Critically exploring and understanding grade 3 rural teachers' mathematics content knowledge and coherent teaching in Acornhoek classrooms, Mpumalanga province

A research report presented to the Faculty of

Humanities (Wits School of Education)

By

Kharoon Nisha Rasool

(377836)

Submitted in fulfilment of a degree of

Master of Education by Research Report

UNIVERSITY OF THE WITWATERSRAND

JOHANNESBURG

Supervised by Dr. Thabisile Nkambule

As the candidate’s supervisor, I have approved this dissertation for submission.

Supervisor: Dr Thabisile Nkambule:

TC. nkambule

Date: 15 March 2018

Contents

Declaration

I, Kharoon Nisha Rasool, student number: 377836, declare that, "Critically exploring and understanding grade 3 rural teachers' mathematics content knowledge and coherent teaching in Acornhoek classrooms, Mpumalanga province" is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

Krasool

Kharoon Nisha Rasool

Dedication

To all the rural kids in South Africa, do not allow the difficult circumstances that you live in to affect your goals and vision in life. I am aware of the fact that you have to work harder than most kids to make it, nonetheless, remember, a bright future awaits those who are willing to learn. You are loved.

Acknowledgements

Before mentioning all the people who have influenced me in the completion of this project, I would like to quote from the Quran: “And your Lord says, call upon me: I will respond to you” (Quran, 40:60). This verse has made me realise that as a human I am nothing without the mercy and guidance of the Almighty; never had I imagined that I would come this far in life, but faith has taught me that because the Almighty is ever-present, whatever I ask for, the Almighty makes it possible. I have gained the strength to complete this challenging yet inconceivable project and all thanks be to the Almighty Allah.

To my supervisor, Dr. Thabisile Nkambule, thank you for your guidance and constructive critical feedback during this stressful period. Your belief in my innate ability speaks volumes about your professionalism and even more about your humanity, especially in light of the encouragement that I have received every step of the way.

To my mother, Hawa Bibi Karodia, thank you for keeping me in your prayers and for your words of encouragement whenever we spoke and I found myself complaining about the pressures which I endured during the course of this study.

To my husband, Dalton Grewe, thank you for the support you gave me during this endeavour and being patient with me throughout my craziness. Thank you for being my human encyclopaedia because I really ran to you with every concern that cropped up in my study. I sometimes believe that you know my study better than I do because it’s all that I spoke about for two years of our life.

To my friend, a very talented English educator, Lubhna Mather, thank you for walking with me throughout this journey; you have read and re-read various drafts of this thesis over the past two years and without your suggestions and assistance on various occasions, this thesis would not have been possible. May the Almighty reward you well.

To my family and friends, I thank you all for the words of encouragement during the course of the study.

To my research buddy, Wiseman Hlamulo Mbhiza, I thank you for your valued support throughout this project; you engaged with me in various research discussions, WhatsApp conversations about research, translating and transcribing my data, and through it all you have been a great guide during this Masters's journey. I've learnt so much from you.

To NRF and Whitmore Richards Bursary, thank you for the financial assistance during the course of my study.

To the Mpumalanga Department of Education, without your permission to conduct this study in your region, this study would not have been possible, so thank you.

This study would have been impossible without the invaluable input of the four teachers to whom I am grateful, who willingly decided to participate.

Abstract

This study wanted to critically explore and understand grade 3 rural teachers' mathematics content knowledge and coherent teaching in classrooms in Acornhoek, Mpumalanga province; to gain insight into grade 3 teachers' mathematics content knowledge, the manner in which they teach mathematics and to identify and categorize factors that shape teachers' coherent mathematics teaching. The scarcity of research regarding Foundation Phase 'rural' teacher's mathematics content knowledge and coherent teaching in particular motivated the conceptualisation of the current study (Balfour, Mitchell and Moletsane, 2009).

This study used Mathematics Discourse in Instruction (MDI) by Adler and Ronda (2014), Adler and Ronda (2015), and Venkat and Adler (2012) as the main lens to make sense of the data while concepts from Sfard's (2008) Commognitive theory was used to complement MDI. The theories also allowed me to critically explore grade 3 rural teachers' content knowledge and coherent or incoherent teaching.

The findings pertaining to this study illustrate that when it comes to coherent teaching, huge social injustice is the reality of many rural teachers and learners. Grade 3 rural teachers are given a voice to express their in- and pre-service training in order to help us understand their experiences regarding mathematics Foundation Phase training. Mathematics discourse plays a significant role in the teaching of mathematics; visual representations and teacher talk also play a vital role in identifying whether or not lessons are coherent. A serious injustice is done to learners when teachers do not teach in such a way that enables the correct sequencing and progression of topics from one grade to another.

Abbreviations

APS	Admission Point Score
ATP	Annual Teaching Plan
CAPS	Curriculum and Assessment Policy Statement
CAPS	Curriculum and Assessment Policy Statement
CCK	Common Content Knowledge
CDA	Critical Discourse Analysis
DBE	Department of Basic Education
FP	Foundation Phase
GDP	Gross Domestic Product
MCK	Mathematics Content Knowledge
MDI	Mathematics Discourse in Instruction
MKT	Mathematical Knowledge for Teaching
NECT	National Education Collaboration Trust
NPFTED	National Policy Framework For Teacher Education and Development in South Africa
NSNP	National School Nutrition programme
PCK	Pedagogical Content Knowledge
PLM	Pedagogical Link Making

SACMEQ	Southern Eastern Africa Consortium for Monitoring Educational Quality
TIMMS	Trends in International Maths and Science Study
VSRI	video stimulated recall interviews

Operational definitions of concepts in the study

Concept	Operational Definition
Coherence	This study views coherence in a twofold manner. First, it views coherence in a 'whole' sense and calls it *macro coherence*, as all parts of the lesson fitting together without contradiction. It is the coherence that exists within a 'whole' lesson. Secondly, it views coherence in 'parts' of the lesson and calls it *micro coherence*, as the coherence that exists within 'part/s' of a lesson.
Incoherence	The moment in the lesson where coherence becomes ambiguous and introduces contradictions. Incoherence is also seen when mathematical uncertainty in the structure of the lesson or in parts of the lesson occur.
Concept connection	Concept Connection highlights that in Mathematics, concepts are seen as interrelated; for example multiplication may be seen as repeated addition. Mathematical concepts may share a link to real-life representations, especially in the FP.
Teacher mathematics content knowledge	Teachers' Mathematics content knowledge is the Mathematics content knowledge which a Mathematics teacher should have as it is presumed to be an imperative and mandatory pre-requisite for teachers, to ensure that learners gain conceptual understanding of the Mathematics subject.
Rural	Rural areas as places where the mode of income and production heavily lies on the primary sectors which includes mining, agriculture, livestock, forestry and fisheries. Conversely, various authors argue that rural areas are full of untapped potential waiting to be explored (Balfour, 2012; Demi, Coleman - Jensen

	and Snyder, 2010; Hlalele, 2011; Minnaar, 2006)
Foundation Phase	Foundation Phase spans over four years starting from grade R, ending at grade 3 and includes children from age 6 – 9. The offered subjects are: Home Language, First Additional Language, Mathematics, and Life Skills [Curriculum and Assessment Policy Statement (CAPS) – Foundation Phase]. The subjects provide the building blocks upon which a solid foundation can be built, and as such are key determinants of a child's success.

Chapter 1

Foundation Phase Teachers and Mathematics Teaching

1.1 Introduction

Research illustrates that the quality of primary and secondary mathematics education that students receive can act as a 'social filter', which means lack thereof might limit students' opportunities to develop mathematics knowledge and consequently restrict community development (Aguilar and Zavaleta, 2012). This study focuses on the importance of Foundation Phase (FP) teacher mathematics content knowledge and coherent teaching, as they are essential in laying strong mathematical foundations to ensure effective teaching and learning. The teacher's knowledge of the subject, Pedagogical Content Knowledge, organisation and application of knowledge, beliefs about teaching mathematics and the nature of training are all important in Foundation Phase and play a significant role in shaping teaching practices (Wessels and Steenkamp, 2009; Hill, Ball and Schilling, 2008; North and Zewotir, 2006). Thus, for this study, teachers' mathematical content knowledge is instrumental in the effective enactment in their classrooms, as it directly impacts on their confidence and capacity to teach effectively (Herbert, Vale, Bragg, Loong, and Widjaja, 2015). Therefore, exploring and understanding rural Foundation Phase teachers' mathematical content knowledge and coherent mathematics teaching is important to contribute to the rural place-based information that is identified as a research gap the current Foundation Phase research.

Venkat and Naidoo (2012) in explaining the systematic organisation of mathematical knowledge, states that mathematical concepts are linked and build on each other throughout a child's schooling, addressing the coherence aspect. However, the systematic and coherent building of mathematical concepts depends on the nature of holistic teacher training with the appropriate mathematical subject and content knowledge, to ensure that mathematics concepts are taught effectively, explicitly and coherently. Hill, Ball and Schilling (2008) contend that mathematical knowledge for teaching (MKT) is "… the mathematical knowledge needed to carry out the work of mathematics teaching", and is mandatory for all teachers who teach mathematics, including Foundation Phase teachers. While MKT is required for all teachers, Mathews (2014) is concerned that South African learners struggle to see the interrelatedness of concepts within mathematics, because they do not have a good grasp of coherence between concepts, which highlights issues pertaining to teacher pedagogy. Recently, Human, Van der Walt and Posthuma (2015) observed that, "…no mathematics knowledge and practice standards have as yet been defined for the preparation of Foundation Phase student teachers in South Africa" (p.1), which links with Mathews (2014) concern. Although the observation was done three years ago, it is still relevant in the current study because it communicates the continuous need to conduct research with Foundation Phase teachers in order to have a picture of their mathematical content knowledge and pedagogical knowledge, especially in rural schools, as a research context that has been unpopular for education researchers.

1.2 Background of the study

Locally and internationally, finding and retaining highly qualified teachers is a challenge for all schools, and rural schools are at an extensive disadvantage to attract and employ quality teachers (Smarick, 2014; Nkambule, 2017). Wessels and Nieuwoudt (2010) noted that learners showed higher performance when taught by a specialised mathematics teacher, who also receives continuous professional development in mathematics higher order thinking skills. As mentioned earlier, even though Foundation Phase teachers are not necessarily specialists in mathematics, they are still expected to be well qualified to teach it, as it is one of the prioritised school subjects in the South African education system. Although written earlier and relevant to contextualise the current study, Khuzwayo (2005) noted that the quality of mathematics teaching in Black African schools across South Africa has always been questioned due to poor teacher training that was offered at colleges during the apartheid era. Similarly, Jansen (2004) stated that one of the factors which contribute to learners' poor performances is teachers' deficits in subject knowledge generally, and especially for Foundation Phase teachers in rural schools, therefore highlighting the need for effective intervention of teacher content and pedagogical knowledge.

While continuing subpar learner performances in mathematics seem to suggest on-going challenges with teachers' content knowledge and mathematics pedagogical content, it also proposes the need to intensify research in Foundation Phase, especially with rural teachers, to understand their mathematics content knowledge as well as whether and how they teach mathematics coherently. According to Nkambule, Balfour, Pillay and Moletsane (2011), rurality and rural education is neglected by education researchers, as their research found that 16 years after apartheid this area of research still remained side-lined among scholars and postgraduate education students. Of concern is that since the publication of their article, rurality and rural schools continue to be marginalised, considering little existing research with Foundation Phase teachers. Similarly, international researchers, Arnold, Newman, Gaddy, and Deanal (2005) highlight that the condition of rural education research is poor, hence the need to conduct more quality research in the field. This, according to Nkambule et al., (2011), is problematic because South Africa needs in-depth researchers to pursue this area of research in order to improve the quality of education, especially in the Foundation Phase as one of the significant phases for a child's cognitive and physical development. Considering the dominance of rural primary schools in South Africa in comparison to urban and township schools (Mbatha, 2014), the little interest to research rurality and rural schools, especially researching rural Foundation Phase teachers, is of concern.

This study therefore suggests that more research interest in rural Foundation Phase teaching and learning dynamics need to occur, to understand rural teachers' mathematical content knowledge and pedagogical practices and make a contribution to the existing urban/township research. The current study interacted with four grade 3 rural teachers to understand the nature of their content knowledge, their training, and the manner in which coherent teaching or a lack thereof in mathematics classrooms occurred.

1.3 Problem Statement

The following question was posed by the minister of native affairs, Dr. Hendrick Verwoerd, during apartheid, "What is the use of teaching a Bantu child mathematics when it cannot use it in practice?” (Fiske and Ladd, 2006, p.1). This powerful question influenced the under-training of previously disadvantaged mathematics teachers in teachers’ colleges, especially primary school teachers. The apartheid era enforced a racially segregated teacher-education system which entailed teachers being trained to produce a particular product to fulfil the then government’s plans. The training ensured that the Black African teacher only focused on teaching practical subjects for manual and menial labour, consequently, they lacked conceptual knowledge and understanding of mathematics and science (Van Der Berg, Burger, Burger, De Vos, Ou Rand, Gustafsson, Moses, Shepard, Spaull, Taylor, Van Broekhuizen, Von Fintel, 2011). The consequences of the above-mentioned apartheid ideology is inconceivable and unknown, as Naidoo (2005) noted that little details are known about ‘what’ and ‘how’ mathematics was taught and learnt by teachers in training colleges. In relation to the current study, Fiske and Ladd (2006) stated that as of 1994 more than one in three teachers in rural and farm areas throughout the country were under-qualified, lacking matriculation and the additional three years of training. Although it is not stated whether this was in primary or secondary schools, it is problematic that some of these concerns, in particular for rural and farm primary school mathematics teachers, are still mentioned 24 years after democracy.

If the poor mathematics results which shows South African learners position 12th in mathematics out of 15 African countries in the SACMEQ study (Van Der Berg, et, al, 2011) are seriously considered, it suggests continuous mathematics challenges nationally, with extreme challenges in rural schools due to the high number of under-trained teachers. This discussion also raises questions about the nature of Foundation Phase teachers’ training, as authors indicate that many of the Foundation Phase lecturers in colleges were not adequately qualified for employment in higher education when the Ministry of Education incorporated colleges to higher education institutions (Green, 2011; Parker, 2008 in Hoadley, 2010). Alarmingly, Foundation Phase teacher education continued with reduced capacity, suggesting that the adequate training of Foundation Phase teachers was side-lined at university level (Green et al., 2011; Organisation for Economic Cooperation and Development (OECD), 2008). Thus, building solid Foundation Phase departments were constrained at universities, and the effects are apparent in the country's poor mathematics results (Spaull, 2013). Surprisingly and also disturbingly, Hoadley and Ensor (2009) stated that universities claimed lack of enough time to cover mathematics for Foundation Phase in great detail, due to time constraints and curriculum overload. Considering the importance of having quality foundations in mathematics, teachers need to be able to build strong mathematical foundational skills and it is alarming that some universities lack in-depth training courses for Foundation Phase teachers, especially in mathematics for this study. The study acknowledges that the above-mentioned studies are relatively old, and currently different South African universities are strengthening the quality of training for Foundation Phase teachers.

