Mathematics fear: The intervention programme decreased fear of mathematics tests.
- ❖ In Q 8: Study knowledge: The adoption of a VTA helped many learners to study for mathematics tests.
- ❖ In Q 9: Hard mathematics at home: The intervention increased the number of learners to find mathematics easy in class and also at home.
- ❖ In Q 10: Classmates better: The intervention made a slight difference in the learners' thinking that the use of visuals would help them to do better than their classmates in mathematics.

4.3.2 The analysis of learners' small MA tests results

In between the big pre-test and big post-test, I administered small MA tests after each lesson. These small tests were used to continuously monitor the change of the learners' MA after each lesson. The small tests were administered by me and the participating teachers. The results of these tests served as good indicators for the teachers as they prepared their lessons for each cycle. The questions for the small test are in Appendix H. I witnessed with interest how the results of these small tests fluctuated up and down in some cycles. Yet, the overall trend in results reveals a reduction in MA among the participating learners.

The learners were asked to score their MA according to six coding criteria, namely: (a) ability to handle hard mathematics tasks; (b) scared by mathematics; (c) mathematics is a good subject; (d) willing to continue learning mathematics; (e) think clearly when dealing with mathematics; (f) confident to do mathematics. After every lesson, learners had to write the test indicating their levels in these concepts. Levels were ranked as follows: strongly agree (5), agree (4), neutral (i.e.

in between) (3), disagree (2), and strongly disagree (1). Figure 4.57 below represents the results of the small tests conducted with the learners.

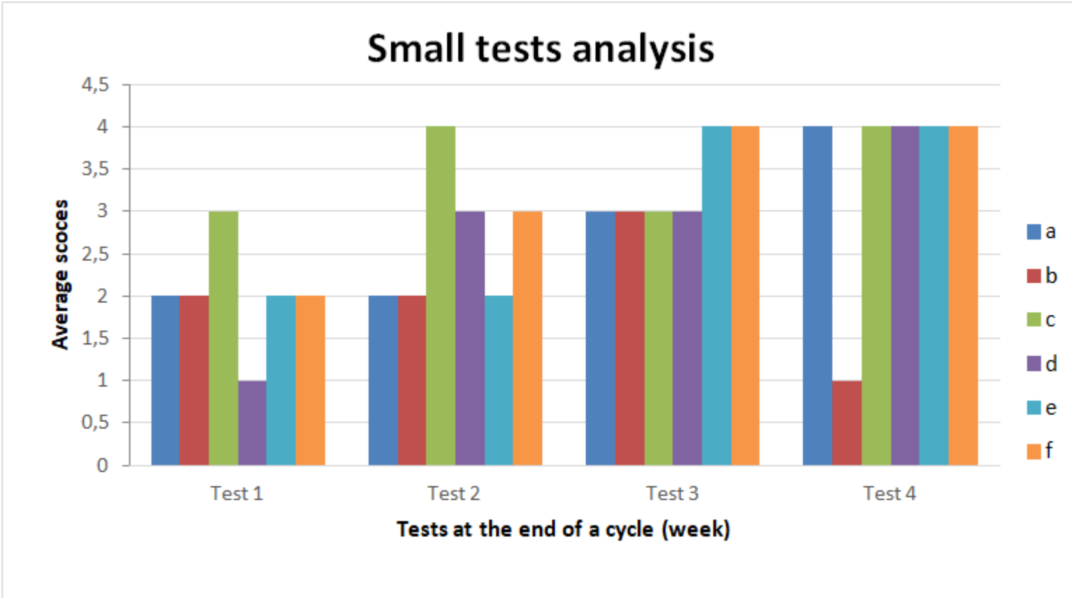


Figure 4.57: Small tests' results analysis

Figure 4.57 shows how the MA amongst the participating learners decreased during the intervention. It also resulted in positive views of mathematics. To analyse the changes in MA using these small tests, I compared the average scores of all participating learners. I got the average scores for each test by dividing the sum of all scores for each question by 54, i.e. the total number of participating learners. Thus, the average score represents the overall picture of how all learners felt about mathematics after each lesson that adopted a VTA.

Initially, i.e. after test 1 and test 2, the learners struggled to handle hard mathematics tasks as indicated by the key *'a'*. However, as the lessons proceeded, the learners indicated that they were able to handle difficult tasks. The learners also indicated that they were scared of mathematics – see key *'b'*. They became more scared in the third test, then it suddenly dropped in test 4. As a result of the intervention, it can be seen that the number of learners that are not scared of mathematics decreased. The participating learners' views of mathematics fluctuated throughout the intervention - see key *'c'*. I argue that a VTA benefitted the learners as they fluctuated around 'neutral' and 'agree' levels that mathematics is a good subject. The results for key *'d'* show how learners are eager to learn mathematics and continue studying mathematics as a subject. It is promising to see how the learners strongly disagreed in the first test (at an average score of one) and the number of learners suddenly went up in the second and third tests until it reached the 'agree' code (four) in the last test. This informs me that the use of a VTA in the intervention increased the learners' willingness to continue studying mathematics. The VTA also activated learners' thinking capacity – see key *'e'*. This was averaged at two (disagree) in the first two tests and eventually rose to the average score of four in the last two tests. This is an indication that during the intervention, the learners developed the ability to think clearly when doing mathematics tasks. The flow of the average score in confidence (key *'f'*) was positive throughout the VTA programme. I thus can say this approach enhanced learners' confidence in mathematics lessons.

T2 in the SRI-L4 thanked the learners for the good attendance in cycles 3 and 4. Apart from guiding teachers in their preparations, the small tests motivated my participant teachers towards the use of visuals in mitigating issues of MA. *"So, MA can simply be addressed through teaching? These results gave us evidence that I did not expect"* (T2 SRI-L4).

4.4 FOCUS GROUP INTERVIEW

This section of the study analyses the data collected from the focus group interview (FGI). The data was collected from the three participating teachers of this study. The data analyzed in this section aimed at answering the third research question of this case study. It concerns the enabling and constraining factors encountered when teaching with a VTA in an ASC. I themed the analysis of this FGI using the questions listed in the focus group interview schedule appearing in Appendix I. Here, I present the answers of all three participants per question in order, from one to seven as follows:

4.4.1 Experiences of teaching in an ASC using VTA

To the question of experiences attained in this intervention programme, T1 said that the learners' attitudes towards mathematics were enhanced by the use of visuals:

"Good experience since this approach has a positive impact on the learner's attitudes and progress towards mathematics, which is the priority of intervention programme I guess. Learners performed well and they were confident to participate in my lessons" (T1 FGI).

T2 concurred with T1 by nodding. He added that VTA enhanced learning through seeing, and learners interacted with each other through visuals and attended to some of the challenges together:

"Learners got to be more involved in the lessons and they paid more attention, simply because they were learning by seeing. We, teachers, displayed materials that helped to convey ideas; we asked learners to sketch out problems, work together, and model new concepts. The approach provided an environment that helped learners to develop positive relationships towards each other and also to attend to some of the challenges in the activities" (T2 FGI).

T3 supported the points of the other teachers. She strengthened them by referring to peer-teaching, suggesting that the use of visuals made learners teach one another. She also proposed that teachers should make use of a VTA and ignore the teacher-centred approach that they are using in schools now.

"My slow learners or learners with special needs as we refer to those that need afternoon class… they catch up at the same pace with those that didn't attend these classes because of the extra classes that they get. There was no teacher-centred system used. Learners were interactively manipulating to solve problems in mathematics to get answers. They were eager to learn. The learners helped one another through peer teaching by using visuals" (T3 FGI).

4.4.2 Differences between the old approach and a VTA

T1 compared the morning classes with the afternoon ones which are mostly dominated by visuals. She stated that time constraints during the morning classes prevent teachers from using visuals. She also suggested that the smaller number of learners in the afternoon classes made it easier to use visuals.

"Morning session teaching is ever shallow and learners are not exposed to visuals due to insufficient time to use manipulatives. Too many learners in the morning prevent the use of manipulatives too, compared to a VTA. The difference is that the visual approach was progressive; because the learners were few and it was effective, it imposed positive changes" (T1 FGI).

T2 cut T1 short as if he was stimulated by what she said. He took the floor and said:

"I realized that in my usual approach, learners focus too much on my presentation, and only a little time is left for them to practice. What I generally do is lecture, whereby I do like 'one size fits all. I don't attend to learners individually, as I said time is also limited. Learners even forget things easily. In VTA, visual learning helped learners to store information for a longer period. Images are directly processed by long-term memory. Learners look at problems differently in a way that they understand. This approach overall built learners understanding of mathematics and they were always interested in the lessons" (T2 FGI).

T3 highlighted that the use of visuals in this programme encouraged the learners' interaction and they asked more questions than before. She even concluded that learners looked different. She also stressed that the approach changed her way of teaching from lecturing to discussions and demonstrations:

"Visuals used in this programme converted the abstract that I used in the morning to the concrete way of doing mathematics. The teaching approach changed from teacher-centeredness to learner-centeredness. Learners were interactive and asked questions and they were also confident in demonstrating their answers. To me, they were like different learners in this programme" (T3 FGI).

4.4.3 The impact that VTA has on learners' participation and motivation

All the teachers affirmed that a VTA had some impact on learners' participation and motivation. It was noticeable that all of them stated critical thinking repeatedly with none defining it:

"Visuals have good impacts: firstly, the learners develop a positive attitude towards mathematics we all know that our learners believe that mathematics is difficult but with visuals, they change the mindset. Critical thinking skills: the learner became self-confident when you are talking about self-confidence the learners are not scared but they can stand up and visually show you what they are saying and why this sum is like this" (T3 FGI).

"VTA increased learners' participation. It brought confidence to learners' questioning and encouraged critical thinking skills. There is also a philosophy that says 'if they cannot learn the way you teach, teach them the way they learn'. For clarity, the VTA implied facts that learners can easily recall whenever necessary. For example, with the fractions, when I showed the learners that $\frac{1}{2}$ *is equivalent to* $\frac{4}{8}$*; learners could likely be able to recall that in the future*

because they had seen it with their own eyes. This approach also changed the learners' mindset about mathematics" (T1 FGI).

"The VTA improved critical thinking skills through me. I facilitated discussions of visual images and provoked the interest of learners. Visuals helped me to explain the concepts easily. Most learners tend to forget, but proper use of visual aids helped them to retain more concepts permanently. In a nutshell, visual aids helped me to create an environment of interest for my learners. Even the learners asked a lot of questions. Learners developed and increased personal understanding of the areas of learning in a few topics I taught in this programme. My learners enjoyed the pleasant learning in the classroom" (T2 FGI).

4.4.4 VTA leading to a reduction of MA

To the question of whether a VTA can reduce MA, T2 indicated a *'yes'*, which he supported by elaborating that learners are not passively receiving information but are part of the learning processes. He further stressed that the learners do not fear mathematics since they use visuals to demonstrate how they got their answers. In his own words he said:

"Yes, yes! Learners were actively involved in the lessons. So in active learning, the learner will no longer passively receive information, but they became part of the learning experience. Through these lessons, learners made mistakes and corrected themselves. But this too can be transferred to a learning experience. Learners developed a positive love of mathematics, and then the fear of mathematics also disappeared. This approach helped learners to develop positive love of mathematics; they started loving the subject because they were helping each other" (T2 FGI).

T3 answered this question by referring to the use of logical reasoning as a skill to reduce MA in learners through the use of visuals in a VTA. She reasoned that a VTA reduces MA because visuals form mental images in the minds of the learners. She said visuals help learners to develop the skills of explaining a single concept in more than one way:

"MA can be reduced by letting the learners explain why they say their answers are correct. Visuals reduce MA because visually you are showing the learners how the length and the width of the rectangle are used in the calculation. Logical reasoning develops because of the use of visuals. That gives learners ways to explain their answers. Again, I am saying this programme

removed the MA in my learners because when they were using visuals at the same time they were forming mental images in their minds. Visuals can help learners to explain one thing in two to three different ways" (T3 FGI).

Also in the FGI session, T1 maintained the use of code-switching as a VL skill that reduces MA:

"The mathematics anxiety is being reduced in the way that: for example, in that lesson where I ended up translating what I was saying into vernacular to the boy sitting at the back. I code-switched because he is over-aged and he had a gap year. He struggles with English, so I translate for him sometimes to accommodate him and for him to catch up with what I mean. That took out his mathematics fear and I am telling you he does not shiver anymore" (T1 FGI).

4.4.5 How VTA can be made desirable

All three participants are in favour of a VTA to be made desirable to other mathematics teachers. They indicated this by describing possible mechanisms on how this can be done. They suggested that a VTA approach should be a compulsory component in teachers' training courses, and curriculum developers should also be involved.

"To make a VTA effective, it should be made compulsory. Let all teachers come together for every topic and plan. The approach should just be implemented in the schools' curriculum. In most cases, we get approaches and programme that are suggested by the ministry but the implementation at the ground level does not take place properly. Nevertheless, for this one, we need proper monitoring systems in place. If this is made compulsory then we can all achieve the goals for developing learners or creating learners that are good at mathematics. Another thing is this: If we have enough visuals then this programme can be successful during the implementation" (T3 FGI).

"Once this approach is communicated to all the mathematics teachers and be made familiar to them, then it will automatically work. Teachers need to be trained on how to use this approach possibly through workshops, or maybe by building strong communication between schools within the circuit, clusters, regions, and countrywide. I suggest advisory teachers must be made aware of this, so they give training to all the mathematics teachers" (T2 FGI).

"I agree with you colleagues, a VTA should be implemented in all schools and be made compulsory in all grades. All learners with special learning abilities would be considered. Teachers need training on the use of VTA" (T1 FGI).

4.4.6 Challenges experienced in the programme

Lack of visuals and time constraints emerged from the FGI data as the main challenges in the use of a VTA. To start with, T3 indicated that:

"Lack of visuals as I said previously there were not enough visuals. As teachers, we always had to improvise. Learners had the mentality that afternoon classes were not normal and not needed. Many learners were absconding from the programme because they think that the morning hours are the only compulsory school hours. The feeding programme that is absent from school sometimes also contributes to the absconding of learners from the programme. Insufficient time after school with the use of visuals is also a major problem. Lack of support from the parents to prepare food for learners attending after school was also a challenge" (T3 FGI).

"High absenteeism and the fact that the programme is voluntarily made learners skip it. Learners that needed more help were the ones that were absent from my class in this programme. Another challenge was: some learners who attended the afternoon sessions started to ignore the morning classes. They were now dependent on the afternoon classes to catch up with what was taught because these were meant for revision. Another setback was that there were too many concepts one had to consider when lesson planning. The period time (1 hour) for the lesson and the learners' learning pace of these below-average learners needed a good balance. Sometimes the lesson could not accommodate the use of all planned visuals. It was taking us (teachers) timeand effort to create these visuals before the lessons" (T1 FGI).

*"**Time restriction**: Time always ran faster beside the one-hour-long lesson. I didn't have adequate time after school because these learners are from far, some walk about 5-10 km to their houses. So, I sometimes tried to release them earlier for them to get to their houses on time and to avoid calls from parents. Some few learners took it like it is a punishment when they stay for afternoon lessons, so some of them are sometimes not interested, but once you encourage and motivate them, then learning goes on.*

***Teaching aids**: The issue is that there are not enough teaching aids within the school. But instead, I could make use of ICT to visualize. There were times I needed to use an overhead projector but my classroom has no electricity. It was electrified but the electricity doesn't work anymore"* (T2 FGI).

4.4.7 Suggestions or Comments

Participants stated that teachers should prepare visuals for learners in all their lessons. It was also suggested that perhaps creative learners could be encouraged by their teachers to create visuals and bring them to school. The advisory services should facilitate training with teachers on how visuals should be designed and used. The curriculum developers should make sure that the curriculum is visually oriented. Moreover, teachers at the Junior Primary level should always make use of visuals when teaching mathematics. T3 and T2 also called for the discouragement of the overuse of the traditional algorithms in mathematics and encouraged the use of visuals. T3 also called for the selection of a committee to monitor the implementation of a VTA programme at school. Many of their suggestions and comments correspond with their answers in Question 4.7.4 about how a VTA can be made desirable to other teachers. However, I decided to draw the reader's attention to the comments of T1 below because it contains some practical aspects of a VTA:

"I would just like to recommend this teaching approach of using visuals. The teacher can either draw or prepare the visuals. I am urging teachers to sacrifice some of their time to prepare/design the visuals or teaching aids to assist the learners. Learning mathematics is fun. It is not difficult as some people label it. So, learners just need a proper interesting way of learning it. Mathematics should be made fun by using attractive materials" (T1 FGI).

4.4.8 Summary of the enabling and constraining factors

4.4.8.1 Enabling factors

- ❖ The participants testified that as a result of the use of visual aids which introduced more fun-filled activities into the mathematics classrooms, most of their learners seemed to enjoy mathematics more, thus making the subject more interesting to them. Teachers observed how learners, particularly the below-average ones, seemed to understand the challenging tasks better and participated more freely in group discussions. Participants believed that a VTA made even the shy and nervous learners present their mathematics work to others.

- ❖ The participating teachers outlined that through adopting a VTA, learners were exposed to manipulatives and concrete materials which were lacking in their old traditional teaching approach. A VTA uses images and pictures and comprises demonstrations and discussions, thus learners are allowed to contribute and ask questions. These aspects are absent in lessons taught with the old approach. The old approach was regarded as too abstract while a VTA is more concrete and activity-based. Therefore, a VTA implies a learner-centeredness approach, whereas the old approach is based on lecturing and teacher-centredness.
- ❖ This approach accommodated all participating learners. The examples used were familiar to the learners, which enabled them to practice even at home.

4.4.8.2 Constraining factors

- o Time constraints: a VTA consumes a lot of time, particularly with the slow pace of learning of the below-average learners.
- o Lack of visuals supplied by the ministry at schools: This means that teachers had to constantly improvise and produce their visuals.
- o Absconding of learners due to extra-mural activities and the ASC being voluntary.
- o Long distances: Some learners have to walk long distances to and from school. This affects their concentration levels and thus compromises their class participation.

4.5 CONCLUSION

This chapter presented and discussed the data and the findings of my research study. The data was drawn from the 12 lessons of the three participating teachers that I observed, stimulus recall interviews, and focus group interviews. Data were also extracted from learners completing various MA tests. Firstly, I qualitatively analysed each teacher’s lessons and extracted all the VTA skills that the teachers used during their four lessons. Secondly, I quantitatively analysed the learners' MA test results in the big MA pre and post-tests plus the small MA tests. My third and final analysis in this chapter was the FGI of the three participating teachers about enabling and constraining factors of using a VTA in the mathematics classroom. The FGI was also analysed qualitatively. The main findings were summarised after each section, based on the themes that were used to categorize and discuss the data. I extracted the themes from the questions used in the data collections.

The next chapter uses the analysis of Chapter 4 to discuss the findings, consider some implications, draw conclusions from this study, formulate several recommendations and explore avenues for further research.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This study used both qualitative and quantitative methods to research how the use of a VTA helps to reduce MA in learners. The quantitative data were obtained from the big MA pre and post-tests answered by learner-participants as it was designed to answer the second research question. The rest of the data was qualitative and was obtained from observations, stimulus recall interviews, and focus group interviews held with the teacher-participants. In essence, the objective of this research was to analyse the usefulness of a VTA towards reducing the learners' mathematics anxiety in an ASC context.

This final chapter provides a summary of the main findings as reported in Chapter 4. The significance of the study and recommendations are included in this chapter. I also discuss the implications of this research project. I further explore the limitations and present some recommendations. Some ideas for further research are identified here too. Finally, I end this chapter with some of my reflections on my experience in this research study.

5.2 SUMMARY OF THE FINDINGS

In this summary, I present and discuss the main findings as per the reflections on the observed and video-recorded lessons and from the two types of conducted interviews. I also provide a summary of the pre and post-test results. I present the summary in the order of the research questions.

5.2.1 Research question one

How do three selected Grade 5-7 teachers use a visual teaching approach in the context of an after-school club as a result of participating in an intervention programme?

My observations of the video-recorded lesson presentations of all lessons and stimulus recall interviews informed this first research question. I answer it by summarising the main findings on how each teacher used visuals in the four observed lessons.