1.4 Rationale of the study

A study done by Venkat and Adler, (2012, p.6) focused on teachers' explanations which they termed 'Mathematical Discourse in Instruction'(MDI) and found that of the four episodes of teaching, only one episode was coherent and connected. This means that some teachers do not teach mathematics in a coherent connected manner, which might negatively affect learners' conceptual understanding. Mathews (2014) draws attention to the disconnections between steps in a teacher's explanation of division, possibly addressing lack of a teacher's concept connection and awareness during lessons. Mhlolo, Venkat, and Schäfer (2012) critique the way in which teachers create opportunities for learning, in order to attain cognitive demand of mathematical connections to use in problem-solving situations. These studies indicate a desperate call for coherent teaching to enable effective learning, and also continuous research with Foundation Phase teachers to understand their teaching approaches of mathematics. In addition, the studies place emphasis on 'instructional coherence' and 'incoherence', and its effects on learners' understanding, or lack thereof, of mathematics. Without overlooking the importance of these studies, there is a research gap about the nature of rural Foundation Phase teachers' mathematical content knowledge and whether and how they teach mathematics coherently. It is the purpose of the current study to critically explore and understand grade 3 rural teachers' mathematical content knowledge and the nature of coherent teaching in mathematics lessons. Given this, it is important to define coherence and incoherence as this study views it. This study views *'coherence'* in a twofold manner. First, it views coherence in a 'whole' sense and calls it *macro coherence*, as all parts of the lesson fitting together without contradiction. It is the coherence that exists within a 'whole' lesson. Secondly, it views coherence in 'parts' of the lesson and calls it *micro coherence*, as the coherence that exists within 'part/s' of a lesson. This study views *'incoherence'* as the moment in the lesson where coherence becomes ambiguous and introduces contradictions. Incoherence is also seen when mathematical uncertainty in the structure of the lesson or in parts of the lesson occur.

After five years of experience as a high school Technika (Mechanical Technology and Electrical Technology) teacher, and having witnessed and read about the poor performance of learners in different national and international mathematics high stakes assessments, I began to question whether the problem was due to inadequate teacher content knowledge and pedagogical practices in the classrooms. The interrogation resulted in the conception of the current study, as I continued asking myself whether the problem is with Further Education and Training (FET), Intermediate and Senior Phase, or Foundation Phase teachers. I decided to focus the study with Foundation Phase teachers with the assumption that the phase plays a significant role in laying strong foundations for understanding mathematical concepts, rules and skills. However, since the Foundation Phase plays an essential role in introducing and, in a way, instilling positive attitudes towards mathematics, I decided to conduct my study with grade 3 rural teachers to gain insight on their mathematics content knowledge and the teaching approach to mathematics coherence during lessons.

1.5 Purpose of the study

- To critically explore the nature of grade 3 rural teachers' mathematics content knowledge.
- To examine whether and how coherence occurs while teaching mathematics lessons.
- To interrogate factors that shape teachers' teaching of mathematics concepts coherently.

1.6 Objectives of the study

- To gain insight of grade 3 teachers' mathematics content knowledge.
- To understand teachers' teaching of mathematics concepts coherently.
- To identify and critically analyse factors that shape teachers' coherent mathematics teaching.

1.7 Main Research Question for the study

To what extent are grade 3 rural teachers teaching mathematics lessons coherently?

1.7.1 Sub questions for the study

- What mathematics content knowledge do grade 3 teachers portray?
- How do grade 3 teachers teach mathematics lessons coherently?
- What factors shape teachers' approaches when teaching mathematics?

1.8 Significance of the study

Given the little existing research with Foundation Phase teachers in rural Mpumalanga province, this study is significant to understand the nature of grade 3 mathematics teachers' content knowledge, training, and coherent teaching, in mathematics classrooms. The current study will contribute with place-based information to the existing mathematical teachers' research knowledge that has been dominantly conducted in urban/township schools. Considering the unpopularity of rural education research, the current study presents different grade 3 teachers' experiences and teaching practices of mathematical topics, concepts and lessons in relation to the teaching experiences and existing mathematical content knowledge. Thus, the current information about grade 3 rural teachers' experiences of teaching mathematics and their nature of content knowledge in the Foundation Phase will inform policy and teacher education programs about the reality in rural classrooms.

1.9 Chapter summary

This chapter highlighted the focus of the study and illustrated that due to the low mathematics results, the quality of South African rural education is questionable (Fiske and Ladd, 2006). The importance of getting the basics right in mathematics within Foundation Phase classrooms is emphasised, since solid foundations or lack thereof affect learning, process and progression in other phases. Thus, serious considerations need to be taken into account when training Foundation Phase teachers, especially for mathematics content knowledge, explicitly foregrounding the importance of coherent teaching to develop learners' mathematics higher order thinking skills (Hill et al., 2008). Rurality and rural education were marginalized during apartheid and continue to be disadvantaged in the post-apartheid era, as education research has popularized urban and township contexts, a concern for social justice and redressing the past inequalities (Nkambule et al., 2011; Maringe, Masinire and Nkambule, 2014).

Chapter 2

The significance of coherent teaching in Foundation Phase mathematics classrooms: a review of literature

2.1 Introduction

South Africa spends almost 20% of the GDP (Gross Domestic Product) for the education sector; however poor performance in mathematics continues to be a challenge from primary to secondary schools (Fleisch, 2008). In particular, learners' mathematical competencies and performances are of concern, as Siyepu (2013) noted that they are below curriculum specifications. The competencies specified in the curriculum are: "high knowledge and high skills - the minimum standards of knowledge and skills to be achieved at each grade are specified and set high ……" (Curriculum and Assessment Policy Statement (CAPS), 2011, p. 9). Given the above information, it is important that mathematics concepts are explicitly introduced and properly taught in the Foundation Phase, so that learners gain the required competencies and perform well to fulfil the requirements set by CAPS. When teachers clearly make strong coherent links between mathematics concepts in early ages of schooling, it may develop mathematics higher order thinking skills as learners will recognise concepts relation. This study views concept relation as the way in which two or more concepts are connected, where one concept has an effect or relevance to another concept and views continuation as the action of a concept being built upon over time as learners progress to different grades.

Thus, this chapter critically reviews literature on the establishment and importance of Foundation Phase in South Africa, especially the teaching of mathematics topics in relation to teachers' content knowledge in rural schools. Rurality and rural education form a significant aspect of this study, as the context is seen as more than just the place where the study is conducted but rather as having an immense impact on teaching and learning mathematics in Foundation Phase classrooms (Balfour, Mitchell and Moletsane, 2009). The literature that addresses the importance of teacher mathematics content knowledge and Pedagogical Content Knowledge will also be discussed critically, because lack thereof influences learners' conceptual understanding of mathematics directly or indirectly.

2.2 The establishment and importance of Foundation Phase in South African education

During the apartheid era teachers were trained as 'junior' or 'lower' primary specialists in teachers' colleges, and the current Foundation Phase was also called 'junior' or 'lower' primary or just the 'grades' (Sayed, 2004). The grades also had different names, for example, Grade one was known as Sub A, Grade 2 was known as sub B and Standard one was the beginning of the next grade and part of the junior primary in government schools (Van Der Berg, et.al, 2011). Within this phase of learning and due to the segregated education system during apartheid, white learners were drilled with well-designed reading, writing and arithmetic by well-trained teachers (Fiske and Ladd, 2006). On the other hand, black (coloured, Indian and black African) learners received Bantu Education and were drilled with basic, watered down reading, writing and arithmetic by teachers that were unqualified and/or under qualified (Fiske and Ladd, 2006). The training of Black African lower primary teachers in mathematics (arithmetic) was non-existent, because it was not necessarily prioritised by the apartheid government due to their ideology (Thembela, 1986 and Khuzwayo, 2005). Given the above, it can be argued that solid foundations in reading, writing and arithmetic were not well built for black learners as they received a diluted curriculum. It is because of the under preparedness of teachers in Foundation Phase that the post-apartheid government prioritised the strengthening of training for Foundation Phase teachers, especially in mathematics.

The democratic government introduced a reform curriculum called Curriculum 2005, and was implemented in 1998 starting in Grade one. The political change and curriculum reform brought the birth of the official 'Foundation Phase' (Gr. 1-3) (Mouton, Louw and Strydom, 2012). The offered subjects are: home language, first additional language, mathematics, and life skills [Curriculum and Assessment Policy Statement (CAPS, 2011) – Foundation Phase]. The subjects provide the building blocks upon which a solid foundation can be built in the intermediate, senior and further education training (FET) phase, especially for mathematics, and as such play a significant role in shaping a child's engagement, understanding and success. In mathematics, as the focus of the current study, five content areas are covered in Foundation Phase, which are numbers; operations and relationships; patterns, functions and algebra; space and shape; and measurement (CAPS, 2011), and each content area contributes to the development and acquisition of specific skills. These areas are not stand alone but directly shape the development and understanding of mathematical concepts to be learnt in higher grades. An example would be, if a child does not understand the 'basic operations' and the 'concept of what a number is', the child could struggle to work on algebra. In the Foundation Phase they learn about space and shape, which eventually affect their understanding of geometry in higher grades.

Thus, this phase is of great importance for learning because during the early years of development, children exhibit the utmost ability to learn and develop an understanding of the relationships between different concepts, depending on the teacher and pedagogical approaches (Hiebert, 1984). Given the importance of this phase, the shortage of well-trained Foundation Phase (FP) teachers in South Africa, especially in rural and farm areas is of concern, as well as the appropriate opportunities to be properly trained (DoE, 2001). One of the existing responses to this challenge is a government research initiative aimed at strengthening the capacity of the Higher Education System to provide more and better Foundation Phase teachers (Dixon, Excell and Linington, 2014). Thus, the government identified the importance of having quality teachers with appropriate knowledge about curriculum and content, and also knowledge about the Foundation Phase child. This is crucial, especially with regard to knowledge about what can be expected from a child in terms of their reasoning, morality and subject-knowledge acquisition (Murris and Verbeek, 2014).

2.3 The significance of Foundation Phase mathematics teachers

In the South African context, it was realized that a contributing factor in ensuring quality education was the need to train and produce quality Foundation Phase teachers (Green, 2011). Notwithstanding this importance, there have been concerns with some teacher's challenges with mathematics content knowledge from primary to secondary school (Mji and Makgato, 2006; Venkat and Spaull, 2015 and Setati

2005). Given that grade 3 teachers are expected to consolidate mathematics knowledge from previous grades and prepare learners for the following grades, it is crucial to understand the state of their mathematics content knowledge and mathematics pedagogical practices. Ma (1999) argues that the best teachers should be recruited for Foundation Phase, because basic knowledge needs to be taught appropriately to ensure that children build further knowledge from the strong existing knowledge. For this study, this also means that well trained and qualified mathematics teachers are important to teach in this phase, to build appropriate mathematical knowledge and skills to enhance mathematical understanding of concepts, and the way in which they relate to each other and show continuity. It is therefore essential that teachers understand the significance of teaching mathematics lessons coherently, so that learners see relativity and continuousness and enhance mathematics appreciation.

To reiterate this point, Zokufa (2013) conducted research in the Western Cape with grade 3 mathematics classrooms and observed 15 lessons, and argued that some teachers do not have the required knowledge and skills to put topics or sub-topics taught over a period of time or within a lesson together into a coherent sequence. While this is unfortunate, it highlights the importance of ensuring that Foundation Phase teachers have appropriate mathematical content knowledge to effectively and efficiently teach mathematics topics coherently. In addition, considering that the study was done in a township area and is also relatively recent, it is stimulating to explore the nature of mathematics teaching in grade 3 rural contexts in relation to teachers' content knowledge. Considering the importance of seeing concepts as connected when building quality foundations in the mathematics subject (Attorps, 2006), it is unclear whether and how Foundation Phase teachers, in particular rural grade 3 for this study, are enacting it in classrooms, hence, the importance of this study.

2.4 Studies on coherent teaching

In defining coherence, this study highlights that it should not be seen as ideal or in a vacuum, but acknowledges the complexity in identifying coherent mathematics teaching. Various factors affect coherent mathematics lessons and the manner in which teachers link mathematics concepts, if at all, such as: teacher's mathematics content knowledge, the use of the textbook, language barriers, poverty, visual mediators and the learners (Niss, 2003; Williams,2008; Askew, Venkat, and Mathews, 2012); Venkat, and Adler 2012). Nonetheless, as mentioned in chapter one, this study views *'coherence'* in a twofold manner. First, it views coherence in a 'whole' sense and calls it *macro coherence*, as all parts of the lesson fitting together without contradiction. It is the coherence that exists within a 'whole' lesson - from the beginning until the end of the lesson, that is, from the lesson topic, to the examples, tasks, teacher talk and teacher and learner interaction, making use of mathematics discourse in instruction (MDI) (Adler and Ronda, 2014; Adler and Ronda, 2015; and Venkat and Adler, 2012). Macro coherence is vital in a FP mathematics lesson, because it provides learners with opportunities to gain mathematics relational and continuous understanding from the beginning to the end of the lesson. Secondly, it views coherence in 'parts' of the lesson and calls it *micro coherence*, as the coherence that exists within 'part/s' of a lesson. For example, coherence may exist between the teacher's example and the teacher talk, but the lesson activity may cause incoherence because it doesn't fit in well with the whole lesson. This study also looks at incidences where *incoherence* occurs and views at it as the moment in the lesson where coherence becomes ambiguous and introduces contradictions. Incoherence is also seen when mathematical uncertainty in the structure of the lesson or in parts of the lesson occur and learner understanding is hampered. This may be due to a teacher teaching the learners content that is mathematically incorrect, for example, if a teacher is teaching a lesson on 'place value', and instead of using hundreds, tens and unit cards to indicate place value only uses unit builder cards to teach the concept of place value (builder cards are used to help learners understand the concept of place value). This may hamper learner understanding and also cause incoherence in mathematics understanding regarding the concept of place value.

This study examines micro and macro coherences within lessons and also incoherencies within lessons. This study uses MDI and Sfard's (2007) concepts from commognition theory, discussed in chapter three, to describe and analyse the nature of coherencies or incoherencies in lessons and the reason for this choice is because coherence exists in mathematics discourse.

Various positions on coherence exist: coherence may be seen from one term to the next and across the years of a child's schooling, it may also occur from one lesson to the next lesson, and also within a single lesson (Venkat and Naidoo, 2012). Due to limited time constraints, this study does not engage with coherence between lessons, from one term to another, or one year to another, instead it focuses on the coherence within a lesson. Therefore, this study looks at a single lesson in-depth and identies the teaching from the introduction, teacher talk, visual representation, examples, learner tasks etc. and then deduces the coherence/incoherence present within the lesson.