T1: The teacher used a VTA in L1 by using concrete materials such as hand-made three-dimensional teaching aids. The materials used were obtained from the local environment (e.g empty milk boxes). In L2, she used fraction pieces as a visual material to help the learners to compare fractions. A boy who asked his question by drawing triangles on a chalkboard also demonstrated a visual presentation in conjunction with language. T1 created a poster of unsolved problems that were all BODMAS based for her L3. She guided learners to solve all the problems in the lesson, so they could produce their notes together. In L4, she used single- digit cards that the class used to work with place value and writing big whole numbers.

T2: In L1 he designed flashcards to use. The cards provided different instructions to learners and made them think out of the box (i.e. by squaring as far as a fraction in Grade 6). The unsolved problems on the poster stimulated the learners' interest in the tasks for the lesson. T2 introduced his second lesson of rounding off by using a real-life situation for 'rounding off to the nearest ten.' He visualised the introduction by sketching the example of a boy running to school and encountering rain on the way. The teacher used rounding-off arrows to minimise his teaching load. In L3, the teacher made use of flashcards to motivate and inspire the learners. He used flashcards to make the prime and composite numbers visible. Sir Kukuta linked abstract ideas to the concrete with tiles and small squares to calculate the perimeter and area of a rectangle in his last lesson.

T3: In L1, T3 taught two problems about subtraction and multiplication. She made the subtraction problem visual by using the number line for a temperature scenario; and the multiplication problem by using a set of tiles for the room floor question. L2 of T3 was about multiplying fractions. Ms. Uukunde made this topic visual by using various fraction shapes to shade and obtain answers. In L3, she presented the topic of directed numbers by projecting number lines using technology and sketching more number lines on the chalkboard. The fourth lesson of T3 was on money and finances. The teacher used a data projector to view the PowerPoint slides of purchased chairs, laptops, and cell phones to teach about percentages of profit and loss.

In the lesson observations, I evaluated using the four visual teaching skills suggested by Debes (1969). They are divided into four categories, namely: designing visuals (*DV*), visual language (*LV*), manipulating visuals (*MV*), and assessing visuals (*AV*). Griqua (2019) argues that simply making use of visuals in teaching may not be enough for promoting learners' understanding but it is important to consider the relevance of visuals to the topic and the way they are used in lesson delivery. Therefore, to break down the above skills I used some observable indicators like relevancies, attractiveness, appeal, grade level, and language balance. The evaluation summary of how these teaching skills were used by the teachers is presented below:

The designed materials looked attractive and appealed to the learners. Some of these visuals were made from the waste products found in the immediate vicinity. The language (*VL*) used by the teachers in the intervention was aimed at the below-average learners. In some presentations, the teachers even code-switched. Naming, labeling, and body gestures were observed in many incidences. I observed learners discussing, giving answers, debating, asking questions, and demonstrating using visuals in these lessons.

The *MV* skills looked at the explanations and how the visuals were made use of during the lessons' delivery. The teachers used a range of real objects and tangible materials in their teaching. This was confirmed by rich visual representations like sketches, diagrams, and drawings on the chalkboards. One teacher integrated electronic presentations with a projector. Some manipulatives and concrete materials used in the observed lessons were 3-D shapes (cubes, cuboids, prisms, and pyramids), flashcards, fraction pieces flashcards, posters, arrows, equal signs, small card squares, coloured paper, and tile manipulatives.

The *AV* skills were observed in some lessons as the teachers linked previous lessons to the new ones, referring to visuals used. Learners were allowed to ask questions by drawing and demonstrating visual solutions on the chalkboard. They sketched their problem-solving solutions in their activity books during class for homework. Labeling and naming of materials were discussed by learners in most cases. Learners were offered materials to work on tasks in their e.g flashcards. Also, in many lessons, the learners got a chance to touch the visuals.

5.2.2 Research question two

How does the adoption of a VTA result in a change in MA amongst the learners of the participating teachers?

Herewith is a summary of the findings of the quantitative data analysis gathered from the big MA pre-test and post-test. This reveals the change of MA amongst the participating learners:

- A reduction in nervousness resulted as teachers gave the learners opportunities to present their work on the chalkboards visually and encouraged learners by nodding and giving verbal praise (visual language). In the process, learners felt good and confident about themselves and the subject.

- Learning was made more interesting and meaningful through the use of visuals. All learners got opportunities to speak, write and demonstrate to others. All these lessened the learners' shyness.
- Learners felt at ease to ask questions in the lessons using a VTA. They were even allowed to present their questions by drawing.
- Learners were actively involved in the observed lessons. They gave the right answers and freely engaged in productive discussions and debates about the topics. Thus, their fear of being singled out in class declined. A VTA boosted learners' participation indeed.
- There was a slight change in the learners' worry about mathematics becoming more difficult. This is evidence of a positive impact. Some learners showed an improved attitude and perception about learning mathematics.
- After the intervention, many learners indicated their willingness to attend mathematics lessons. The lessons were lively and motivating. The feeling of hiding away from the class was reduced.
- Only a few learners indicated a fear towards mathematics tests in the post-test. This is evidence that a VTA enhances comprehension and mastery of mathematics skills. Thus, learners were less worried about tests.
- A VTA equipped learners with study skills. The lessons were enriched by interesting examples which were made visual. They were exposed to realistic situations where they could employ mathematics. Indeed, they were made to realise that mathematics is involved in our everyday lives.

The intervention also succeeded in easing mathematics concepts in class and at home. I believe most learners who indicated *never* and *few times* in post-tests, realised the reality of mathematics and the need for it not to be the following of some meaningless algorithm memorization.

5.2.3 Research question three

What are the enabling and constraining factors when teaching with a visual teaching approach in an after-school club?

5.2.3.1 The enabling factors

- During the interviews, teacher-participants revealed a reduction in learners' MA and improved performance in mathematics achieved during the programme.

- Teachers made comparisons between the use of a VTA and their old teaching approach in terms of lesson presentations, learners' engagement, and classroom interactions. A VTA was favoured as more effective in teaching because of its unique use of visuals.
- Visuals were seen by all teachers to be best for increasing learners' participation and classroom interactions and encouraging curiosity. It was also shown that a VTA helped to encourage the shy, nervous, and below-average learners, and it made them more confident learners in their mathematics classes.
- Apart from those benefits, the teachers suggested that to make a VTA desirable to other teachers, the following factors should not be overlooked:
    - training – teachers should be made familiar with the importance of a VTA, as well as on how to design and use visuals in classrooms.
    - information –teachers, principals, and advisory teachers should be made aware ofthe approach.
    - monitoring - the implementation of a VTA and inspection of visuals should be reinforced.
    - implementation – the use of a VTA should be made compulsory in all schools and at all phases.

5.2.3.2. Constraining factors of a VTA adoption

- **Lack of time:**

  Because of other duties of the teachers, they have little time left to improvise/design teaching visuals. The limited duration of lessons does not sufficiently accommodate the manipulation of visuals.
- **Lack of resources:**

  Most schools lack even basic teaching aids. The cut in national budgets has tightened the supply of teaching visuals. There is no electricity in some classes – thus teachers cannot use projectors.
- **Low attendance:**

  Often absenteeism is caused by learners being hungry. Some days the cooks of the voluntary feeding scheme do not come and the learners become hungry. When this happens some learners skip ASC lessons and go home.

Long distances - walking long distances between home and school is another reason for absconding from ASC lessons. In some instances, the teachers release their learners earlier so that they can reach home in time.

- Other factors that the teachers identified are learners' stigmas. Some learners regard afternoon classes as punishment. Some learners label visual lessons as a 'slow learners' thing'. Thus, they refrain from such lessons to avoid being stigmatised by their peers.
- One of the participants withdrew from the project because she felt that she was too old to be video-recorded and that she was not good at expressing herself in English. She said she code-switched too much in her lessons.

5.3 SIGNIFICANCE OF THE STUDY

The hope is that the findings of this study will inspire Namibian primary mathematics teachers to try and implement the use of a VTA to meet the educational needs of primary mathematics in terms of the alleviation of MA. My engagement in this study has enlightened me on how local visual manipulatives and hand-made concrete materials can be used to effectively make lessons more exciting to the learners.

The intervention programme at the heart of this study created an awareness of a visualization approach (a VTA) that can contribute to the effective teaching of mathematics, especially to the participating teachers. Its findings provided insightful information on how a VTA can be used by teachers to alleviate symptoms or signs of MA among the learners in mathematics classes. Further, it enabled me and my participating teachers to design and use appropriate and attractive visuals that provide excitement and make mathematics fun to the learners. The learners' MA tests results revealed a reduction in MA signs.

5.4 RECOMMENDATIONS

By reflecting on the summary of findings made above, I have identified the following recommendations:

- It emerged clearly that the three selected teachers were impressed by the use of a VTA in the context of an ASC. However, support, exposure, and more practical training need to be provided to all other teachers to gain the confidence and competence to design and use visuals in their teaching. Therefore, training at tertiary institutions should train teachers in designing and using visuals for their teaching. More emphasis should be placed on the use of a visual teaching approach. This means that visual teaching should be infused into the entire teacher training programme.

- Teaching pedagogies should be expanded to accommodate the use of a visual teaching approach to allow mathematics teachers to make their lessons more exciting and exploratory for their learners.
- Mathematics education officers and curriculum developers should encourage mathematics teachers, particularly in rural and remote schools of Namibia, to make use of visuals from their local environment. This would assist those schools to secure more teaching resources without spending a lot of money from their coffers. These materials should be designed in such a way that they are attractive to be able to stimulate the learners' interest and increase their participation.
- Mentor tutors and university lecturers should put in place regular control measures and reinforce the use of a VTA in lessons more frequently, thus allowing the student teachers to prepare in advance for such lessons.
- The teachers should be exposed to and allowed to prepare teaching materials more frequently before they complete their probations. They could store them in files or in rooms to be able to retrieve them for repeated use or lend them out for others to use.
- To promote creativity, teachers should involve their learners in designing some visual resources. This would also instill a feeling of belonging and worth in learners. They would enjoy lessons where their materials are used.

5.5 LIMITATIONS

As normally expected in every research journey, this study also encountered some limitations and challenges.