Concept connection highlights that in mathematics concepts are seen as interrelated, for example, multiplication may be seen as repeated addition, and mathematical concepts may also share a link to real life representations, especially in FP. The CAPS mathematics illustrates the way in which sequencing and progression of topics should be done from one level to the next, starting from grade 1 level up until grade 3 level, which proves the importance of coherence in the CAPS curriculum (Department of Basic education, CAPS, 2011, p.36-37). While this is the case, it does not to specifically emphasise the importance of teachers making explicit connections between mathematical concepts to learners across grades and within a grade. The assumption could be that teachers are expected to connect mathematical concepts coherently, even if it is not explicit in the CAPS policy document, because the nature of mathematics requires such an approach. Dossey, Giordano, Mc Crone and Weir, (2002) talk about the necessity of understanding mathematics as connections, and claim that a learner who is able to connect different mathematical concepts is more likely to cultivate a deeper mathematical understanding. They suggest that highlighting the connection of concepts during the teaching of mathematics helps learners to build stronger basis for continuous learning. Dossey,et al. (2002) highlights the importance of making connections between and within mathematical concepts, which emphasises that concepts embedded in the subject of mathematics share connections amongst other concepts.

This also means that if students are incapable of making mathematical connections, their mathematical understanding will be limited (Dossey, et al., 2002). In addition, Venkat and Adler (2012); Venkat and Naidoo (2012) and Mathews (2014), focus on lesson structures and events within and across lessons, as well as the coherent connectedness of concepts within a topic to understand ‘instructional coherence’. They suggest that a serious lack of instructional coherence exists in South African classrooms, and illustrate that the absence causes gaps between what learners already know and what they are currently exposed to. In addition, Naidoo and Green (2011) suggest that to counteract the problem of lack of coherent concept connections, mathametics teachers should use different techniques of effective repetition such as: recaps, reviews or questions explicitly throughout a lesson, to assist learners to make coherent connections and make the learning experience meaningful to learners.

Internationally, a study done by Cai, Ding and Wang (2013) found a direct relationship between East Asian students’ coherent instruction and their excellent mathematics performance. In addition, their study with Chinese and United States mathematics teachers found that teachers in America paid attention to connections between teaching activities, topics or lessons, while Chinese teachers emphasised the interconnected nature of mathematical knowledge beyond what occurred in the teaching of a specific lesson (Cai, Ding and Wang, 2013). Thus, if a teacher has adequate content knowledge beyond the lesson being taught, they will be able to identify the connections between mathematical concepts and effectively show learners the links to effectively engage with challenging mathematical problems and questions (Ball, Thames and Phelps, 2008 and Cai, Ding and Wang 2013). Pedagogical knowledge is crucial in ensuring that a teacher is able to present appropriate understandable knowledge to learners through suitable teaching methods (Heaton, 1992), which also depends on teacher’s mathematical content knowledge. Unfortunately, due to little research on rural foundation teacher’s content knowledge and coherent teaching of mathematics, as mentioned earlier, it is unclear how coherent mathematics is taught in grade 3.

Cai et al, (2013) also emphasise that when teachers overestimate learners abilities to make coherent connections from the previous lesson or within a lesson in mathematics, the learning process could fail. This might be shaped by a teacher’s assumption that learners are able to make adequate connections during the learning process, when none has possibly happened. Cai et al, (2013) further illustrate the importance of coherent connections being made explicit from a pedagogical perspective, which means teachers should be consciously reflective while teaching to identify any incoherencies. As mentioned earlier in chapter one, research on rural grade 3 teachers' mathematical coherent teaching is lacking, which makes the current study significant. This study intends to bridge this research gap by interacting with teachers to gain insight into their coherent mathematics teaching in rural classrooms.

2.5 Teachers' mathematics content and pedagogical knowledge

Content knowledge is presumed to be an imperative and mandatory pre-requisite for teachers, to ensure that learners gain conceptual understanding of any school subject. Research studies (Hill, Blunk, Charalambous, Lewis, Phelps, Sleep, and Ball, 2008; Heaton, 1992) suggest a direct link between teacher's content knowledge and learner performance, because teachers with a stronger content knowledge are more likely to respond to learner's mathematical questions and concerns adequately. In addition, regarding mathematics content knowledge, this study argues that teachers may gain knowledge overtime during in-service training programme experiences, but it is the responsibility of the teacher to apply the content after workshops. This means teacher knowledge is not automatically developed over time; rather teachers need to consciously develop their knowledge over time. In South Africa, there is a crisis in the level of acceptable teacher mathematical content knowledge in general, and particularly in primary schools holistically, resulting to poor learner mathematics results (Fiske and Ladd, 2006). If this is the case, it is questionable whether and how teachers contribute effectively to learners' conceptual understanding or lack thereof in mathematics. Hiebert (1984) defines conceptual knowledge as "knowledge that is rich in relationships … a network in which the linking relationships are as prominent as the discrete pieces of information" (pp. 3-4, cited in Simon, 2006). Thus, teacher's mathematics conceptual understanding is important, to effectively and explicitly connect mathematical topics, concepts and instruction coherently for learners.

Shulman (1987) identified Pedagogical Content Knowledge (PCK) as one of the most important knowledge bases that teachers should possess in order to teach effectively. He highlighted that having knowledge of the subject matter is not enough to teach it, it is also important that teachers possess Pedagogical Content

Knowledge as well. Pedagogical Content Knowledge (PCK) is a notion rooted in the belief that teaching entails substantially more than delivering subject content knowledge to learners; it is also teaching content in ways that lead to enriched learner understanding (Loughran, 2010). Mishra and Koehler (2006) see Pedagogical Content Knowledge as the knowledge which "involves knowledge of teaching strategies that incorporate appropriate conceptual representations in order to address learner difficulties and misconceptions and to foster meaningful understanding" (p.1027). The knowledge of teaching (PCK) consists of knowing how to prepare for instruction, and of mastering the different modes of delivering instruction. Such knowledge also includes the knowledge of how mathematical topics are connected (Brent and Simmt, 2006). This notion of PCK is essential for this study as FP teachers need to be able to use various modes of representation effectively and appropriately, to show learners that mathematics requires a conceptual understanding where topics are seen in relation to other topics and this requires coherent teaching instruction.

Hashweh (2005) further states that it is evident that PCK should be possessed by all teachers, irrespective of learners' age and/or the school's context. However, one cannot overlook the fact that PCK is not the same for all teachers of a specific content area, due to different training, beliefs and knowledge of the learner, and contextual and personal factors that influence the development or lack thereof of teaching experience (Ball and Bass, 2000).Therefore, the importance for this study to understand teachers' training backgrounds and their contextual factors as they affect the effective delivery of mathematics content.

2.6 Rurality and rural education

Regarding the definition of rural, various authors have noted that defining 'rural' is a difficult task, because different countries have different perceptions of what rurality means (Atchoarena and Gasperini, 2003; Stelmach, 2011; Cloke, 2006). In an effort to better capture the concept of rurality (the state of being rural), Atchoarena and Gasperini (2003) used a multi-criteria approach and defined rural areas as places where the mode of income and production heavily lies on the primary sectors which includes mining, agriculture, livestock, forestry and fisheries. This definition is relevant in South Africa because rural areas engage in primary sector activities, which means that the economic activities that rural communities provide for South Africa are very important. However, this important role seems to be overlooked as rural areas are still conceived as places of deprivation and exclusion from urban progressive ways of life (Moletsane, 2012), irrespective of the economic role that it plays. Educationally, the problem that arises for rural schools is that if they continue to be viewed in a negative and degrading way, the education system might be looked down upon making it challenging to attract teachers, especially newly qualified teachers to teach in such areas (Balfour, Mitchell and Moletsane, 2009; De Lange, Khau and Athiemoolam, 2014; Masinire, 2015 and Nkambule, 2017)

On a positive note, various authors argue that rural areas are full of untapped potential waiting to be explored (Balfour, 2012; Demi, Coleman - Jensen and Snyder, 2010; Hlalele, 2011; Minnaar, 2006), a reason for doing the study and interacting with grade 3 teachers to access the untapped information about mathematics teaching in relation to the nature of content knowledge. While international literature advocates for the importance of making curriculum relevant for children in rural communities (Wright, 2003 in Stelmach, 2011; Walker, 2000), in South Africa curriculum policies and practices assume that teachers implement curriculum policies appropriately attending to the needs of rural contexts. The assumption is possibly influenced by inconceivable consideration that rural areas are progressive places in their own rights, without being compared with urban areas (Balfour, Mitchell, and Moletsane, 2008). It is imperative to acknowledge that rural schools, teachers, learners and society could contribute different researched knowledge to the dominant existing urban knowledge, if teachers and learners may be given voices through research. Mbatha (2014) posits that it is important to understand the different challenges and success stories that occur in rural areas and schools, considering that 62% of all South African schools are found in rural areas. This means that the majority of children in South Africa attend Foundation Phase classrooms in rural areas, making it fundamental to interact with teachers to understand their teaching and learning experiences. Due to little research in rural schools, the status of Foundation Phase teachers' qualifications, especially in regard to mathematics content knowledge and teaching approaches, is unclear.

2.7 Chapter Summary

This chapter discussed the importance of Foundation Phase and Foundation Phase teachers, in relation to learners' understanding and development of mathematical skills and knowledge. Of concern is the shortage of properly qualified FP teachers in South Africa, especially considering the undertraining of rural foundation teachers that influence effective teaching of mathematics. The importance of coherence during mathematics teaching was also discussed, especially for Foundation Phase teachers to teach lessons in ways that will allow learners to make sense of the mathematical connections for future grades. Additionally, lack of MCK can affect PCK negatively, and possibly result in learners learning mathematics in a linear way. Another important aspect of this reviewed literature is the unpopularity of rural education research, especially mathematics education research in Foundation Phase.

Chapter 3

Understanding mathematics teaching and discourse in Foundation Phase: theoretical framework

3.1 Introduction

The theoretical framework is one of the most important aspects in the research process and, according to Iqbal (2007); its identification is “the most difficult, but not impossible part of the proposal” for students (p.17). Similarly, Lysaght (2011) states that students express confusion, lack of knowledge and frustration with the challenge of choosing a theoretical framework and understanding how to apply it throughout the dissertation (p.572). Without overlooking the difficulty and challenge to choose a theoretical framework, it is still important to identify the relevant theoretical framework, to have a lens that evaluates the study (Grant and Osanloo, 2014). Similarly, although it was difficult to choose the appropriate theory and concepts for this study, it was still important to think and re-think about the main concepts in the topic and the focus of the study which shaped the choice of a theory and concepts as lenses to make sense of the data. Thus, the study used Mathematics Discourse in Instruction (MDI) by Adler and Ronda (2014), Adler and Ronda (2015), and Venkat and Adler (2012) as the main lens to make sense of the data, and Sfard’s (2008) concepts from the commognitive theory are also used to address aspects that MDI did not cover. Furthermore, this study sees a relationship between MDI and mathematical discourse because coherence/incoherence is present within mathematics discourse - by this I mean that when analysing the discourse used by teachers during mathematics lessons coherence or incoherence may be deduced.

3.2 Mathematical Discourse in Instruction (MDI)

Venkat and Adler (2012) state that teachers’ mathematical discourses in instruction (MDIs) is essentially the mathematical aspects of what teachers say, do and write during teaching and learning, and also while interacting with learners. They are key features of classroom practice, and influence learners’ understanding or lack thereof of mathematics concepts and rules in Foundation Phase. Before I engage with MDI, it is important to briefly discuss the concept of mathematics discourse to have a clearer understanding of MDI. According to Dörfler (2000, p. 339) teaching and learning mathematics is a process of “learning to use and understand its language, its symbols, its diagrams, mediators and its procedures”, to teach mathematics concepts and rules effectively and explicitly. Thus, mathematical discourse is characterised by its words, visual mediators, routines and narratives (Ben-Zvi and Sfard, 2007; Sfard, 2007), and discourse is a special type of communication characterised by a range of permissible actions and reactions (Berger, 2013) within mathematics. This means that teaching and learning mathematics is “tantamount to modifying and extending ones mathematical discourse” (Sfard, 2007, p. 565) as teachers continue teaching, to ensure that learners’ mathematical knowledge is appropriately developed.

The development of MDI was to foreground concerns with the quality of mathematics made available to learn in schools, and to work with teachers on their instructional practices (Adler and Ronda 2017). It draws from Vygotsky’s (1987) sociocultural theory of mediated learning and scientific knowledge as a network of connected concepts, making MDI an essential asset in the classroom to give learners access to mathematical concepts (Venkat and Adler, 2012). Teacher’s work is to mediate mathematics concepts, rules and principles explicitly in a relational manner, for learners to understand that concepts are connected and that progression of concepts occur from one grade to the next (Adler and Ronda, 2017). MDI includes a problem or object of learning, a selected representation that is transformed, and explanations and justifications for the representations selected (Venkat and Adler, 2012). To add, Adler and Ronda (2015) discussing from the secondary mathematics, states that mathematical objects such as numbers and functions are abstract entities that need to be exemplified and explained, and occurs within patterns of interaction and towards a particular goal. Vygotsky (1978, p. 86) believes that in “social interactions with teachers, learners achieve more sophisticated goals than they do on their own”, including providing opportunities for learners to use the target mathematics language which is the output. According to Allahyar and Nazari (2012) cognitive development happens through interaction, depending on the teacher’s strategy in terms of opportunity given to learners which could trigger their willingness to talk or not to talk in class.

3.2.1 The object of learning

According to Adler and Ronda (2015) "the object of learning is defined in terms of the content and in terms of the learner's way of handling the content" (p. 238). Prioritizing the connection between object and learning is significant, because teachers are expected to explicitly and effectively teach the content and be constantly aware of what learners would be able to do with respect to that content (Adler and Ronda, 2015).Thus, an object of learning in a mathematics lesson could be a concept or a topic, procedure, algorithm, or meta-mathematical practice, and should be the focus of the teacher (Venkat and Naidoo, 2012). It is therefore important that teachers in Foundation Phase, specifically grade 3 for the study, make the object of the lesson as clear as possible at the beginning of the lesson. This is to ensure that they consciously focus on a specific mathematics concept or topic in relation to the previous and following concepts, to show conceptual or topic relationships and continuity to the learners. Of importance for the study is to observe whether and how grade three teachers write the object of learning on the board or explicitly tell learners the lesson topic, to allow learners to think within that frame of mind. Thus, a teacher may use this component of MDI as a means to enhance learners' consciousness and ensure teacher's mathematics coherent enactment.

3.2.2 Visual mediators

Venkat and Adler (2012) posit that during the primary years of schooling the use of real-life examples, diagrams, and physical artefacts is essential for the child, in order to provide strong imaginable foundations for the abstract symbolic mathematical language. On the same line of discussion, according to Sfard (2008) in Berger (2013), the use of visual mediators constitutes mathematical thinking or communication. Sfard (2008) distinguishes between iconic mediators (such as graphs and pictures), symbolic mediators and concrete mediators (such as beads of an abacus). The nature of mediation (physical or psychological) is a culturally constructed 'auxiliary device' in an activity that links learners to the world of objects or mental behaviour when engaging with mathematics (Allahyar and Nazari, 2012). Thus, the mediators are essential in FP for teachers to use while communicating mathematics concepts and encouraging learners to think about the meaning of mathematics iconic mediators. A mathematics representation on the board has a major impact on learner understanding, because if mathematics content is misrepresented visually it may cause disconnections in learner understanding. FP learners are more responsive to visual representation due to their age, hence, the need for teachers to carefully choose visual mediators to enable lesson coherence and learner comprehension of rules and concepts.