Firstly, the study used a sample of three teachers only and 54 learners at one school. This is a small sample and thus no generalisations to a bigger population can be made. Also, only using the four teaching skills observed in every lesson, the ten pre and post-tests questions answered by learners, and seven FGI questions answered by the three participating teachers limited the responses. Therefore, the findings of this study cannot be generalised.

Secondly, the COVID 19 pandemic disrupted the teaching and learning processes which affected the smooth running of the planned intervention. It brought in unexpected learners' absenteeism as well as anxiety of physical contact between the researcher and the participants and between teachers and learners.

Lastly, the data of this study was collected over six weeks. This is a short period – more time is required to implement a more meaningful VTA in an ASC. Also, a similar approach should be followed in the formal morning sessions to see a more comprehensive picture of its effects in terms of alleviating mathematics anxiety. That could have provided more rich and detailed data.

5.6 SUGGESTIONS FOR FURTHER RESEARCH

I suggest that further research could look at the use of a VTA to help reduce teachers' reluctance to teach geometric concepts. This may help to reduce learners' MA for this particular section of mathematics which is often a cause of anxiety for many teachers and learners.

Curriculum implementers, mathematics advisory teachers, other mathematics teachers of all levels, and future researchers could benefit from continuing to build on this study. Many professional development opportunities could be created to allow teachers to be informed of the use of a VTA that may help to address mathematics anxiety. These professional development opportunities could allow mathematics educators the opportunity to practice the required teaching skills like designing visuals, visual language, manipulating visuals, and assessing visuals.

During the interviews, the participating teachers emphasized the positive impact of visuals on MA as stated above. They regard VTA as effective in learning mathematics. According to them, a VTA facilitates concept formation and motivation and increases participation and critical thinking. These are all interrelated aspects of learners' MA. Thus, this could be an interesting area to research as well.

5.7 PERSONAL REFLECTIONS

Ever since I completed the Bed Hons at Rhodes University in 2005, I looked forward to pursuing a degree of a Masters in Mathematics Education. I tried to register for the master's degree in 2008but things did not go well. In 2019, I took this study's journey with Rhodes University again and obtained the research experiences I presented in this thesis.

This study contributed to my professional growth, especially regarding writing, reading academic articles, sourcing of information, and critically investigating concepts for data collection and analysis. My understanding of visualization has improved significantly during my study. Moreover, this study granted me an opportunity to meet Prof Marc and fellow researchers again, from whom I have learned much about research in general and various research themes in particular.

In a nutshell, this study has developed me professionally and academically. I am grateful to my supervisors for their support, guidance, and patience during this academic journey.

5.8 CONCLUSION

This chapter concludes the study by presenting a summary of findings, discussing the significance of this case study and some recommendations, and outlining the limitations of the study. The suggestions for further research are also highlighted. Finally, a reflection of my experiences throughout my entire research journey concludes this chapter and the entire thesis.

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APPENDICES

Appendix A: Ethical Clearance

RHODES UNIVERSITY

Human Ethics subcommittee
Rhodes University Ethical Standards Committee
PO Box 94, Grahamstown, 6140, South Africa
t: +27 (0) 46 603 8055
f: +27 (0) 46 603 8821
e: ethics-committee@ru.ac.za

[illegible]
NHREC Registration no. REC-241114-045

2 March 2020

Daniel Ngonga

Review Reference: 2020-0982-3267

Email: g00N4897@campus.ru.ac.za

Dear Daniel Ngonga

Re: Investigating how a visual teaching approach can be used in the context of an after-school club

Principal Investigator: Professor Marc Schafer

Collaborators: Mr. Daniel N Ngonga

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Ethical Standards Committee (RUESC) – Human Ethics (HE) sub-committee.

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying when the annual report is due.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on the completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloging number allocated.

Sincerely

Prof Roman Tandlich

Chair: Human Ethics sub-committee, RUESC- HE

Appendix B: Approval letter from the Director of Education

REPUBLIC OF NAMIBIA

OSHIKOTO REGIONAL COUNCIL
DIRECTORATE OF EDUCATION,
ARTS AND CULTURE

Tel (065) 281900
Fax (065) 240315
Enq:

Private Bag 2028
ONDANGWA
28 February 2020

Ref: 12/3/10/1

Mr Daniel N. Ngonga
Email: melcledn@gmail.com
Cell: 0812551874

Dear Mr Ngonga

RE: PERMISSION TO CONDUCT RESEARCH IN OSHIKOTO REGION

The Office of the Director acknowledges receipt of your letter, seeking for permission to conduct a research study to investigate how the visual teaching approach can possibly address issues of Mathematics anxiety. Kindly be informed that permission has been granted to carry out the research study, using Okankolo CS as the study site.

It is very important that your research does not interfere with the normal teaching and learning process at school, any participation should be on a voluntary basis and the information to be gathered should be used for research purposes only. Please consult the school principal well in advance to ensure a proper co-ordination of other school activities.

Thank you for showing interest to do the research in the Oshikoto Region. It is our sincere hope that the information you are going to get will be useful towards the completion of your qualification.

Yours faithfully

....

DIRECTOR OF EDUCATION, ARTS AND CULTURE
OSHIKOTO REGION

Appendix C: Approval letter from the Circuit Inspector

REPUBLIC OF NAMIBIA

OSHIKOTO REGIONAL COUNCIL
DIRECTORATE OF EDUCATION
ONYUULAYE CIRCUIT

[redacted]

P/Bag 2028
Ondangwa
02 March 2020

RE: PERMISSION TO CONDUCT RESEARCH AT OKANKOLO COMBINED SCHOOL IN ONYUULAYE CIRCUIT

Dear Mr Ngonga,

Our office acknowledges received your letter dated 27 February 2020, seeking permission from the Inspector of Education to conduct a research at Okankolo CS.
Please be informed that permission is hereby granted.

It is very important that your research does not interfere with the normal teaching and learning at the school. Also take note that any participation in a research by individuals should be voluntary.

Please consult the school board chairperson as well as the school management before you start with your research.

Let me take this opportunity to thank you for showing interest to do research in one of our schools in Onyuulaye circuit. It is my sincere hope that information you will gather, will be useful towards the completion of your studies and qualifications.

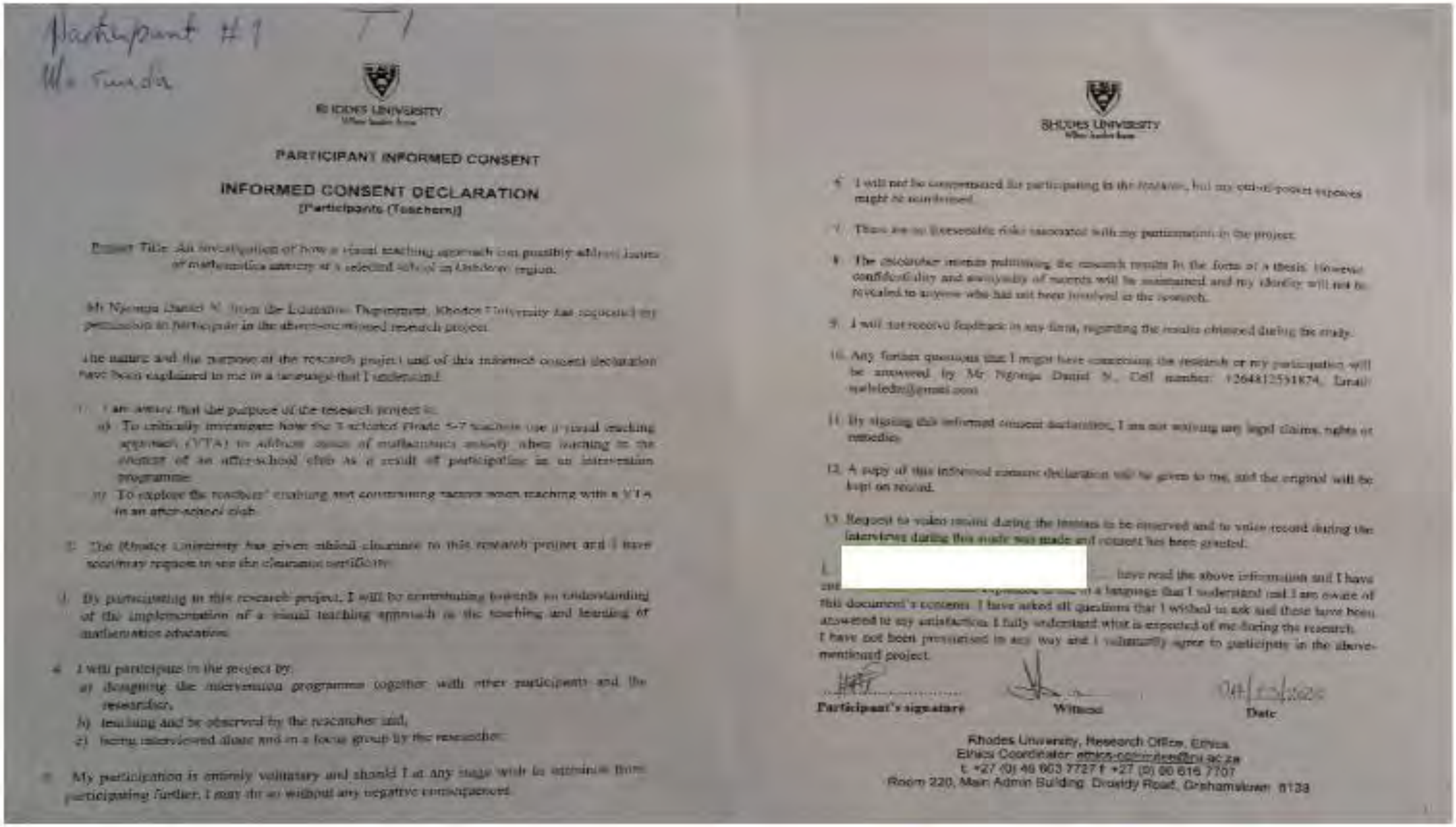
Wish you all best in your studies.

[redacted]

INSPECTOR OF EDUCATION
ONYUULAYE CIRCUIT

Appendix D: Participants' consent letters

(a) Teacher 1



Participant #1 T1
Ms Tuuda

RHODES UNIVERSITY
Where leaders learn

PARTICIPANT INFORMED CONSENT

INFORMED CONSENT DECLARATION
[Participants (Teachers)]

Project Title: An investigation of how a visual teaching approach can possibly address issues of mathematics anxiety at a selected school in Oshikoto region.

Mr Ngonga Daniel N. from the Education Department, Rhodes University has requested my permission to participate in the above-mentioned research project.

The nature and the purpose of the research project and of this informed consent declaration have been explained to me in a language that I understand.

1. I am aware that the purpose of the research project is:
   a) To critically investigate how the 3 selected Grade 5-7 teachers use a visual teaching approach (VTA) to address issues of mathematics anxiety when learning in the context of an after-school club as a result of participating in an intervention programme.
   b) To explore the teachers' enabling and constraining factors when teaching with a VTA in an after-school club.
2. The Rhodes University has given ethical clearance to this research project and I have seen/may request to see the clearance certificate.
3. By participating in this research project, I will be contributing towards an understanding of the implementation of a visual teaching approach in the teaching and learning of mathematics education.
4. I will participate in the project by:
   a) designing the intervention programme together with other participants and the researcher,
   b) teaching and be observed by the researcher and,
   c) being interviewed alone and in a focus group by the researcher.
5. My participation is entirely voluntary and should I at any stage wish to withdraw from participating further, I may do so without any negative consequences.

RHODES UNIVERSITY
Where leaders learn

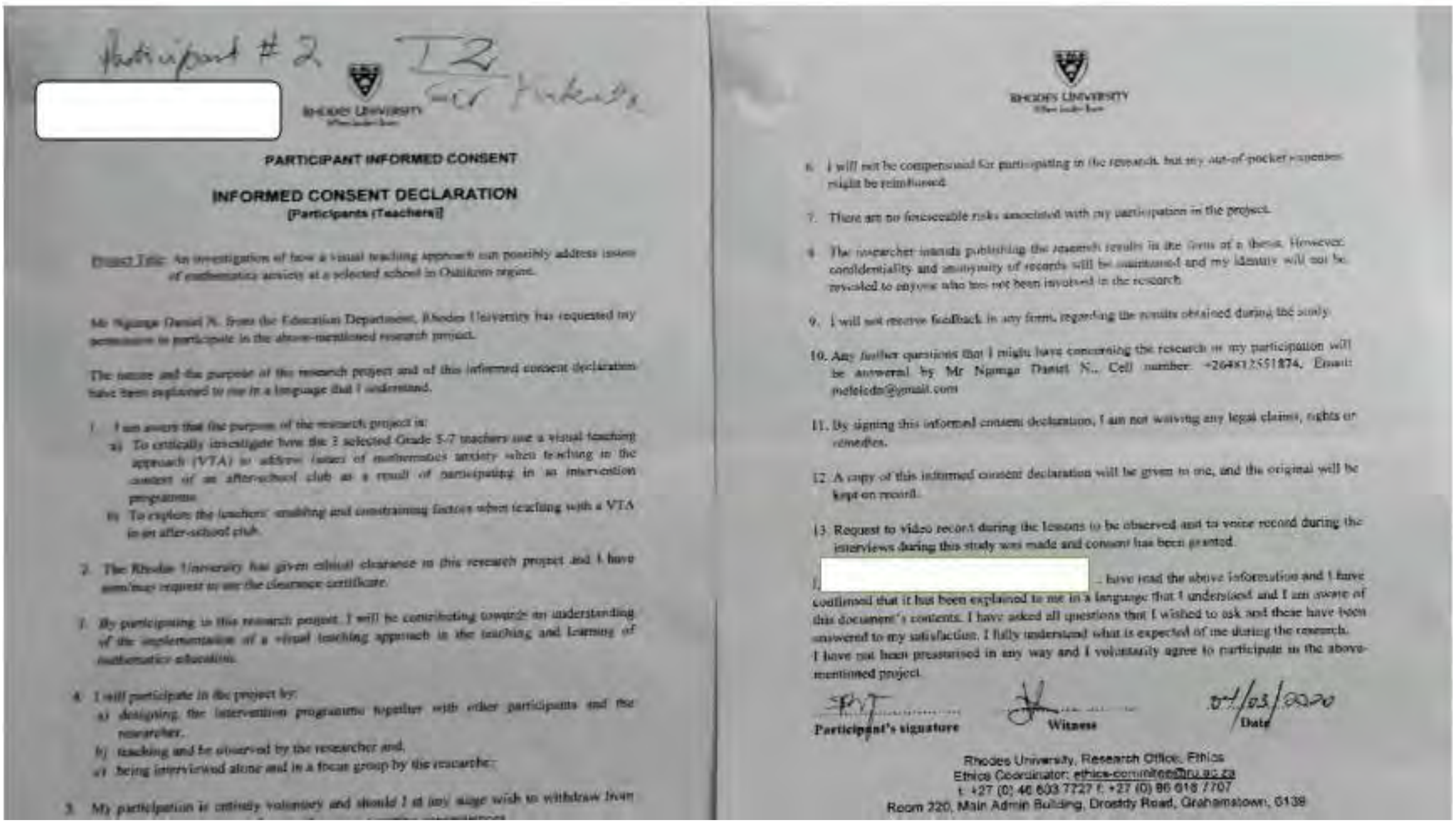
6. I will not be compensated for participating in the research, but my out-of-pocket expenses might be reimbursed.
7. There are no foreseeable risks associated with my participation in the project.
8. The researcher intends publishing the research results in the form of a thesis. However, confidentiality and anonymity of records will be maintained and my identity will not be revealed to anyone who has not been involved in the research.
9. I will not receive feedback in any form, regarding the results obtained during the study.
10. Any further questions that I might have concerning the research or my participation will be answered by Mr Ngonga Daniel N., Cell number: +264812551874, Email: ngelokedn@gmail.com
11. By signing this informed consent declaration, I am not waiving any legal claims, rights or remedies.
12. A copy of this informed consent declaration will be given to me, and the original will be kept on record.
13. Request to video record during the lessons to be observed and to voice record during the interviews during this study was made and consent has been granted.

I, [redacted] ...... have read the above information and I have [redacted] a language that I understand and I am aware of this document's contents. I have asked all questions that I wished to ask and these have been answered to my satisfaction. I fully understand what is expected of me during the research. I have not been pressurised in any way and I voluntarily agree to participate in the above-mentioned project.

Participant's signature | Witness | Date: 04/03/2020

Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-committee@ru.ac.za
t: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707
Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

(b) Teacher 2



Participant # 2 T2

[redacted]

RHODES UNIVERSITY

PARTICIPANT INFORMED CONSENT

INFORMED CONSENT DECLARATION
(Participants (Teachers))

Project Title: An investigation of how a visual teaching approach can possibly address issues of mathematics anxiety at a selected school in Oshikoto region.

Mr Ngwenga Daniel N. from the Education Department, Rhodes University has requested my permission to participate in the above-mentioned research project.

The nature and the purpose of the research project and of this informed consent declaration have been explained to me in a language that I understand.

1. I am aware that the purpose of the research project is:
   a) To critically investigate how the 3 selected Grade 5-7 teachers use a visual teaching approach (VTA) to address issues of mathematics anxiety when teaching in the context of an after-school club as a result of participating in an intervention programme.
   b) To explore the teachers' enabling and constraining factors when teaching with a VTA in an after-school club.
2. The Rhodes University has given ethical clearance to this research project and I have seen/may request to see the clearance certificate.
3. By participating in this research project, I will be contributing towards an understanding of the implementation of a visual teaching approach in the teaching and learning of mathematics education.
4. I will participate in the project by:
   a) designing the intervention programme together with other participants and the researcher,
   b) teaching and be observed by the researcher and,
   c) being interviewed alone and in a focus group by the researcher.
5. My participation is entirely voluntary and should I at any stage wish to withdraw from

RHODES UNIVERSITY

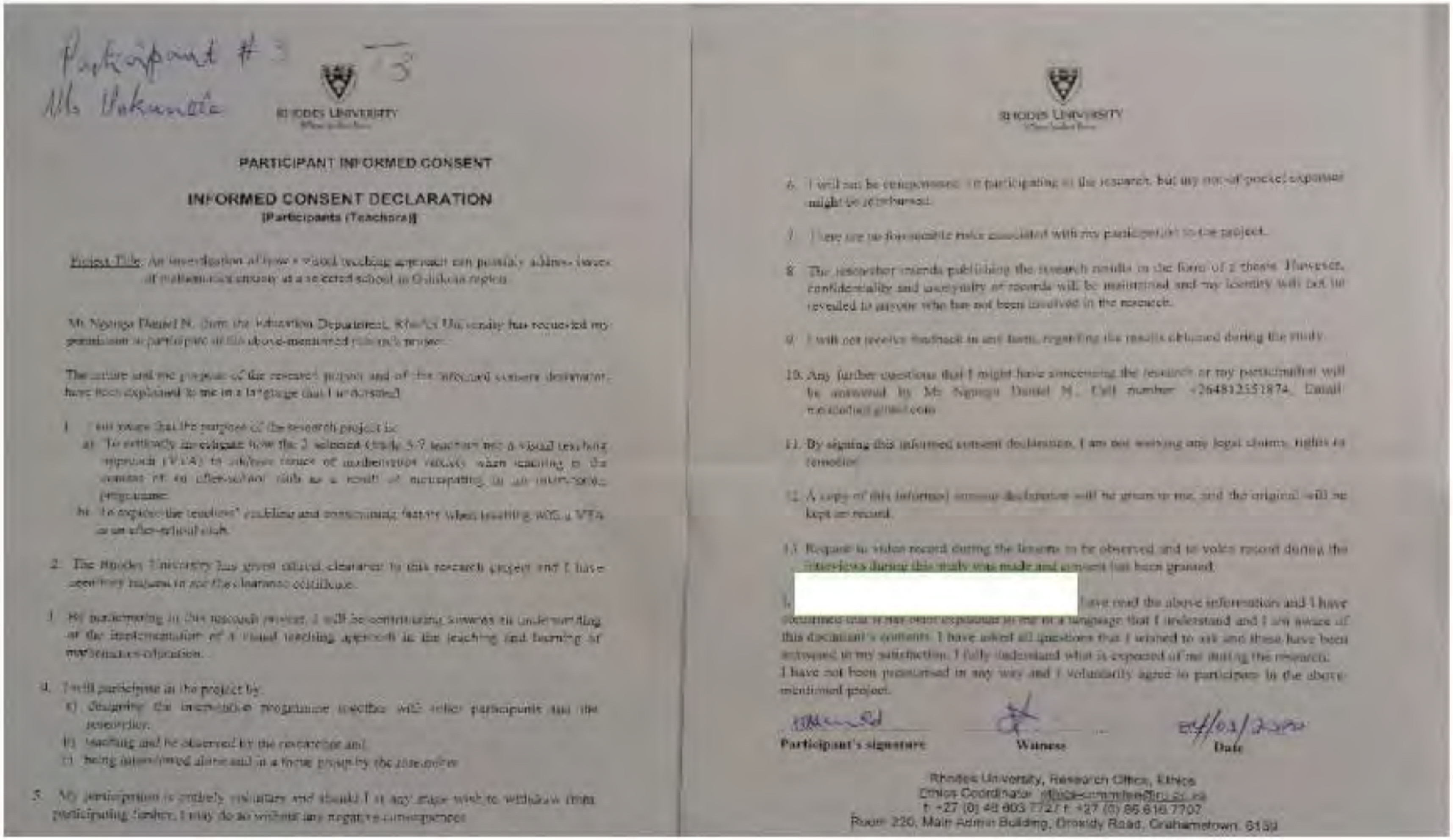
6. I will not be compensated for participating in the research, but my out-of-pocket expenses might be reimbursed.
7. There are no foreseeable risks associated with my participation in the project.
8. The researcher intends publishing the research results in the form of a thesis. However, confidentiality and anonymity of records will be maintained and my identity will not be revealed to anyone who has not been involved in the research.
9. I will not receive feedback in any form, regarding the results obtained during the study.
10. Any further questions that I might have concerning the research or my participation will be answered by Mr Ngwenga Daniel N., Cell number: +264812551874, Email: [illegible]@gmail.com
11. By signing this informed consent declaration, I am not waiving any legal claims, rights or remedies.
12. A copy of this informed consent declaration will be given to me, and the original will be kept on record.
13. Request to video record during the lessons to be observed and to voice record during the interviews during this study was made and consent has been granted.