Additionally, Scott, Mortimer and Ametller (2011), states that in order to carry out the task of using visual mediators effectively, a teacher needs to have a good grasp of mathematics content knowledge, because it could impact pedagogical practice. During the classroom observations this study showed interest in identifying the kinds of visual mediator's teachers use to make mathematical concepts accessible to learners, it also showed interest in whether and how real-life, concrete examples and the teacher's explanations were used to enable or constrain mathematical thinking during the learning process. Thus, for this study, I noticed that some teachers used the chalk board as the only means of visual representation and in some cases misrepresented the mathematics information which will be discussed in chapter 5. This may be due to the rural context which influenced the nature of visual mediators that teachers used during lessons, due to a lack of additional resources being supplied by the department of education.

3.2.3 Explanatory talk

This mechanism addresses the way in which the teacher explains mathematical concepts to learners, and whether appropriate words are used to explain concepts. Explanatory talk is drawn from Bernstein's (2000) insight of pedagogic discourse and gives focus to the discourse used in a mathematics lesson, it also transmits criteria of what counts as mathematics (Adler and Ronda, 2015). The function of explanatory talk is to name and legitimate what the focus of the lesson is, the lessons related examples and tasks, and the analysis of how the objects of focus are named. In addition, what is legitimated in an episode is key to being able to describe the mathematics made available to learn through explanatory talk, as well as reach a summative judgment on naming and legitimating as these accumulate over time in a lesson (Adler and Ronda, 2015, p. 5). Naming, according to Venkat and Adler (2014), means the use of words to refer to other words, symbols, images, procedures, or relationships during mathematics teaching and learning.

Venkat and Adler (2014) notice tension in managing both formal and informal ways of talking mathematically, especially in Foundation Phase as teachers might be tempted to simplify the words and concepts to give learners access and enhance understanding, thus naming what is focused on in class might be complicated by informality. The complexity was identified in some teachers' reluctance to use formal mathematical language in Venkat and Adler's (2014) study, as it is "abstract and the learners are put off by over reliance on formal talk with neglect of connecting mathematical ideas to colloquial meanings" (p. 132). Interestingly, this study also noticed that some teachers did not use mathematics discourse to explain essential concepts, for example, a teacher used the words 'straight line' to describe what 'vertical' and 'diagonal' means during a symmetry lesson.

3.2.4 Exemplification

Once the teacher has the goal of the lesson in mind, he/she needs to take into consideration the examples and tasks that are going to be used during lessons to reinforce mathematics concepts. The exemplification is important because it is used to re-emphasise the concepts and also make the lesson relevant to the learners and also links with the appropriate tasks for the learners to enhance their understanding of mathematics knowledge. Thus, exemplifying is concerned with the choice of examples that the teacher uses, whether it be similar examples, contrasting examples or a fusion of the two (Adler and Ronda, 2014; Adler and Ronda, 2015; Venkat and Adler, 2012).The choice and use of examples link with the goal of the lesson, because a teacher should prepare in advance which examples to be used in the lesson, to fit coherently with the entire lesson and not cause confusion amongst the learners. Bearing in mind the current study, the teacher's choice of examples should also take into consideration the rural context and use appropriate and realistic examples. The teacher can draw from the diverse learner's background, because the purpose is to develop learners' interest and understanding of mathematics. Another essential factor of exemplifying is the importance of learner tasks, as examples do not stand-alone (Adler and Ronda, 2014; Adler and Ronda, 2015; Venkat and Adler, 2012).

Learner tasks are an important part of learning in general and specifically in mathematics to reinforce concept relationships and continuity. The goal of a task is to bring specific competences to the fore, and well-planned tasks allow learners' minds to be stimulated while working on the task. Tasks are also used to check learner understanding, making it important that tasks are designed systematically (Adler and Ronda, 2014; Adler and Ronda, 2015; Venkat and Adler, 2012). A disconnect between examples and lesson tasks may cause learner's confusion and eventually disengagement in mathematics, consequently hinder future learning in mathematics. Learners' disengagement in mathematics could negatively influence the passion for the subject, which may cause them to struggle in higher grades because all mathematical concepts build on each other (Marton and Pang, 2006; Marton and Tsui, 2004 in Adler and Rhonda, 2014).

Additionally, learner tasks require different actions at different levels of complexity or cognitive demand in order to allow for different mathematics learning opportunities which means a teacher needs to plan effectively to allow for the different levels of complexity to come to the fore (Adler and Ronda, 2014; Adler and Ronda, 2015; Venkat and Adler, 2012). Thus, teacher's use of examples and whether and how they are foregrounded coherently in relation to the learners' task was observed, including the manner in which learner tasks are set at different cognitive levels to stimulate learner thinking in mathematics. During classroom observations it was noted that a teacher consistently used addition examples which required a lower level of cognitive demand from the learners then that required by the Foundation Phase CAPS document (2011), which will be discussed in-depth in chapter 5.

3.2.5 Patterns of interaction

Regarding MDI 'patterns of interaction', the main focus is to identify what learners are invited to say, whether and how learners have the opportunity to use mathematical language and engage in mathematical reasoning, as well as the teachers' engagement with learners (Adler and Ronda, 2014; Adler and Ronda, 2015; Venkat and Adler, 2012). The role that a teacher takes in FP classrooms have a great impact on the nature of learner interaction, for example, if a teacher takes on the authoritative role learners might be afraid to correct the teacher if mistakes are made. Given that learning does not take place in vacuum, learners are always part of the lesson whether actively or passively, and the nature of participation or lack thereof plays an important role in developing mathematics knowledge in Foundation Phase, especially grade three. Adler and Ronda (2015) are also concerned with what learners are invited to say, and specifically whether and how learners have the opportunity to speak mathematically and to verbally display mathematical reasoning. The nature of interaction, communication and usage of words to explain the understanding of mathematics concepts and rules during lessons is important to encourage learner higher order thinking skills.

Therefore, patterns of interaction requires mediated learning experiences, this occurs when one person (in this case the teacher) assumes the role of the mediator in an interaction and directs the other party's attention to a specific topic or subject. Learning improves when the mediator gets involved in whatever is being learned (Sharron, 1987). According to Greenberg (1990), an effective mediator assists the student in interpreting and giving meaning to the topic, guiding the student so that he or she is able to gain an understanding of new content. Mediated learning is dependent on both the teacher and the learner to be successful, therefore requires the learner to become an active participant in the learning process. Regarding the current study, meditational means occurred within rural classrooms amongst teachers teaching mathematics in Xitsonga or English to learners in grade 3 classrooms.

3.3 Sfard’s (2008) elements of mathematical discourse

Sfard’s commognitive framework conceptualizes mathematics as a discourse, that is, a form of communication consisting mainly of its word use, endorsed narratives and mathematical routines which will be used to analyse the teaching of mathematics topics and concepts. The communication component is used to analyse how teacher–learners and learner–learner engage in discourses, including verbal and non-verbal activities, during mathematics teaching and learning (Kim, Choi and Lim, 2017). In Foundation Phase, teachers introduce learners to the mathematical community by laying conceptual foundations - using specific words, routines and narration that may influence future decisions pertaining to whether or not learners choose to be part of the community or not.

3.3.1 Words and their uses

In any discipline, there are words that consist of distinctive meanings and are used differently compared to any other disciplines and/or how they are used in everyday discourse (Sfard, 2007). Although some words are used in everyday discourse, they have different meanings in the context of mathematics. While words such as 'equal', 'sum' or 'vertical' are used in everyday discourses, they also have specific meanings in mathematics lessons indicating mathematical discourse. For example, in colloquial discourse we say: "I ate half an apple', to indicate that we ate approximately half an apple. In mathematical discourse, we use the word 'half' to mean exactly half" (Berger, 2013, p, 3). Sfard's (2008) words and their uses is linked with explanatory talk in MDI as the teacher has to be aware of the selection of words and how they are used in mathematics, because mathematics has its own language. It is therefore important for FP teachers to always be conscious of the words they use in class to explain mathematics concepts, because mathematics words have their own specific meanings and learners need to understand this as they are built upon.

For the current study, language played an essential role because teachers use Xitsonga to teach mathematics in grade 3, and viewed it as challenging because of limited mathematics words in Xitsonga. This means teachers had challenges with the selection of words to explain mathematics concepts and procedure, and also how to use them mathematically due to language limitation. A teacher's mathematics words and usage is essential since learners gain access to mathematical content through teacher's choice of words, and when mathematics words are watered down learners might not have access to powerful mathematics knowledge.

3.3.2 Endorsed narratives

Endorsed narratives are facts and ideas that are true in conventional mathematical knowledge. These entail definitions, axioms, theorems and formulae (Sfard, 2008). Words and their uses link with endorsed narratives because teachers need to have appropriate content knowledge to present facts and ideas of mathematical knowledge using the correct words to describe mathematical definitions, axioms, theorems and formulae (Siyepu and Ralarala, 2014). Thus, effective explanation, narration and definition of mathematics ideas are important in Foundation Phase, as teachers introduce learners to the community of mathematics. This study was interested in exploring the way in which teachers define mathematical concepts to learners, which could be shaped by a teacher's content knowledge, because if a teacher lacks appropriate mathematics content knowledge (MCK), it might affect the endorsed mathematics narration.

3.3.3 Mathematical Routines

According to Sfard, (2008), mathematical routines are procedures that are repeatedly applied to engage with mathematical objects and reach a solution while solving a mathematical problem. Routines may be helpful in learning a new discourse, as learner's ability to act in new situations often depends on recalling one's or others' past experiences (Tabach and Nachlieli 2011). Mathematical routines are governed by the specialised mathematical words, visual mediators and endorsed narratives, which makes it fundamental for teachers to be aware of during lessons. This means that a routine may be a procedure that teachers follow to communicate mathematical ideas to the learners, which involves practices such as generalizing and justifying mathematical narratives, which in turn makes them rule-laden (Sfard, 2008). Given this, it is essential for the FP teacher to enact the correct mathematics routines to learners, because a lack thereof may be detrimental to mathematics learning. If a teacher consistently misrepresents mathematics concepts, it may cause major incoherence in learners' understanding. Considering the importance of repetition within routines in the in Foundation Phase to reinforce content, I observed that teachers enacted routines which were not mathematically correct, for example, a teacher did not use a ruler to measure all four sides of a square equally, and another teacher used the incorrect sign to signify rounding off which will be explained in chapter 5. When teachers carry out mathematics routines incorrectly, learner understanding and development in the subject of mathematics is affected negatively.

3.4 Limitations of mathematical discourse and coherence

Notwithstanding the above discussion, it is essential to mention that mathematical discourse and coherence do come with limitations. A limitation for mathematics discourse is that the language of mathematics is different to the home language spoken by many, given this; a barrier to learning is created. Additionally, coherent teaching requires thoughtful lesson preparation time, however due to the reality teachers' face, that being inundated with admin and curriculum overload, thoughtful lesson planning for coherent teaching is not an easy task for most teachers. Another factor affecting coherent teaching and learning is that teachers do not know the type of background learners have who have been taught by other teachers. Therefore, teachers may know what learners are supposed to know but what learners actually know is different, so even if teachers have coherent lessons planned - if the learner doesn't actually have the background knowledge they would still get lost and may become disengaged in mathematics learning. Furthermore, due to curriculum overload, there is little time to allow learners to investigate new ideas and knowledge in mathematics which leads to teachers spending a lot of time telling learners what they ought to know.

3.5 Chapter summary

Foundation Phase learners are vulnerable and they see the teacher as the powerful source of knowledge, and given this, learners are likely to practice exactly what the teacher does. This means that if the teacher does not teach to foreground mathematics understanding and coherence, learners might lose conceptual mathematics understanding. Given this, the chapter provided a detailed account of MDI and discussed specific concepts from Sfard's commognitive theory (2008), to gain insight on teachers' discourse and coherent teaching of topics and concepts in mathematics (Venkat and Adler, 2012).

Chapter 4

Commencement of the Research Expedition: Research Methodology

4.1 Introduction

In this chapter, I discuss the research paradigm, methodology and design the study used to generate data. A detailed discussion of the chosen research approach, the justification of choices and the ethical discussion for the study has been presented. This study is part of a larger research project that critically explores the conditions of teaching and learning that facilitate and/or constrain learning in Acornhoek rural schools, which commenced in the year 2015 until the end of 2017.

4.2 Research Paradigm

In this section I firstly present a brief discussion of my ontological and epistemological stance followed by the chosen paradigm for the study. Ontology is described as "…assumptions which concern the very nature or essence of the social phenomena being investigated" (Cohen, Manion and Morrison, 2007, p.7). In this study, teaching and learning of mathematics is viewed as a social construction, because its foundations are built upon the actions and knowledge of teachers and with learners in and out of school contexts. I acknowledge that within the same school and grade, teacher's teaching experiences of mathematics are not the same as they are shaped by the nature of training teachers have experienced, as well as learners' socio-cultural and educational backgrounds. This influences teachers' perceptions of what the reality of mathematics is and the approach of teaching it (Nightingale and Cromby, 2002; Bryman, 2004).

Epistemology is concerned with "…how knowledge can be acquired and communicated to other human beings" (Cohen, Manion and Morrison, 2007, p.7). In relation to the ontological view of social constructivsm, this study views knowledge as "experiential, personal and subjective" (Sikes, 2004, p. 21). This is because I asked teachers about their experiences and perceptions of mathematics, pre-service training and professional development, and experiences of teaching mathematics in grade 3. As such, the epistemological position in this study is social constructivism because knowledge and truth in teaching mathematics are not discovered, but socially constructed, and learners and teachers are part of the constructors, de-constructors and re-constructors of such truths and knowledge (Cohen, Manion and Morrison, 2006).

A paradigm is a set of beliefs or a theory that guides action with regard to conducting research (Creswell, 2012; Rubin and Babbie, 2010; Babbie, 2011). Critical theory guided this study as the research paradigm, which influenced the establishment of critical pedagogy in mathematics education, mathematics education for social justice (Gutstein, 2006) and critical mathematics education (Powell and Brantlinger, 2008; Frankenstein, 2009). Critical theory is complex and constituted by various conceptualisations (Kellner, 1989; Thompson, 2013; Tyson, 2014). For this study, critical theory is used to interrogate the nature of teacher's coherent mathematics teaching in rural grade 3 classrooms, in relation to rural Foundation Phase training and content knowledge.

With the above information in mind, the mission for any critical theorist, as argued by Foucault (cited in Gaventa, 2003), is to make it possible to think differently and open the possibility for acting differently. Interacting with teachers, talking about their personal experiences with mathematics, pre and post training and teaching experiences of mathematics using video stimulated interviews, will hopefully make them identify the possibility to enhance their teaching approaches and think differently about mathematics. Considering that teachers watched themselves teaching, using video stimulated recall interviews, to understand reasons for using specific words and doing certain things, they will see possibilities for improving and acting differently. In particular, the significance of thinking differently about mathematics coherent teaching of concepts in grade 3 was highlighted during discussions with teachers, which opened a future possibility for teaching mathematics differently to ensure coherent organisation and teaching of mathematics topics and concepts. The reflective discussions further made teachers aware of what teachers took for granted about the importance of mathematics coherent teaching, and encouraged them to interact and act differently in the classroom during teaching and learning. This means that if teachers are encouraged to critically reflect on the nature of their mathematical knowledge and the way they teach lessons and concepts coherently, they can constantly and consciously make developmental decisions in the classroom (Babbie and Mouton, 2000).

4.3 Research Design

A research design is concerned with all the steps needed to successfully reach the end product, and is seen as the blueprint (Babbie and Mouton, 2008) or the functional plan that makes links between certain research methods and procedures. The purpose is to ensure that valid and reliable data is analysed, conclusions drawn and theory formulation may occur (Bless, Higson-Smith and Kagee, 2006). This study used case study which enables the researcher to gain insight into a particular phenomenon within a particular bounded context (Simons, 2009). Case study research focuses on in-depth exploration of the actual case in its real-life context, and one of the purposes of a case study is to contribute to action and intervention (Yin, 2008 in Creswell, 2012). The cases for the current study involve grade three rural teachers who are observed teaching mathematics topics and concepts in a real-life classroom context, in order to identify whether and how their mathematics lessons are coherent. Therefore, the chosen paradigm and research design for the study share elements of contributing to action and change, as they encourage teachers' to critically reflect on if/how they teach mathematics topics and concepts coherently. Furthermore, Creswell, (2012) suggests that regardless of the phenomenon being studied, at the heart of every case study lies a method of observation – how things are done or not done – in relation to interview responses.

According to Yin (2003) in Baxter and Jack (2008), three essential factors determine a case study. First, a case study approach should be used when the focus of the study seeks to answer 'how' and 'why' questions. This is relevant to the current study because the intention was to explore whether and how teachers teach mathematics coherently, and why they teach mathematics the way that they do using video stimulated recall interviews. Secondly, he suggests that a case study should be considered when the behaviour of those in the study cannot be manipulated, which means that while teachers are teaching in their classrooms, the assumption is that they are behaving naturally during the data collection process so that reliable data may be collected (Yin, 2003). Thirdly, the researcher intends to incorporate contextual conditions because it is believed that they are relevant to the phenomenon under study. With regard to the current study, the rural context is seen as more than the context, as Moletsane (2012) argues that the context in which the school is located has an impact on the teaching and learning. Furthermore, considering that more than one teacher will be a research case, this will enable me to explore differences and similarities within and between cases, in relation to the theoretical framework mentioned in chapter three (Yin, 2008 in Creswell, 2007).

4.4 Research Methodology

A research methodology is taken as a theory that informs the manner in which researchers gain understanding about the subject under scrutiny in research contexts, and the reasons for choosing particular strategies or methods over others to address the identified research problem (Scott and Morrison, 2005). The chosen research methodology for this study is post-structuralism. One of the basic assumptions that shapes poststructuralist thinking is that every aspect of human experience – our modes of communication, social habits, values and even our personal identities – are textual. This means that everything we think we know about ourselves and our world is shaped by discourse and language, which are socially constructed (St. Pierre, 2000). Discourse and language are socially constructed, and teachers use language to communicate mathematics and specific words to explain mathematical rules and principles. Given this aspect of post-structuralism, a link may be seen between the studies ontological position, that being social constructivsm and the language aspect of post structuralism. Hence, post-structuralism sees discourse and language as the systems by which meaning is communicated and made, and dictates what can be known and communicated during mathematics lessons (Scott an d Usher, 1996).

Given the above view of discourse and language, it is essential to highlight the link with the MDI theory by Adler and Ronda (2014, 2015) and Venkat and Adler (2012) and Sfard's (2008) concepts within commognitive theory. This link is essential because mathematics teachers' present ideas and concepts in the classroom using language pertaining to mathematics content (Dörfler, 2000) – the language that teachers' use to teach mathematics, constitutes a discourse specific to mathematics.

Post-structuralism also foregrounds disrupting ideas which may be taken for granted (Bové, 1990), hence the need to listen to the rural teachers' utterances during interviews to identify ideas they might have taken for granted about mathematics.

4.5 Research Approach

The study used a qualitative research approach, because it takes an in-depth look at a certain phenomenon to gain detailed understanding of it (Creswell, 2012). This approach created an opportunity to interact closely with the participants to co-create their experiences of mathematics teaching in rural grade 3 classrooms, and make sense of their mathematics training experiences in relation to their personal views of mathematics. The use of a qualitative research approach links well with the case study research design, as it advocates for researchers to focus on an in-depth exploration of the actual case in its real-life context (Creswell, 2012). A quantitative approach would not have been appropriate for this study as it does not promote close interaction and detailed narrative explanation of gathered data. Mixed methods research is another approach used by researchers which takes advantage of the combination of quantitative and qualitative methods in a single research project depending on the nature of the study (Brysman and Burgess, 1999). Similarly, mixed methods research was unsuitable for this study because of the focus on teachers' perceptions and teaching approaches in mathematics lessons, which means that it is dominantly qualitative without any quantitative aspect.

4.6 Research Sampling and participants

The current study took on a non-probability approach to sampling, more specifically, purposive sampling (Babbie and Mouton, 2007, p.164). This sampling method allows the researcher to make strategic choices concerning whom, where and how one's research will be done (Scott and Morrison, 2005). For this study, grade 3 mathematics teachers were chosen purposively because of the perceived experience and knowledge they have about the subject matter, grade and context. Considering the limited time to conduct this study, the schools were conveniently chosen and informed by the existing partnership with the Wits School of Education for the in-service teacher training program (i.e. Teaching Experience) and the research project as explained at the beginning of the chapter. The teachers were purposively selected through the assistance of school principals and mathematics Head of Departments (HODs). The sample size for this study was not influenced by age or gender, but rather by teachers who teach grade 3 classes in Acornhoek, rural Bushbuckridge, Mpumalanga province.

The sample size of this study is therefore as follows:

	Number of teachers	**Number of classroom observations**	**Teacher interviews**
Selection Criteria	Four Grade 3 mathematics teachers	Between 4-6 mathematics lessons per teacher given the time constraints	One semi-structured interview per teacher and video stimulated recall interviews depending on the nuances present in the mathematics lesson.

4.7 Research Methods

With regard to data collection, this study adopted a qualitative research approach which allows close interaction with participants in a natural setting in order to understand their perceptions, experiences and approaches to teaching mathematics. Given this, the data collection methods that were chosen are: semi-structured interviews, semi-structured non-participatory observation and video-stimulated recall interviews. These chosen methods assisted in addressing all research questions for the study (Creswell, 2012).

4.7.1 Interviews

An interview is seen as an exchange of views between two or more people on a topic of mutual interest (Cohen, Manion and Morrison, 2007; Babbie and Mouton, 2007). According to Shneiderman and Plaisant, (2005) and Creswell, (2012), interviews can be productive since the interviewer can pursue specific issues of concern that may lead to focused and constructive suggestions. The disadvantage of using data gathered from interviews is that it may be deceptive; since the interviewee may respond in such a way that s/he provides the perspective the interviewer wants to hear (Babbie and Mouton, 2007). However, if that were the case, the observation data would assist the researcher in identifying whether what the teacher said in the interview concurs with the action taking place in the classroom while the lesson is being enacted. Depending on the need and design of the research study, interviews can be unstructured, structured or semi-structured with individuals, or may be focus-group interviews. This study used semi-structured interviews with teachers, which entails “the researcher deciding on the sequence and wording of the questions during the interview” (McMillian and Schumacher, 2010, p. 355).

Although I predetermined the questions to ask teachers during conversations about their experiences and approaches towards teaching mathematics, the sequence of the questions I asked were influenced by teacher’s responses. Thus, the semi-structured interviews were used because they are flexible, as they allowed manoeuvring questions to suite responses. The semi-structured interviews guaranteed confidentiality and encouraged confidence because only the participant and the interviewer were present (Creswell, 2012 and Mason, 2002). The semi-structured interviews with the teachers took place during breaks and after school to avoid disturbing their lessons or other everyday activities. The interview sessions took approximately 40 - 50 minutes per teacher, and were determined by the responses of a teacher as some teachers responded in detail. Additionally, the interviews were audio-recorded with the permission of the participant, to ensure that no information was missed. Considering the importance of listening to the participant while talking about their perceptions and experiences, the audio-recorder gave me the opportunity to focus on what, how, and why teachers say what they do by observing their gestures. Creswell (2012) suggests that recording allows the researcher to become aware of the participants’ body language, which indicates the participants’ attitude and feelings regarding the phenomena being researched.

4.7.2 Observations and video stimulated recall interviews

The process of observation entails gaining live information by observing people at the research site. This form of data collection may yield interesting results as people do not always do what they say they do (Cohen et al, 2007). In addition to semi-structured interviews, the study used semi-structured non-participatory observations to generate data in order to gain richer information. The advantages of observation include having the opportunity to record information and actual behaviour as it happens. Semi-structured observations are done in a far less pre-determined way as compared to a highly-structured observation, which knows in advance precisely what outcome is being sought (Cohen et al, 2007). The disadvantage, however, is that those who are being researched may feel awkward and therefore behave in a way that they think the interviewer expects them to behave, in turn, negatively affecting the collection of data (Creswell, 2012). As mentioned earlier, even though this could happen, participants do not act forever; they quickly go back to the normal behaviour as that was also observed with the teachers.

In this study, I took on the role of a non-participant observer, where the observer visits a site and records notes without becoming involved in the activities of the participants, as opposed to a participant observer who takes part in the activities that they intend to observe. However, the challenge of being a non-participant observer is that by not actively participating, the researcher removes themselves from the actual experiences and the observations may not be as concrete as an observation done by a participant observer (Creswell, 2012).

Videotaping the observations allowed me to explicitly capture the way teachers taught mathematical concepts as well as every step of their actions and interactions with learners. The video recorder ensured that I did not miss any action as it happened, in contrast to writing down information while action was continuing which could result in misrepresentation and an information gap (Creswell, 2012). Furthermore, failure to make use of a videotape may have lead to missing essential actions and information which assisted with understanding the teaching and learning process in grade three mathematics classrooms. Essentially, videotaping allowed viewing and re-viewing the manner in which teachers taught mathematics, and also allowed me to identify teaching episodes that were relevant for the study. In order to protect the identities of my participants, the video camera only focused on the teacher in front, and if it happened that the teacher moved around the classroom while teaching, I ensured that the learners' faces were blured out.

Video-stimulated recall interviewing is a research technique in which subjects view a video sequence of their behavior and reflect on their decision-making processes during the videoed event (Nguyen, Nga Thanh, Mc Fadden, Tangen, Donna and Beutel, 2013). During observations, I focused on how teachers used words and mathematics discourse to understand their content and pedagogical knowledge, and also coherent mathematics teaching. After recording observed lessons, I asked the teachers to watch some sections of their teaching and to reflect on certain issues pertaining to their lessons. It is important to mention that even though I chose specific episodes to discuss with teachers, they were also given the opportunity to watch the recordings of their lessons before the video-stimulated recall interview occurred. The purpose was to give them the opportunity to critically reflect on their teaching before the video-stimulated recall interview occurred.

4.7.3 Data generation and context of the study

Before I discuss data analytical tool and process, this section presents a detailed narration of the process and experiences in the research field, for the reader to understand the nature of data generation for the study. The first day of data generation was exciting and insightful, because my supervisor arranged a meeting with the district manager and our research team to discuss the research in the schools. In this meeting alone interesting data started emerging as the district manager explained that Foundation Phase is not taken seriously, because the main concern is producing matric results. He further suggested that when the district identifies a teacher to be 'weaker', they send them to the FP and place the stronger teachers into the higher grades. Given this information, a major concern arose and I started to question myself: what are the conditions of teaching and learning in these schools if FP is not taken seriously? How do teachers in the FP feel, knowing that they are seen as 'weaker' teachers? Does the education system not realize the importance of FP teachers in building solid foundations for learning? Nonetheless, I was now eager to visit the research sites so that I could explore these factors myself.

When I got to the first research site, Imfundo Primary, I was acquainted with the two teachers whom I worked with and everything worked out as I had expected. However, when we got to Impumelelo Primary, we found that the school is a Xitsonga medium school and mathematics was not taught in English, and I realised that the language barrier was going to affect my data collection. To counter this concern, my research peer, who speaks Xitsonga, assisted with translating the data every day after school while we were in Acorhoek to understand what teachers were saying. He also assisted with transcribing the data once we arrived in Johannesburg, to ensure that I understood everything that took place in the classrooms. Teachers indicated that they also found it difficult to teach mathematics in Xitsonga up to grade 3, because it becomes a shock for the grade 4 teacher and learners when they start learning mathematics in English. Most teachers, including the grade four teachers, mentioned that it may be more effective to teach mathematics in Xitsonga throughout primary school as learners would have received a better grasp of the English language during English class and the low mathematics pass rate in grade four would be improved.

The intention for this study was to focus on the topic of measurement, specifically the topic of mass, however, the research site determined otherwise. When I interacted with the teachers they made me aware that in Mpumalanga, rural schools were working with the National Education Collaboration Trust (NECT) programme. The NECT programme prescribes specific topics to be taught on specific days and provides each teacher with a "planner and tracker", and is a book that teachers were expected to strictly adhere to. The planner and tracker, in line with the CAPS curriculum, prescribes the lesson content which needs to be taught in the lesson; it stipulates the page numbers which teachers need to refer to in order to access the lesson plans for the day, and it instructs teachers to find the lesson activity in the Department of Basic Education (DBE) workbooks. The NECT program is aimed at improving learner performance in the Mpumalanga province, aiming to get 90% of the rural pupils to master 50% of the curriculum by 2030.

An example of the NECT planner and tracker programme:

Week 1					
Day	**CAPS Content**	**Lesson Plans, number and page**	**DBE Workbook**	**Resources**	**Date Completed**
1	Place Value: Numbers 100-300	1 (p. 9)	Worksheet 41 (p. 96-97)	Base 10 blocks, flash cards, number cards (see printable resources.)	
2	Place Value: Numbers 301-400	2 (p.12)	Worksheet 43 (p.100-101)	Base 10 blocks, flash cards, number cards (see printable resources.)	
3	Place Value: Numbers 401-500	3 (p.15)	Worksheet 45 (p.104-10)	Base 10 blocks, flash cards, number cards (see printable resources.)	
4	Place Value: Numbers 200-300	4 (p.18)	Worksheet 35a (p. 80-81)	201-300 Number Board (see printable resources), counters	

Concern, however, is that teachers seemed to be misinformed about the program, because they saw NECT as curriculum change rather than a programme which enhances teaching within the CAPS curriculum. They also found it problematic because they were always called to training workshops on how to implement the NECT programme, and felt as if they were missing out on valuable teaching time. The NECT program caused them to do a lot more administration, as they had to record how far they were with the completion of the programme every day. Furthermore, this study found it challenging to identify the extent to which the context of Acornhoek was rural and suggests that Acornhoek may be seen in two ways: deep-rural or semi-rural. The following table will give insight into the two different classifications of rural Acornhoek.

Table highlighting the challenge of classifying Acornhoek as rural

<table>
<tr><th colspan="2">The challenge of classifying Acornhoek</th></tr>
<tr><td>Context of the study (brief description of Acornhoek)</td><td>Acornhoek is located at the heart of the Bushbuckridge region, in the Greenvalley circuit in Mpumalanga province of South Africa.