I, [redacted] have read the above information and I have confirmed that it has been explained to me in a language that I understand and I am aware of this document's contents. I have asked all questions that I wished to ask and these have been answered to my satisfaction. I fully understand what is expected of me during the research. I have not been pressurised in any way and I voluntarily agree to participate in the above-mentioned project.

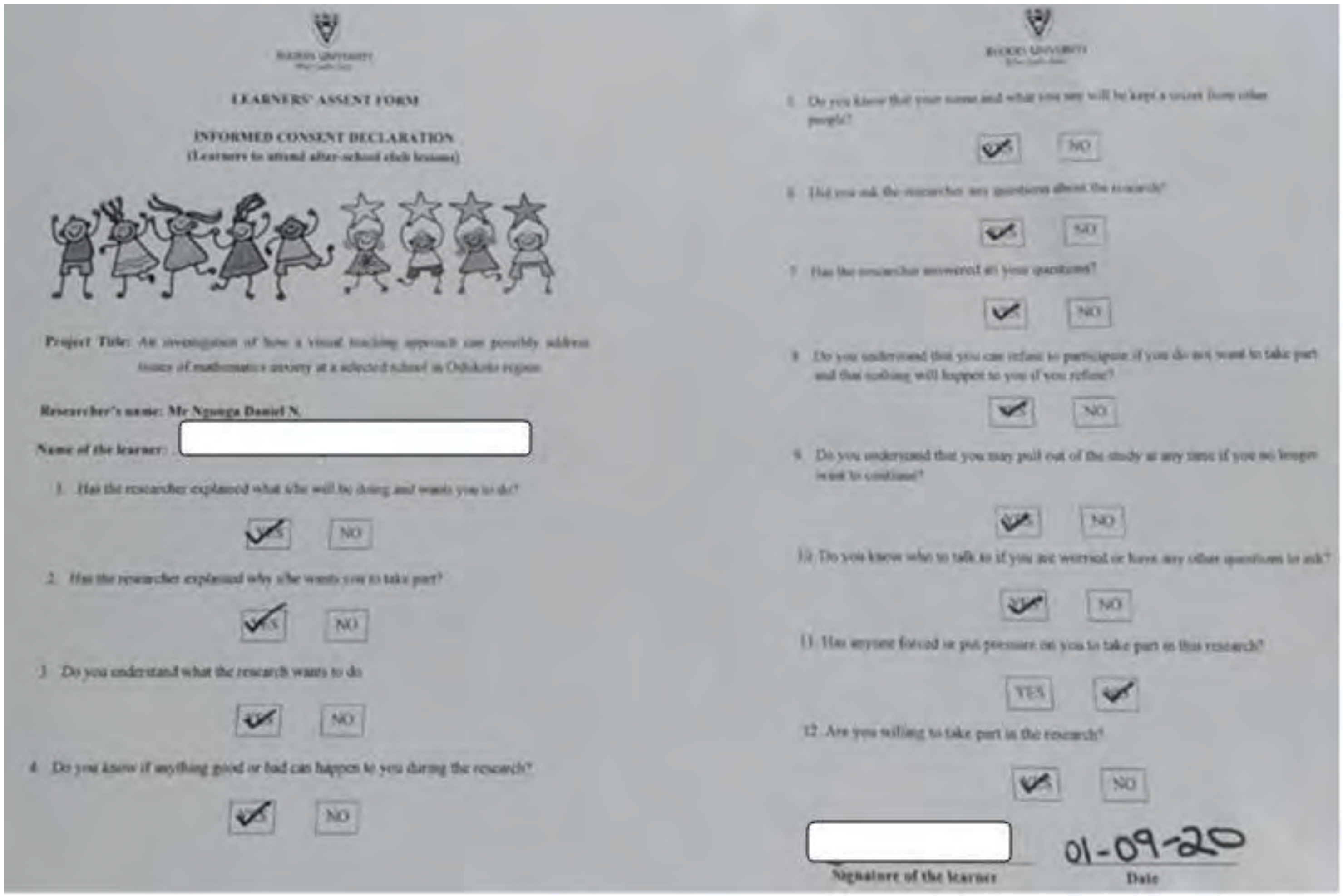
Participant's signature | Witness | 04/03/2020 Date

Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-committee@ru.ac.za
t: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707
Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

(c) Teacher 3


Participant #3
T3
RHODES UNIVERSITY
PARTICIPANT INFORMED CONSENT
INFORMED CONSENT DECLARATION
(Participants (Teachers))
Project Title: An investigation of how a visual teaching approach can possibly address issues of mathematics anxiety at a selected school in [illegible] region
Mr Ngunga Daniel N. from the Education Department, Rhodes University has requested my permission to participate in the above-mentioned research project.
The nature and the purpose of the research project and of the informed consent declaration have been explained to me in a language that I understand.
1. I am aware that the purpose of the research project is:
a) To critically investigate how the 2 selected Grade 5-7 teachers use a visual teaching approach (VTA) to address issues of mathematics anxiety when teaching in the context of an after-school club as a result of participating in an intervention programme.
b) To explore the teachers' enabling and constraining factors when teaching with a VTA in an after-school club.
2. The Rhodes University has given ethical clearance to this research project and I have seen/may request to see the clearance certificate.
3. By participating in this research project, I will be contributing towards an understanding of the implementation of a visual teaching approach in the teaching and learning of mathematics education.
4. I will participate in the project by:
a) designing the intervention programme together with other participants and the researcher;
b) teaching and be observed by the researcher and
c) being interviewed alone and in a focus group by the researcher.
5. My participation is entirely voluntary and should I at any stage wish to withdraw from participating further, I may do so without any negative consequences.
RHODES UNIVERSITY
6. I will not be compensated for participating in the research, but my out-of-pocket expenses might be reimbursed.
7. There are no foreseeable risks associated with my participation in the project.
8. The researcher intends publishing the research results in the form of a thesis. However, confidentiality and anonymity of records will be maintained and my identity will not be revealed to anyone who has not been involved in the research.
9. I will not receive feedback in any form regarding the results obtained during the study.
10. Any further questions that I might have concerning the research or my participation will be answered by Mr Ngunga Daniel N. Cell number: +264812551874. Email: [illegible]
11. By signing this informed consent declaration, I am not waiving any legal claims, rights or remedies.
12. A copy of this informed consent declaration will be given to me, and the original will be kept on record.
13. Request to video record during the lessons to be observed and to voice record during the interviews during this study was made and consent has been granted.
I, [redacted] have read the above information and I have confirmed that it has been explained to me in a language that I understand and I am aware of this document's contents. I have asked all questions that I wished to ask and these have been answered to my satisfaction. I fully understand what is expected of me during the research.
I have not been pressurised in any way and I voluntarily agree to participate in the above-mentioned project.
Participant's signature
Witness
Date
Rhodes University, Research Office, Ethics
Ethics Coordinator [illegible]
t: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707
Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix E: Learners' consent form



LEARNERS' ASSENT FORM

INFORMED CONSENT DECLARATION
(Learners to attend after-school club lessons)

Project Title: An investigation of how a visual teaching approach can possibly address issues of mathematics anxiety at a selected school in Oshikoto region

Researcher's name: Mr Ngunga Daniel N.

Name of the learner:

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

[✓] YES NO

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

[✓] YES NO

3. Do you understand what the research wants to do

[✓] YES NO

4. Do you know if anything good or bad can happen to you during the research?

[✓] YES NO

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

[✓] YES NO

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

[✓] YES NO

7. Has the researcher answered all your questions?

[✓] YES NO

8. Do you understand that you can refuse to participate if you do not want to take part and that nothing will happen to you if you refuse?

[✓] YES NO

9. Do you understand that you may pull out of the study at any time if you no longer want to continue?

[✓] YES NO

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

[✓] YES NO

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

YES [✓] NO

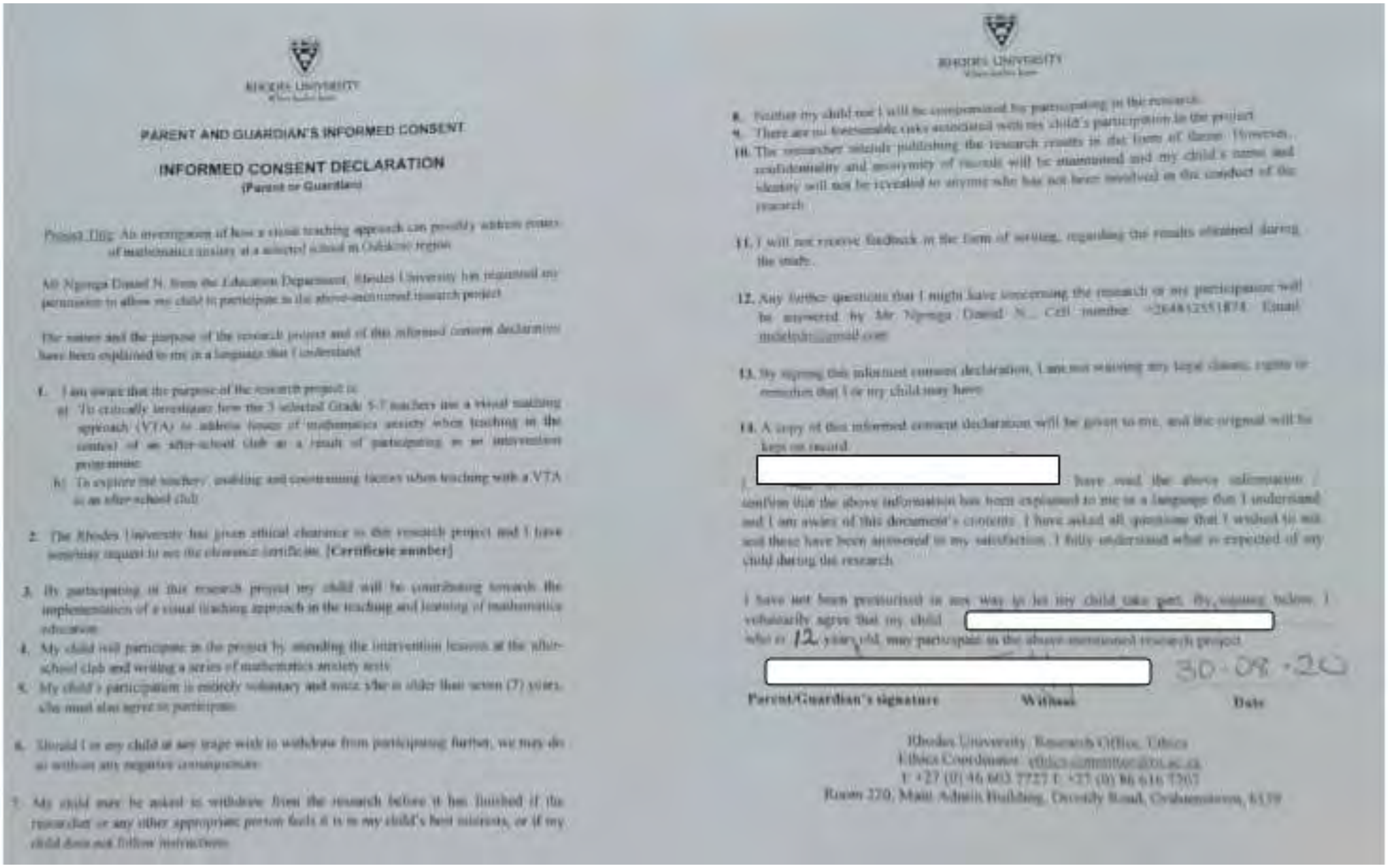
12. Are you willing to take part in the research?

[✓] YES NO

Signature of the learner

01-09-20
Date

Appendix F: Parents' consent letter (a) English version



RHODES UNIVERSITY

PARENT AND GUARDIAN'S INFORMED CONSENT

INFORMED CONSENT DECLARATION

(Parent or Guardian)

Project Title: An investigation of how a visual teaching approach can possibly address issues of mathematics anxiety at a selected school in Oshikoto region

Mr Ngenga Daniel N. from the Education Department, Rhodes University has requested my permission to allow my child to participate in the above-mentioned research project.

The nature and the purpose of the research project and of this informed consent declaration have been explained to me in a language that I understand.

1. I am aware that the purpose of the research project is:
   a) To critically investigate how the 3 selected Grade 5-7 teachers use a visual teaching approach (VTA) to address issues of mathematics anxiety when teaching in the context of an after-school club as a result of participating in an intervention programme.
   b) To explore the teachers' enabling and constraining factors when teaching with a VTA in an after-school club.
2. The Rhodes University has given ethical clearance to this research project and I have [illegible] to see the clearance certificate. **[Certificate number]**
3. By participating in this research project my child will be contributing towards the implementation of a visual teaching approach in the teaching and learning of mathematics education.
4. My child will participate in the project by attending the intervention lessons at the after-school club and writing a series of mathematics anxiety tests.
5. My child's participation is entirely voluntary and since s/he is older than seven (7) years, s/he must also agree to participate.
6. Should I or my child at any stage wish to withdraw from participating further, we may do so without any negative consequences.
7. My child may be asked to withdraw from the research before it has finished if the researcher or any other appropriate person feels it is in my child's best interests, or if my child does not follow instructions.
8. Neither my child nor I will be compensated for participating in the research.
9. There are no foreseeable risks associated with my child's participation in the project.
10. The researcher intends publishing the research results in the form of thesis. However, confidentiality and anonymity of records will be maintained and my child's name and identity will not be revealed to anyone who has not been involved in the conduct of the research.
11. I will not receive feedback in the form of writing, regarding the results obtained during the study.
12. Any further questions that I might have concerning the research or my participation will be answered by Mr Ngenga Daniel N., Cell number [illegible] Email [illegible]
13. By signing this informed consent declaration, I am not waiving any legal claims, rights or remedies that I or my child may have.
14. A copy of this informed consent declaration will be given to me, and the original will be kept on record.

I, [redacted] have read the above information / confirm that the above information has been explained to me in a language that I understand and I am aware of this document's contents. I have asked all questions that I wished to ask and these have been answered to my satisfaction. I fully understand what is expected of my child during the research.

I have not been pressurised in any way to let my child take part. By signing below, I voluntarily agree that my child [redacted] who is 12 years old, may participate in the above-mentioned research project.

[redacted] 30-09-20

Parent/Guardian's signature **Witness** **Date**

Rhodes University, Research Office, Ethics

Ethics Coordinator: [illegible]

Appendix F: Parents' consent letter (b) Oshindonga version

RHODES UNIVERSITY

Ethics Coordinator: ethics-committee@ru.ac.za

t: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707

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

OMBAPILA YEZIMINO
YA TOLOKWA MOSHINDONGA
(OMUVALI / OMUTEKULI)

Oshipalanyolo: ***Ekonaakono lyonkalo gwokulonga tagu yanda uumbanda gwohilongwa shomwaalu moshikandjo shaShikoto***

Daniel N Ngonga, omwilongi gwoshikandjo shelongo mOshiputudhilo sha Rhodes okwa pula epitiko opo okanona kandje ka kuthe ombinga mepekaapeko lyoshipalanyolo sha gandjwa.

Uukwatya ndalakano lye pekaapeko ndho wo ezimino ndika oya fatululwa Molako ndili uvite.

Onda tseya kutya:

1. Elalakano lyepekaapeko ndika olyoku holola ompito yomukalo gwokulonga kwalongi ya 3 moondondo dha 5-7 opo ya longe nomukalo goku yanda uumbanda moshilongwa shomwaalu. Oshilongadhalwa otashika la ko kosima yootundi.
2. Oshiputudhilo sha Rhodes osha gandja epitikilo opo ndi ninge omapekaapeko ngaka. **[Onomola yepitikilo:** 2020-0982-3247**]**
3. Mokukutha ombinga ombinga mepekaapeko ndika okanona kandje otaka kutha wo ombinga melongitho lyo kosima yootundi. Mekuthombinga okanona kandje otakilongo wo omikalo dhopankalathano pamwe nooyakwawo.
4. Okanona kandje otaka kala noku nyola uutumbu wekukonaakona ondjelo yuumbanda moshilongwa shomwaalu.
5. Ekuthombinga lyokanona kandje olili paiyambo nongele okwa oomvula dha adha po heyali (7), otaka pulwa epitiko opo ka kuthe ombinga mepekaapeko.
6. Ngele okanona kandje oka sholola okwa uuthembe woku tinda, ina pulwa / pewa oshilanduli.
7. Ngele okanona kandje oka kala itaka landula omalombwelo nenge ka shololo, otaka vulu oka kuthwa mo monando epekaapeko inali adha ehulilo.
8. Kapuna ofuto kongame nenge kokanona kandje.
9. Iiningwanima ndhika otai vulu okuholoka pethimbo lye pekaapeko.

   a) Onda tseya kutya:
      i) Oshipala shokanona kandje otashi vulika shi kwatwe methano.

   b) Otaku ka kuthwa oonkatu dha landula opo ka yandwe iiningwanima ndhika:
      i) Ethano otali ka tulwa korimo yokanona opo oshipala shako kashiye mo methano.

   c) Ompito yiiningwanima ndhika oya tengenekelwa po 35%

10. Omupekaapeki okuna elalakano lyoku nyanyangidha iizemo yepekaapeko ndika, kakele kiiholekwa itaika etwa pauyelele, omadhina gota nokanona kandje itaga ka holola komantu inakutha ombinga mepekaapeko ndika.
11. Itandika pewa iizemo ngele epekaapeko ndika lya pu.
12. Omapulo nome yelitho kombinga yepekaapeko ndika otaga ka yamukulwa ku Daniel N Ngonga ndelodhno@gmail.com. Onomola yongodhi: +264812551874.
13. Moku Shaina ombapila yepitiko ndjika otaka gandjwa egameno lyopaveta kutya ngame nokanona kandje itatu ka pula ofuto nenge olupandu yekuthoombinga mepekaapeko ndika.
14. Otandi ka pewa okopi yombapila yegameno ndika nombapila yezimino otaitu talw omeepangulilo.