Mpumalanga is a relatively small province which accounts for approximately 7.2% of all schools in the country according to School Realities 2016. The prominent languages in this region are mainly Xitsonga and Sepedi.

The language of teaching and learning (LOLT) at Imfundo Primary was English and the LOLT at Impumelelo Primary was Xitsonga.</td></tr>
<tr><th colspan="2">The Rurality of Acornhoek viewed in two different ways by this study.</th></tr>
<tr><th>Deep rural area - Impumelelo primary school</th><th>Semi-rural area - Imfundo primary</th></tr>
<tr><td>➢ The first research site for this study fits into the deep-rural category, as explained by participants.

➢ High numbers of residents work at the farms.

➢ According to the teachers at the schools, parents usually leave very early and come back late from</td><td>➢ Second research site for this study, fits into the semi-rural category, as explained by participants.

➢ Gravel roads still exist, however, evidence of development was apparent such as the shopping centre which was recently built, large houses, (some with running water and others without) electricity, and very small households</td></tr>
</table>

work at the farms. This leads to a lack of parental involvement and an increase in child-headed households, as parents sometimes leave for a number of days before returning. Learners at primary school level are left to fend for themselves without adult supervision. ➢ Cattle are clearly visible. ➢ Vendors are present in the street. ➢ The principal also indicated that many learners in this school are orphans and have lost their parents due to TB and AIDS. ➢ Learners in this school cannot afford the proper school uniform. ➢ The principal also alerted us to the fact that the school experiences lack of funding from parents, due to high unemployment and educational illiteracy. ➢ Buildings are small in size and are usually dilapidated	with flushing toilets. ➢ Complexity sets in, due to the fact that while speaking to the residents and viewing their homes, it is apparent that these large houses barely have any furniture or appliances inside. ➢ The resident I spoke with suggested that they preferred to use pit toilets even though they have fitted in flushing toilets, because it caused less hostility amongst their neighbours. ➢ When some residents have running water, others want to 'borrow' running water from them instead of fetching it at the river as usual. ➢ Thus, having running water ends up costing the owners too much financially-so, to keep the social cohesion and because it's too expensive to afford, owners prefer not to use their running water and flushing toilets. ➢ The school has built flushing toilets, but due to the fact that the school cannot afford the water bill, only the teachers use the flushing toilets whereas the learners have reverted to using the pit toilets.

- Gravel roads - learners have to walk long distances to school.

- Teaching and learning occurs in dilapidated classrooms with very limited resources.

- Lack of sanitation - pit toilets

- No running water - a Jojo tank is placed on the schools premises

- Imfundo primary may be seen as semi-rural because they have a garden which is well-taken care off.

- The caretaker also mentioned that every day they give a different grade a fruit, and they use the vegetables in the feeding scheme, hence making use of the garden as a resource to benefit the learners nutritionally

- Fee-paying school with a total

- Inside each classroom, a bucket of water is placed. A cause for concern with regard to personal hygiene is the fact that learners use the same bucket of water to wash their hands after eating and using the toilet, and as a source of water to drink from – every morning a bucket of water is placed in each classroom for these purposes.

- Learners receive food from the feeding scheme every day (In 2009 the NSNP National School Nutrition programme started distributing food to all quintile 1, 2, and 3 schools), usually pap (maize meal) and milk, pap and cabbage or pap and beans. In some cases, the teachers explain that the meal received at school is the only meal learners eat in a day. This is true as I witnessed learners coming back for more, but unfortunately there wasn't enough for a second serving.

requirement of R1700 per annum.

- Many teachers from other schools and residents near the school view the school as a 'private school'; they further mention that the children who attend Imfundo primary are the children of doctors, lawyers and teachers.

- Additionally, the school has a built-in play area for the learners which would allow them to build on their gross motor and social skills

	

4.8 Data Analysis

Data analysis entails the researcher organising, accounting for and explaining the qualitative data (Cohen et al, 2007). This study uses ‘Critical Discourse Analysis’ (CDA) as the analytical tool. A dialectical relationship between language and society is highlighted in CDA, because language is influenced by society while society is shaped by language (Wang, 2006). This means that situations, objects of knowledge and the identities of people are embedded in discourse, which links with MDI. Given this, CDA is relevant for this study because it seeks to understand teachers’ perceptions and experiences which are explained through language and represent particular discourses, as well as their approaches of mathematics coherent teaching which is also influenced by the nature of mathematics discourse. Teachers make use of language to talk about these issues, which could represent the way mathematics is talked about in society. The current research project used Fairclough’s analysis of text, that is, transcribed interviews and classroom observations, to explore the relationship between text and its social context, which are the two rural schools for this study. The analysis is based on three components, namely: description, interpretation and explanation. The linguistic properties of texts are described (text analysis: interview transcripts and observation transcripts), the relationship between the productive and interpretative processes of discursive practices as well as the texts are then interpreted critically, and the relationship between discursive practice and social practice is interrogated and explained in detail (Fairclough, 1995 in Wang, 2006).

In order to analyse my data, teachers’ uttered words and classroom discourses were transcribed and then the texts (during interviews, VSRI and lesson observations) were critically interpreted using the study's theoretical framework as a lens. Thereafter, an explanation of the text in relation to mathematics teaching and learning in rural mathematics classrooms was foregrounded. Fairclough (1995) suggests that the analysis of text should go beyond the "what" and move towards understanding the "how" and "why" behind the oral, thought and transcribed text. This means that in order to obtain the whole meaning in a text(s), as both stated and implied, an analysis of discourses were taken into account in relation to the immediate context (where and when the words were uttered/written) and the broader context (which exists in the mind and experience of the recipient) (Van Dijk, 2008). Thus, this study identified CDA as an invaluable lens for gaining awareness of the "how" and "why" of the responses from teachers during interviews, and their action and discourses in the classroom. Notwithstanding this, a link can be drawn between this study's research methodology, post-structuralism and Critical Discourse Analysis (CDA) as it enables me to demystify teachers' utterances about their experiences of FP mathematics training and teaching.

4.9 Ensuring the quality of the studies trustworthiness

In order to enable trustworthiness and the validation of qualitative research, four crucial strategies are needed: credibility, transferability, dependability and confirmability (Creswell, 2009; Babbie and Mouton, 2007). Considering the importance of these strategies, they are further discussed below in relation to the current study.

4.9.1 Credibility

Credibility involves establishing that the results from the research participants' responses are believable, due to the notion that qualitative research explores perceptions and experiences. The confirmation and approval from the research participants suggest a higher validity of the study (Smith, 2012 and Scott and Morrison, 2005). I contacted participants after some observations and interviews to check that I understood what they were trying to get across to me while I was still in the research field .The findings have also been confirmed through constant engagement with my supervisor who is an expert in rural education research. Additionally, telephonic conversations were held between the researcher and some participants when more information and confirmation was required, although this process proved expensive.

4.9.2 Transferability

Transferability is concerned with the degree to which the findings can be applied in other contexts with other participants (Babbie and Mouton, 2007). The strategies for ensuring transferability include providing “detailed descriptions of data” (Babbie and Mouton, 2007, p.277). To ensure detailed descriptions, comprehensive descriptions of the data are provided in the following chapter.

4.9.3 Dependability

Dependability is concerned with the consistency of findings, especially if the study is repeated in a similar context with the same or similar respondents (Babbie and Mouton, 2007). In order to address issues of dependability, the usage of similar research methods could address consistency of findings. Furthermore, the chosen research methodology ensured dependability due to the coherence between the research paradigm, research design, and data analysis.

4.9.4 Confirmability

Confirmability is concerned with the degree to which the results of the study could be verified by the respondents and not the researcher’s bias, motivation and interests (Smith, 2012). For the current study, confirmability was attained through confirmation of findings with my supervisor, and teachers were also contacted telephonically and through emails, – although the latter was not successful – to confirm or clarify their original meaning. The telephone conversations with teachers were effectively used, especially in the early evenings when I was sure of the possibility of the teachers being home. I had detailed conversations with teachers as they re-explained some information as a way of clarifying their original responses. As mentioned earlier, although this process meant a high telephone bill, it was successful in ensuring confirmability of the information and in doing so, representing teachers accurately.

4.10 Ethics

Researchers must fully understand the effects of research on its participants, and also uphold the dignity of their fellow human beings and not inflict any pain upon them (Cohen et al, 2007; Scott and Morrison, 2005). On the same line of discussion, Creswell (2007) suggests that in order for the participants to share information honestly and openly, the researcher should identify an environment that is comfortable for them, where they feel secure enough to reveal information. Given this, information letters were issued to all participants to ensure that they were cognisant of their rights throughout this study. I also applied for ethical clearance from the Ethics Committee of the University of the Witwatersrand and my proposal was subsequently passed before the study could commence. Since this study is located within a larger research project, permission to conduct the study at the selected schools was granted after my supervisor sought permission from the Mpumalanga Department of Education to do so (see appendix D). To gain access to the schools, I used the larger project's acceptance letters from the Mpumalanga Department of Education (MDE) to gain access to the schools and to work with the selected teachers.

4.10.1 Informed consent and the right to withdraw

Obtaining consent from research participants is an essential aspect of social research, because participants experience an invasion of privacy (Cohen et al, 2007; Babbie and Mouton, 2007). The study solicited participation of the teachers through their written consent. Permission was granted by the teachers to allow the researcher into their classrooms when filling in the consent forms (see appendix C). Further consent was given by the principal to allow teachers to contribute as research participants after reading and agreeing upon the information sheet for principals (see appendix A). It is also important to note that while a participant may have given their consent, they had the right to withdraw at any point once the research had begun (Cohen et al, 2007). With this in mind, the participants of this study were informed in writing in the information letter that they are allowed to withdraw from the interview or observation at any time without any consequences (see appendix B).

4.10.2 Anonymity

Any information provided by participants should in no way reveal their identity as individuals (Cohen et al, 2007 and Babbie and Mouton, 2007). As a result, in this study the teachers' identities were protected through the use of pseudonyms in the research report. Furthurmore, the schools names were anonymised.

4.10.3 Confidentiality

Even though researchers may be able to identify participants from the information given during the data collection process, they should by no means expose the participants in public (Cohen et al, 2007: Babbie and Mouton, 2007). The teachers were assured in writing on the consent forms that their identities would be protected at all times and that the information collected would be used only for academic purposes. In my case, the information collected will be used for my degree requirements, the project, conference presentations, and journal publications.

4.11 Chapter summary

A qualitative research approach was employed in conducting this research, as it allows the researcher to obtain an in-depth look at a certain phenomenon in order to gain an understanding of that particular situation. Semi-structured interviews, VSRIs and semi-structured non-participatory observations were used as tools in the data collection process because they have the ability to address the study's research questions (Creswell, 2012). Additionally, this chapter outlined important aspects regarding the different methods involved in conducting and analysing qualitative data. Lastly, the essentiality of ethics and that which it encompasses were also taken into account (Cohen et al, 2007).

Chapter 5

Making sense of mathematics teaching: data presentation, analysis and discussion of findings

5.1 Introduction

In this chapter I critically discuss the findings of the study which explored grade 3 rural teachers' mathematics content knowledge and coherent mathematics teaching after having used classroom semi-structured observations, semi-structured interviews and video-stimulated recall interviews. To interpret and discuss the findings, I use photographs to illustrate occurrences during lesson observations for readers to also see what I am referring to. I also use teacher's excerpts as evidence of their utterances during interviews and video-stimulated recall interviews to exemplify teacher mathematics content knowledge and the process of coherence while teaching mathematics.

This study views *'coherence'* in a twofold manner. First, it views coherence in a 'whole' sense and calls it *macro coherence*, as all parts of the lesson fitting together without contradiction. It is the coherence that exists within a 'whole' lesson - from the beginning until the end of the lesson, that is, from the lesson topic, to the examples, tasks, teacher talk and teacher and learner interaction, making use of mathematics discourse in instruction (MDI) (Adler and Ronda, 2014; Adler and Ronda, 2015; and Venkat and Adler, 2012). Secondly, it views coherence in 'parts' of the lesson and calls it *micro coherence*, as the coherence that exists within 'part/s' of a lesson. For example, coherence may exist between the teacher's example and the teacher talk, but the lesson activity may cause incoherence because it doesn't fit in well with the whole lesson. This study also looks at incidences where *incoherence* occurs and views at it as the moment in the lesson where coherence becomes ambiguous and introduces contradictions. Incoherence is also seen when mathematical uncertainty in the structure of the lesson or in parts of the lesson occur and learner understanding is hampered. This may be due to a teacher teaching the learners content that is mathematically incorrect, for example, if a teacher is teaching a lesson on ‘place value’, and instead of using hundred, tens and unit cards to indicate place value only uses unit builder cards to teach the concept of place value (builder cards are used to help learners understand the concept of place value). This may hamper learner understanding and also cause incoherence in mathematics understanding regarding the concept of place value.

In this chapter, I specifically focus on the interpretation of data and critically discuss the themes and sub themes for the study. Two themes emerge: theme one is the significance of mathematics training and professional development and theme two is incoherent and coherent mathematics teaching.

5.2 Theme one - The significance of mathematics training and professional development

It is undeniable that passionate teachers play a powerful role in the process of teaching and learning (Hattie, 2003), however, passion on its own is never enough. Appropriate content knowledge influences teaching as Kanyongo and Brown (2013) posit that teacher content knowledge is important in three main ways: it influences how teachers engage students with the subject matter; it influences how teachers evaluate and use instructional materials and it is related to what students learn in the classroom.

From the participants’ responses, mathematics training was insufficient and not prioritised, as illustrated by Charlotte, a Foundation Phase teacher who has over 20 years of experience in teaching said:

> *“With us, they didn’t cover maths as well as the students who studied for a Senior Primary Teaching Diploma (SPTD). With regards to mathematics, we were not well-trained. The SPTD teachers were trained well in mathematics.”*

Her response suggests that lower primary teachers did not receive in-depth training in mathematics, which proposes an ‘inferior’ introduction and presentation to mathematics knowledge and raises questions about preparedness on mathematics pedagogical knowledge. This response also proposes that lower primary teachers’ training was not prioritised as compared to SPTD teachers, and again raises questions about their content knowledge in the subjects that are taught in

Foundation Phase. In addition, the participant stated, *"I was not that good in maths … not everybody can do maths"*, suggesting a need for proper mathematics training, to close the personal and schooling mathematics gap. The under-training of lower primary teachers in teacher training colleges led to a gap in mathematics content knowledge.

Notwithstanding the recognition that not everybody can do maths, it is still expected that a teacher has what Ball, Thames and Phelps (2008) calls "Common Content Knowledge" (CCK) which is "the mathematical knowledge known in common with others [i.e. not teachers] who know and use mathematics" (p. 389). If the participant was not good in mathematics and also experienced undertraining in mathematics knowledge, it becomes important to gain insight on how mathematics lessons are taught and whether awareness of mathematics coherence exists. Ma (1999) describes the need for primary mathematics teacher knowledge to exhibit profound understanding of fundamental mathematics, which is seen in awareness of connections between concepts and progressions of key ideas allowing for flexible movements between representations and related ideas. While Venkat and Adler (2012) are concerned with the disconnections evident in teaching at all levels of the South African schooling system, the participant's response presents the importance of understanding teacher's training backgrounds in relation to their personal experiences of mathematics to make sense of the disconnections.