Ngame,........ [redacted] ....ondi lesha nonda gandja ezimimino kweyelele noshikalimo shombapila ndjika ondeshi pewa melaka ndili uvite. Onapulo nda kala ndi na shina sha noshikalimo shika ondega gandja nega yamukulwa ngeke. Ondi na omateyo yaashike shoka sha tegelelwa kokanona kandje.

Ina ndi thiminikwa nando omomukalo gwasha opo ndi pitike okanona kandje ka kuthe ombinga mepekaapeko ndika. Pamukalo gweiyambo, ondi pitika okanona kandje [redacted] ....**(edhina lyokanona)**, hoka kena oomvula ......12......ka kuthe ombinga mepekaapeko ndika.

...[redacted]...   ...30-08-20...

Eshaino-kaha lyomuvali/tekuli **Ombangi** **Esiku**

Rhodes University, Research Office, Ethics

Ethics Coordinator: Siyanda Manqele

ethics-committee@ru.ac.za +27 (0) 46 603 7727 f: +27 (0) 86 616 7707

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

Appendix G: Analytical template A – Skills and observable indicators of a VTA. Adapted from Debes, (1969)

		Coding				
Types of teaching skills	Teachers' activity in the classroom (Observable indicators)	1	2	3	4	Remarks or E.g.
Designing visuals This is the ability to identify visual aids for mathematics and making them available for teaching.	A teacher prepares and designs visual aids to use before the lesson starts.					
	Visual materials used in a class are related to the topic taught.					
	Visual materials look attractive and appeal to the learners.					
	Appropriate materials for a grade level.					
Visual language This skill refers to the teacher's ability to teach the elements of the visual language of mathematics.	Naming and labeling of visuals and concepts					
	The language used is leveled to the grade taught.					
	Spelling and grammar adhered to.					
	The teacher uses body language (gestures) to visualise orders, directions and rules.					
	Learners are allowed to speak, read or write.					
Manipulating visuals The skill refers to how the teacher uses the visuals to explain and interpret the concepts to	Clear explanations of concepts about their visual materials.					
	Visual representations (diagrams or pictures) used in the lesson.					
	Any physical materials (manipulatives) e.g. a					

be taught in the lesson.	box used in the lesson presentation.					
	Any sign of advanced visual style in solving a problem came in a lesson.					
Assessing visuals This skill refers to an ability of a teacher to assess or test if the learners can do tasks visually.	Rough sketching and accurate measuring of diagrams of manipulatives.					
	Labeling and naming of figures/shapes.					
	Identifying appropriate tools to use for a task (e.g. a ruler, a set square and pencil to find the centre of a circle).					
	Visual solutions performed by the learners while doing a task.					

Analytical template B: The coding categories and their descriptions. Adapted from Debes, (1969)

Codes	Categories	Descriptions
1	No evidence	Only 1 or no visuals used or demonstrated
2	Weak evidence	Few visual representations are seen, e.g. 2 incidences
3	Medium evidence	More visuals used up to 3 times
4	Strong evidence	Abundant visuals' use up to 4 times or more and related well to the concepts.

Appendix H: Big and small MA test questions

Big Pre and post-test on learners' MA - Adapted from Ellen, (2006).

Instructions to learners: Indicate how often each statement describes you by circling one of the five terms next to the statement. Do not write the name on your paper, only the grade. Grade: …

Q#	Statement	1 Never	2 Few times	3 Some times	4 Many times	5 Always
1	I feel nervous in mathematics class.	1	2	3	4	5
2	I am shy to go to the chalkboard in mathematics class.	1	2	3	4	5
3	I am afraid to ask questions in mathematics class.	1	2	3	4	5
4	I am worried about being mentioned in mathematics.	1	2	3	4	5
5	I understand mathematics now, but I worry that it will get harder soon.	1	2	3	4	5
6	I develop the feeling of hiding from mathematics class.	1	2	3	4	5
7	I fear mathematics tests more than other subjects.	1	2	3	4	5
8	I don't know how to study for mathematics tests.	1	2	3	4	5
9	It's clear when I am in mathematics class, but when I go home it's like I wasn't in class.	1	2	3	4	5

10	I am afraid that the majority of my classmates are better than me at mathematics.	1	2	3	4	5

Small test on learners' MA - Adapted from Ellen, (2006).

For each statement, circle one number to indicate whether you: 1-strongly disagree, 2-disagree, 3-in the middle, 4-agree, or 5-strongly agree. Just write your grade. Grade: ….

Statement	Coding Scores				
(g) I can handle difficult mathematics.	1	2	3	4	5
(h) Mathematics does not scare me.	1	2	3	4	5
(i) Mathematics is a good subject.	1	2	3	4	5
(j) I wish to carry on with mathematics.	1	2	3	4	5
(k) I think clearly when working with mathematics tasks.	1	2	3	4	5
(l) I am confident to do mathematics.	1	2	3	4	5

Appendix I: Focus group interview questions

1. What are your experiences of teaching in the after-school programme using a visual teaching approach (VTA)?

   …………………………………………………………………………………………

2. Have you detected any differences between your usual teaching approach and a VTA? Elaborate more.

   …………………………………………………………………………………………

3. What impacts do you think a VTA can have on learners' participation and motivation towards mathematics?

   ....

4. Do you think a VTA can reduce learners' mathematics anxiety? Motivate your answer.

   ………………………………………………………………………………………….

5. How could this approach (a VTA) be made a desirable one to all the mathematics teachers?

   …………………………………………………………………………………………

6. Could you please highlight some of the challenges experienced during the intervention programme and how could these be overcome?

   …………………………………………………………………………………………

7. Any other suggestions or comments?

   …………………………………………………………………………………………

Appendix J: Raw data of big pre and post test results

Table 4.3: Big pre and post-tests' tally marks and the number of learners per grade

<table>
<tr><th></th><th></th><th></th><th colspan="6">Pre-test's tallies and # of Ls per grade</th><th colspan="6">Post-tests tallies and # of Ls per grade</th></tr>
<tr><th>Questions in KEY-WORDS</th><th>Grades</th><th></th><th>1 Never</th><th>2 Few times</th><th>3 Some times</th><th>4 Many times</th><th>5 Always</th><th>TOTAL</th><th>1 Never</th><th>2 Few times</th><th>3 Some times</th><th>4 Many times</th><th>5 Always</th><th>TOTAL</th></tr>
<tr><td></td><td>5</td><td>Tally</td><td>|</td><td>||</td><td>||||</td><td>||||</td><td>||||</td><td></td><td>|||</td><td>|||| |</td><td>||||</td><td>||</td><td>||</td><td></td></tr>
<tr><td>1</td><td></td><td>#</td><td>1</td><td>2</td><td>5</td><td>5</td><td>5</td><td>18</td><td>3</td><td>6</td><td>5</td><td>2</td><td>2</td><td>18</td></tr>
<tr><td>Nervousness</td><td>6</td><td>Tally</td><td>|</td><td>|||</td><td>|||| |</td><td>||||</td><td>|||</td><td></td><td>|||</td><td>|||| |</td><td>||||</td><td>|||</td><td>|</td><td></td></tr>
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<tr><td></td><td>7</td><td>Tally</td><td></td><td>||||</td><td>|||| |</td><td>|||</td><td>||||</td><td></td><td>||||</td><td>|||| |</td><td>||||</td><td>||</td><td>|</td><td></td></tr>
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<tr><td></td><td></td><td>Total</td><td>2</td><td>9</td><td>17</td><td>13</td><td>13</td><td>54</td><td>11</td><td>18</td><td>14</td><td>7</td><td>4</td><td>54</td></tr>
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<tr><td>Shyness at the chalkboard</td><td>6</td><td>Tally</td><td></td><td>||</td><td>|||</td><td>卌 |||</td><td>||||</td><td></td><td>||</td><td>||||</td><td>|||| |</td><td>||||</td><td>||</td><td></td></tr>
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<tr><td></td><td>7</td><td>Tally</td><td></td><td>||</td><td>||||</td><td>||||</td><td>|||| |</td><td></td><td>|||</td><td>|||| |</td><td>||||</td><td>|||</td><td>||</td><td></td></tr>
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<tr><td></td><td>5</td><td>Tally</td><td>||</td><td>||</td><td>|||| |</td><td>|||</td><td>||||</td><td></td><td>|||| |</td><td>||||</td><td>||||</td><td>||</td><td>|</td><td></td></tr>
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<tr><td>Afraid to ask</td><td>6</td><td>Tally</td><td></td><td>||</td><td>卌 |||</td><td>||</td><td>|||| |</td><td></td><td>|||</td><td>|||| |</td><td>|||| |</td><td>|</td><td>||</td><td></td></tr>
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<tr><th></th><th></th><th></th><th colspan="6">Pre-test's tallies and # of Ls per grade</th><th colspan="6">Post-tests tallies and # of Ls per grade</th></tr>
<tr><th>Questions in KEY-WORDS</th><th>Grades</th><th></th><th>1
Never</th><th>2
Few times</th><th>3
Some times</th><th>4
Many times</th><th>5
Always</th><th>TOTAL</th><th>1
Never</th><th>2
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Some times</th><th>4
Many times</th><th>5
Always</th><th>TOTAL</th></tr>
<tr><td>questions</td><td></td><td>#</td><td>0</td><td>2</td><td>8</td><td>2</td><td>6</td><td>18</td><td>3</td><td>6</td><td>6</td><td>1</td><td>2</td><td>18</td></tr>
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<tr><td>Afraid of being mentioned in class</td><td>6</td><td>Tally</td><td>|</td><td>|</td><td>𝍸 |||</td><td>||||</td><td>||||</td><td></td><td>||</td><td>||||</td><td>||||</td><td>||</td><td>||||</td><td></td></tr>
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<tr><td>Afraid of mathematics becoming difficult</td><td>6</td><td>Tally</td><td>|</td><td>||</td><td>|||| |</td><td>||||</td><td>||||</td><td></td><td>||</td><td>|</td><td>|||| |</td><td>||||</td><td>||||</td><td></td></tr>
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Few times</th><th>3
Some times</th><th>4
Many times</th><th>5
Always</th><th>TOTAL</th></tr>
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