Charlotte assumed that senior primary teachers were better trained in mathematics when compared to lower primary teachers. Fonky, a trained SPTD teacher with over 20 years of experience in teaching said: *"My training was not enough. I was trained in a lot of things but maths was not stressed upon at college … and coming into the field is a different thing."* The response indicates that even senior primary teachers did not receive appropriate training in mathematics knowledge and teaching; it was not recognised as one of the important subjects for primary teachers to specialise in. Although the reasons are unclear, it is suspicious that the undertraining colluded with Verwoerd's statement as mentioned in chapter 2, when he said "...What is the use of teaching the Bantu child mathematics when he cannot use it in practice?" (Hirson, 1979, p.45). If this was the case, it is unsurprising that lower and senior primary teachers in this study were undertrained in mathematics, to produce a particular product that will be limited to manual and menial work. Considering that primary teachers were well-trained in other subjects and methods, having received mediocre training in mathematics is concerning, given the importance of laying good mathematical foundations. The responses make it interesting to observe the teaching of mathematics topics and concepts, and whether teachers reflect on their teaching as the lesson progresses.

It is because of such teacher training experiences in colleges during apartheid that teacher content knowledge became a popular topic in post-apartheid South Africa. Taylor and Vinjevold (1999, p. 230) summarized 54 studies and "the conclusion is that teachers' poor conceptual knowledge of the (mathematics) subjects they are teaching is a fundamental constraint on the quality of teaching and learning activities, and consequently on the quality of learning outcomes." Thus, it is important to observe mathematics lessons given the under-training and recognition that "*coming into the field is a different thing"*, which suggests a need to interrogate mathematics coherent teaching.

Inadequate training in mathematics affects teacher Mathematics Content Knowledge (MCK) negatively, which in turn affects PCK negatively, as stated by Thembiwe:

> *"Even some of us, the maths information, we don't know it … calculating distance as a teacher, I don't understand it, so what can happen to a learner? Mathematics training workshops are too short … mathematics content is large."*

The participant demonstrates the importance of comprehensive content knowledge and expresses concern regarding insufficient understanding of knowledge about calculating distance, which could influence the teaching, learning and understanding of mathematics concepts or lack thereof. On the same line of discussion, it is also interesting to note that the participant reflected on one of the difficult concepts of a lesson during the interview, which illustrates that rural Foundation Phase teachers continue to experience mathematics knowledge gaps, irrespective of attending workshops for professional development. Dörfler (2000, p.339) states that teaching and learning mathematics is a process of "learning to use and understand its language, its symbols, its diagrams, mediators and its procedures" to teach mathematics concepts and rules effectively and explicitly. The participant's response shows that it is challenging to mediate mathematics knowledge if the knowledge is insufficient, which might further influence effective and explicit explanation of mathematics concepts. In addition, Venkat and Adler (2012) state that teacher's work is to teach mathematics concepts explicitly and in a relational manner for learners to understand the continuity of mathematics concepts, which can only happen if a teacher is confident with the content knowledge.

Teacher workshops are perceived as lacking focus in enhancing teacher's content knowledge, Carol said: *"The in-service training helps with policy, not content, because just when you start to understand and get used to it (content), it changes."* The workshops are critiqued for lack of enhancing teachers' content knowledge, especially for mathematics which is a challenging subject for teachers. The history of under training resulted in inadequate mathematics content knowledge. In addition, when teachers start to grasp mathematics content knowledge, topics are changed when curriculum reform occurs, leaving teachers with incomplete knowledge. While Boston (2013) argues that "Better teaching requires teachers to engage in learning experiences that transforms their knowledge and understanding of how mathematics is best taught and learned" (p. 8), the participant suggested that the focus on policy understanding and implementation without foregrounding and enhancing teacher's content knowledge could result in ineffective teaching and learning.

Of concern for the study is that if Foundation Phase, especially grade 3 teachers' content knowledge is not well developed in workshops, where else can they be assisted with professional development. Such an experience could perpetuate social inequality because rural learners might have mathematics knowledge gaps, and it may limit future choices. Although not the focus of the study, teacher's insufficient knowledge affects learning if compared with urban learners who have various centres to attend for mathematics extra classes, and rural learners are disadvantaged when it comes to the luxury of choices for extra mathematics lessons. These findings suggest that the department needs to re-evaluate the nature of workshops, especially for rural teachers who evidently have restricted mathematical knowledge to confidently teach learners.

5.3 Theme two: Incoherent and coherent mathematics teaching

Findings pertaining to incoherent and coherent mathematics teaching as well as factors which influence coherent mathematics teaching are presented in this theme. This theme entails three sub themes, namely: visual representation-instructional-incoherence, occurrence of macro- coherence and factors which influence coherent teaching.

5.3.1 Sub theme one: visual representation-instructional-incoherence

This theme presents the role of teacher talk in relation to the visual representation of mathematics concept(s) during teaching. It also discusses whether there was coherence during lessons or not. The nature of teacher mathematics content knowledge, teacher talk and mathematics visual representations come to the fore from the data generated, and influences coherence within mathematics lessons. To illuminate this sub-theme, I only selected specific episodes within each lesson, instead of focusing on the entire lesson. An episode constituted specific parts of lessons where occurrences of coherence and/or incoherence had occurred.

One mathematics lesson in English by teacher Fonky pertaining to the topic of *symmetry* will be used and five episodes will be extracted from this lesson. Two mathematics lessons in Xitsonga will be used by teacher Thembiwe, the first lesson pertains to the topic of *place value* and the second lesson pertains to the topic of *rounding off*. From each of these lessons two teaching episodes are extracted and discussed. Similarly, two different mathematics lessons in Xitsonga will be extracted and discussed from teacher Carol, lesson one pertains to the topic of *addition using the method of expanding the digits according to place value, adding the tens together, adding the units together, re grouping them and then adding to get the final answer* - four teaching episodes are extracted from lesson one and discussed. Lesson two pertains to the topic of *place value* and three teaching episodes from lesson two are discussed. For a brief overview of each lesson see appendix G.

Teacher Fonky (English medium school)

Teaching episode 1 - incoherence between the lesson topic written on the board and the lesson enacted

Fonky has over 20 years of teaching experience and was trained as a Senior Primary teacher at Mapulaneng College of Education. Interestingly, she didn’t attend high school but was able to complete a SPTD during the apartheid era. Although I was surprised, Bunting, Sheppard, Cloete and Belding (2010) state that the first ever national audit of teachers in South Africa found high numbers of un and under qualified teachers, as well as fragmented provision of teacher education and training. Considering Venkat and Adler's (2012) explanation that teachers' mathematical discourses in instruction (MDIs) is essentially what teachers say, do and write during teaching and learning, Figure 1 below presents the beginning of the lesson where Teacher Fonky wrote: 'Symmetry line and symmetry shape on the board, making the lesson concepts explicit to the learners.

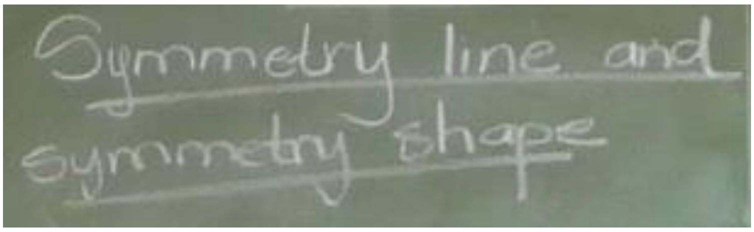

Figure 1: Lesson heading - Teacher Fonky

The writing of the topic on the board prepares learners for the lesson and what to expect, and Mathematics Discourse in Instruction (MDI) states that the action of making the lesson objective/goal clear to the learners is vital. It is expected that a teacher follows the lesson objective during the lesson, which means present the lesson coherently in relation to the topic written on the board to ensure that learners don't get confused. During the whole lesson Fonky foregrounded symmetry lines and did not mention anything about symmetry shape, even though both concepts were still on the chalkboard. Of concern is that Fonky told learners at the beginning of the lesson that they will be learning about symmetry line and symmetry shape (as figure 1 illustrates), and yet she did not present any content specific to symmetry shape considering the relationship between the concepts. There was no coherence between what was written on the board and what the teacher taught.

Considering that Fonky taught symmetry line for the entire lesson and never mentioned symmetry shape, I was surprised when she introduced place value as a new topic in the next lesson without concluding the previous topic. I wanted to understand the reasons for such a decision and I used a video-stimulated-recall interview to engage in a conversation with Fonky.

Researcher: *Are symmetry lines and symmetry shapes different or are they related to each other?'*

Fonky: "*I can say that they are different because with the symmetry shape, they are supposed to finish it and the line just shows that the shape is cut in half.*"

Researcher: showing her the clip of her writing symmetry line and symmetry shape on the board, I asked: "*from this clip ma'am, do you think it was important to explain the difference between symmetry lines and symmetry shapes in your lesson*?"

Fonky: "*It is very important, because with symmetry lines, they are going to draw the line. Then symmetry shapes, we will give them the other part, then they will finish up the other part to be the same as the other part."*

This VSRI response illustrates that Fonky is aware of the difference and also acknowledges the importance of explaining the difference to the learners, although during the lesson she did not explicitly explain the difference to the learners instead prioritised the teaching of symmetry line. In addition, Fonky focused on talking about the differences and not the relationship between the two concepts, which linked with her inability to explain how she could have linked the two concepts in the same lesson or else build the foundation of one concept for the next one. Thus, Fonky's presentation and representation of mathematics content is revealed through the teaching approach of concepts as isolated rather than interrelated. It is concerning that the teacher took it for granted to explain at the beginning of the lesson to the learners that symmetry lines will be taught first followed by symmetry shape as related concepts, to ensure that learners do not think of the two concepts as isolated but relational. There was an assumption by the teacher that learners would figure out the structure of the lesson themselves.

While I did not expect grade 3 learners to ask the teacher about symmetry shape, the teacher did not think of explaining to the learners the reason for not engaging with symmetry shape. It could be argued that the teacher took advantage of their lack of mathematics knowledge, because she knew they would not question her about the missing information about symmetry shape.

I noticed that the reason for introducing place value was because the teacher followed the NECT programme (mentioned in chapter four), which stipulated that she needed to teach place value, seemingly, irrespective of whether the previous topic and concepts are completed or not. Even though this was the case, the teacher could have planned the lesson properly to ensure that both concepts were taught relationally. The discontinuity with symmetry shape and the introduction of place value could result in knowledge gaps and confusion for the learners when the topic is re-introduced in future. Due to such practices there was incoherence between the lesson topic that was written on the board and the actual incomplete lesson, and it was also unclear whether and when the teacher would teach symmetry shape after introducing place value.

Teaching episode 2 – the Nature of teacher talk

Fonky continued with the lesson and said:

Teacher: "*Before we get deeper, what is a symmetry line?"*

Teacher: (without giving learners the opportunity to respond) "*A symmetry line is a line that shows two pieces, that the one is the same with the other one."*

Fonky did not give learners the opportunity to respond to the question, to allow learners to participate in the lesson, possibly rushing to continue with the lesson. While giving the response the teacher did not use mathematical language to explain symmetry line as quoted above. To use a formal definition, a symmetry line divides a figure into two mirror-image halves (Stylianou, and Grzegorczyk, 2005). I initially assumed that the teacher wanted to simplify the concept for learners to understand the basic meaning, but further engagement with the explanation made me realise that her choice of words made the definition unclear. The teacher's explanation may result in misunderstanding, where learners might think that symmetry line means that two parts of the line are the same. However, it is irrelevant if the line is the same because the line is the split that shows two halves of the image as the same.

According to Sfard (2008), pertaining to words and their uses, mathematics has its own language to be used during explanation, therefore, in FP it is important for teachers to be aware of the words they use in class while explaining mathematics concepts, because mathematics words have their own meaning that learners need to distinguish and understand. Such an explanation could be classified as ineffective because learners may lose the foundational meaning of the concept.

Teaching episode 3 - real-life examples (micro-coherence)

Fonky continued with the lesson and called a learner in front of the class; she then placed a long ruler vertically down the middle of the learner to demonstrate the concept of symmetry. Episode 3 represents the usage of real-life examples to reinforce the meaning of the concept which is crucial in Foundation Phase as learners also learn by visual examples.

Teacher: "*When you cut him in half, you find symmetry. On this side there's an ear, on that side there's an ear, on this side there's a hand and on that side there's a hand, and the ruler is the symmetry line."*

To illustrate the concept further, she introduced a mirror:

Teacher: "*If you want to know better, we can use a mirror."*

The teacher used a flash card with the number 50 and placed the mirror between the five and the zero in the middle of the card to show learners that the 0 appears on the flash card and it also appears on the mirror. With these examples, we see facets of MDI, exemplification, because Fonky used real-life objects to mediate understanding. She used the real-life examples and linked them to the lesson concepts using teacher talk, adding meaning to the concept for the learners thereby enabling them to understand the concept of symmetry. The use of two different real-life examples illustrate that the teacher is able to teach the same content in different forms to enhance learner understanding. The teacher showed the illustration to all six groups as a way to further clarify what was meant by symmetry, ensuring micro coherence between the explanation and usage of visual representation and in doing so displaying evidence of effective teaching.

According to Sfard (2008) (in Berger, 2013), the use of 'visual mediators' constitutes mathematical thinking or communication while visual mediators are used as objects with which to think or communicate. Considering the grade of learners, the teacher used appropriate objects to explicitly show learners what she meant by symmetry line, which illustrates that she understood the basic meaning of the concept. The use of visual examples helps learners to see the usage of and also make sense of the meaning of the concept as it connects with the explanation. It could then be argued that there is micro-coherence in the teacher's explanation and visual examples that were used to illustrate the concept, because the examples fitted in well with the teacher's explanation of the concept. They were coherent and less likely to confuse learner understanding given the grade of learners. The visual representations that the teacher uses play a vital role in mathematics instruction, because each representation provides information about certain aspects of the concept (Kaldrimidou and Ikonomou, 1992). Furthermore, according to the Foundation Phase Mathematics CAPS document, at Grade 3 level learners should be able to recognise and draw line of symmetry in 2-D geometrical and non-geometrical shapes (2011, p.27). Given this, it is good that the teacher is using real life examples (non-geometrical shapes) to show learners that symmetry exists, hence fulfilling a requirement of CAPS.

The attendance of workshops exposed Fonky to different methods of teaching mathematics, irrespective of being undertrained, as her response illustrates: *"… I was used to go to some of the workshops that helped me … you must have content knowledge because you cannot teach without knowing anything."* The teacher was aware of her limited mathematics knowledge, possibly through reflection, Fook (2007) states that reflective practice may lead to fundamental changes. The participant took it upon herself to improve her mathematics content knowledge by attending teacher professional development workshops.

Teaching episode 4 - paucity of mathematics discourse

In this episode of the lesson Fonky drew a 'square' on the board, (see yellow highlighted square in figure 2 below):

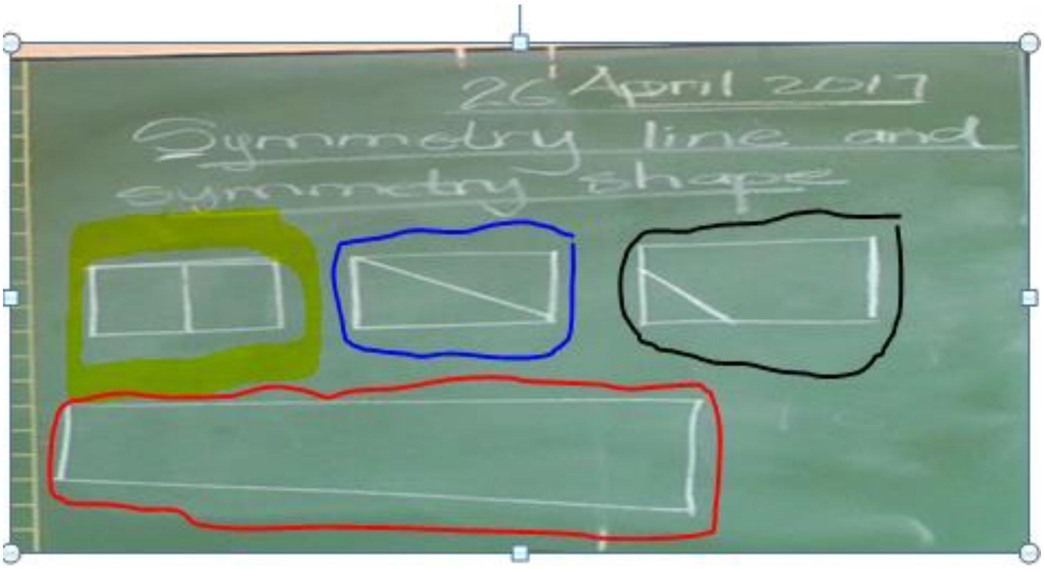

Figure 2 - Symmetry and Asymmetry illustrated on the board

The teacher asked the learners:

Teacher: *"What is this shape called?"* (See yellow highlighted square in figure 2)

Learner: *"It's a square''*.

Teacher (probe learners): *"Who can tell me why it's a square?"*

Learner: *"It's a square because it has four corners."*

The teacher immediately went back to the board and drew a rectangle (see red highlighted rectangle in figure two) and said:

Teacher: "*This also has four corners".* She waited for a while until one learner raised her hand.

Learner: "*Teacher, it is a square because it has four equal sides."*

The teacher's probing is significant in this example because it shows that she wanted to make sure that learners are linking previously learnt mathematics concepts regarding shapes to the current lesson. By doing this, Fonky is illustrating that it is not enough that learners give a chorus response, but it is important to be sure that the answer is mathematically correct (Kazemi, 1998). In addition, considering that teacher's questions play an important role in managing classroom routine, it could be argued that the teacher used referential questions that aim to convey the answer through interaction with the learners (Hamiloğlu and Temiz, 2012). Without overlooking the teaching approach above, of concern with the usage of the rectangle drawn on the board is that the teacher didn't address what symmetry is in a rectangle, but seemed to take it for granted that learners would transfer the existing knowledge to make sense of symmetry in a rectangle.

To continue with the lesson, Fonky took a ruler and 'estimated' the middle of the square (see figure 2 highlighted in yellow) and drew a solid line in the middle of the square. The challenge with this practice is that instead of estimating, the teacher could have used a ruler and measured the square to find the centre of the shape to emphasise proper practice. Considering that learners practice what they have observed from the teacher, especially in FP, it is worrying that the teacher took a short-cut and did not properly demonstrate to learners how to measure the square to ensure symmetry, a practice that might encourage learners to also 'cut corners' when engaging with such tasks. While MDI insists that teachers should be aware of what they say, do and write during teaching (Venkat and Adler, 2012), the teacher told learners to draw a 'straight line' to show symmetry rather than a 'vertical line'. She did not show learners that the square can be symmetrical if a line was drawn horizontally in the square, and this might hamper learner foundations which should be built well for future grades.

Fonky drew another square on the board, and drew a diagonal line from the top left corner to the bottom right corner (see blue highlighted square in figure 2 above) and asked the learners if it was symmetrical. The learners exclaimed in the affirmative. At this point in the lesson, according to MDI, *explanatory talk*, she did not use mathematical language, because, instead of using the term 'diagonal', she said: "*straight line from one corner to the other*" as she drew it. Since she does not use the terms *vertical* and *diagonal* during the explanation process, when learners proceed to a different grade and encounter these concepts, they will struggle to make sense of them due to lack of mathematics discourse.

Of concern with the manner in which Fonky drew 'squares' on the board is the taken-for-granted assumption that all shapes in the top row of figure 2 were 'squares', even though she did not measure all 4 sides to be equal to ensure proper presentation of knowledge. This seems to be a mathematical routine that Fonky follows to communicate mathematical ideas to the learners and may be detrimental to future mathematics learning (Sfard, 2008).

Teaching episode 5 - incoherence between visual representation on the board and lesson activity appearing in the textbook

Learners were asked to open to page 110 of their Department of Basic Education (DBE) books to complete the activity. See Figure 3 below.

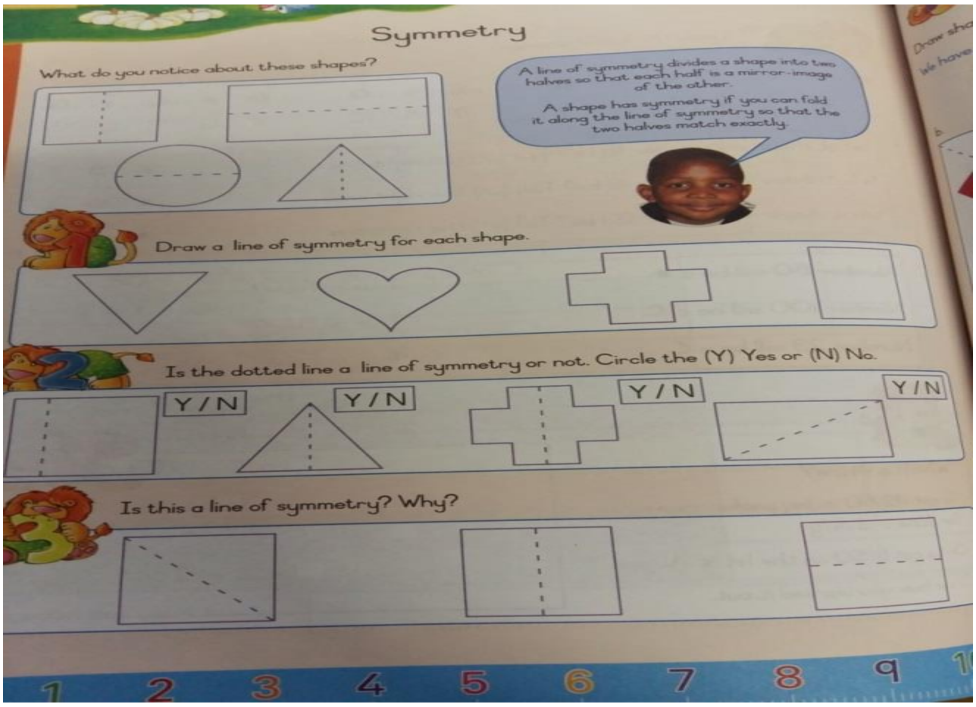

Figure 3 – Lesson activity

There is incoherence between the teacher's representation of symmetry line using a solid line (in figure 2 earlier) and the textbook activity (in figure 3 above) that shows the line of symmetry using a broken line, which may seem like a small error but could hamper learners' understanding of what a symmetry line should look like. This means that learners might use both representations of a symmetry line because the teacher did not explicitly explain during the lesson whether it is acceptable for a symmetry line to be drawn in both ways, either dark and continuous as she had drawn them, or broken as it appears in the textbook.

With regards to the abovementioned, in the video-stimulated interview, I asked the teacher if there was a specific reason for using a solid line rather than a broken line to show symmetry. She said: *"I thought maybe when I'm using a solid line they will easily understand that it means you cut it. They will easily understand that the other* *part is the same with the other part. When you do the broken line, it's also the same as a solid line. There's no difference."* The teacher wanted to simplify the content and make it 'easy' for them to understand its meaning, this may be a reason why she stated that there is no difference between a broken line and a solid line. The teacher's purpose for simplification rather than representing mathematics concepts effectively illustrated the teacher's misconceptions of mathematics discourse and caused incoherence between the teacher's talk, mathematics representations on the board and the lesson activity given to the learners (Venkat and Adler, 2012).

Sfard (2008) posits that the teacher should be able to use mathematics terminology and communicate it effectively through talk and representation. The nature of communication has great impact on the learners' understanding of mathematics concepts or lack thereof and completion of mathematics tasks (Sfard, 2008). Along the same line of discussion, during the video-stimulated interview with the teacher I asked whether she would teach the lesson differently and address the usage of a solid line to show symmetry to ensure that learners grasp the proper concept, and she confidently said she would not change it because the solid line will help learners to remember better than a broken line. The teacher seems to argue that it won't make any difference whether a solid or broken line is used for learners to understand this mathematics concept and how to use it, therefore, overlooking the importance of enforcing mathematics principles that learners will be required to use in future grades.

Of interest is that the teacher reiterated what she said earlier, that "…*When you do the broken line, it's also the same as a solid line. There's no difference…*" a reason she won't change the way she teaches it. Considering the above, Adler and Ronda (2014) posit that learners' access mathematical learning through the teacher's discourse (Adler and Ronda, 2014), this is a concern when teachers do not represent mathematics topics properly. In particular, when Dörfler's (2000, p.339) statement is taken into consideration that teaching and learning mathematics is a process of "learning to use and understand its language, its symbols, its diagrams, mediators and its procedures", to teach mathematics concepts and rules effectively and explicitly.

In addition, when asked in an interview what she understood by coherent teaching, she said: *“I don’t know, I’ve never heard of this term before.”* This may be the reason why she does not teach to enable effective progression of topics, her lack of mathematics discourse and pedagogical errors may be enabling factors which hinder her from teaching coherently.

Teacher Thembiwe (Xitsonga medium school)

The following episodes include extracts of two different Mathematics lessons taught by the same Teacher

Teaching episode 1 lesson 1 - unclear lesson objective

Teacher Thembiwe had 13 years of experience in the teaching profession and studied a Junior Primary Teaching Diploma (JPTD) at the Mapulaneng College of Education. At the beginning of the lesson, Thembiwe did not mention the lesson topic to the learners, making the lesson objective unclear to identify. It is important for teachers in general and specifically for FP teachers to clearly indicate the lesson topic, to allow learners to think within that frame of mind during the lesson. MDI emphasises the importance of teachers making the topic of the lesson explicit, to form the basis for coherence in a lesson and allow learners to see concept continuation (Venkat and Adler, 2012). Considering the importance of stating the objective of the lesson, the teacher should have highlighted that the topic of the lesson was ‘place value’, rather than leave it to learners to figure it out as she continues to teach.

Teaching episode 2 lesson 1- mathematical content error

The teacher took out number builder cards and placed them on a desk in front of the class. She selected a learner and verbally instructed: *“Use the number builder cards to build the number 329 according to place value”*. The learner did what the teacher asked by placing what he believed to be the relevant cards on the board, to which the teacher commented: *“Good”* (see figure 4)

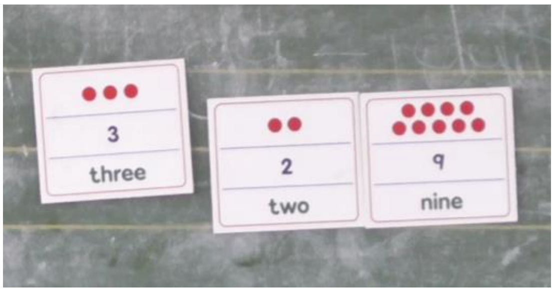

Figure 4 – Mathematically incorrect unit number builder cards to show place value

Notwithstanding that the teacher took it for granted whether the learner understood what place value was or not, a mathematical content error occurred because the number cards were all units. The numbers are not correctly represented in the number cards, because they were supposed to show 300, a 20 and a 9 according to place value. It may be assumed that the teacher took the value of representation for granted, as it was not representative for the purpose of the lesson.

Thembiwe then pointed at the 329 representation on the board and said:

Teacher: *"Thinking of place value, what does the 9 stand for?"* At this point, the teacher is talking as if she has introduced the concept before, it seems like she's building on content taught in a previous lesson.

Learners: "*vun'we*" (units in English)

The teacher pointed at the 2 and asked the learners what it stands for and learners responded "*vun'we*" (units). She looked at them and further asked:

Teacher: *"Are you sure?"*

Learners: Only a handful of learners realised the right answer and said **"***vukhume***"** (tens in English)

Teacher: she pointed at 3 and asked what it represented

Learners: shouted out in a chorus "*vun'we*".

Teacher: She then asked the same question again.

Learners: once more a handful replied **"***dzana*" ('hundreds' in English)

Teacher: *"very good"*

There is a gap between the representation on the board (see Figure 4) and the place value questions the teacher asked, which means that the teacher's talk was not coherent with the representation of numbers on the board. She did not make a concerted effort to write it out as 300, 20 and 9 to make the place value explicit to the learners or write 'H T U' (hundreds, tens and units) on top of each number to indicate its value. In addition, the teacher's choice of unit number builder cards to represent place value on the board could cause a disjuncture in learners' understanding of place value, which was noted when few learners participated while she questioned them about the 329. For MDI, another challenge may arise in identifying learner misunderstanding because of the nature of the patterns of interaction that was practiced during the lesson, where a teacher resorted to use chorusing approach to present the lesson topic (Venkat and Adler, 2012). Considering Adler and Ronda's (2015) concerns about what learners are invited to say, and specifically whether and how learners have the opportunity to speak mathematically and to verbally display mathematical reasoning, it could be argued that Thembiwe did not give learners the opportunity to verbally display mathematical reasoning because of her chorusing teaching approach that conceals learners whom do not understand the concept. The teacher only focused on learners that gave the correct answers and overlooked the majority that showed no understanding of the concept.

Even though the assumption for the chosen interaction could be due to the challenges of overcrowding and possibly pressure on teachers to finish the syllabus on time, of concern is that in FP classes such choices might influence individual learner interaction negatively, as mentioned above, because the teacher focused on learners who gave the correct answers and no mediation occurred to help the learners who gave incorrect responses. The majority of learners did not provide the correct answers, possibly because they were not sure of the right answer. Although, this is alarming as the content should have been introduced and covered in Grades 1 and 2 (CAPS, P.20), Alshwaikh and Adler's (2017) observation is relevant when they state that it is "common in South African schools to meet learners who face challenges in the current lesson because of lack of prerequisite knowledge" (p. 7). Nonetheless, it is worth arguing that in rural schools, it is worse because of teacher's insufficient mathematics content knowledge, and lack of alternative centres to attend if a teacher wishes to enhance content knowledge as compared to cities with various places including universities. Considering the correct responses from the handful of learners', it highlights the complexity of making judgement in a lesson, where a teacher has to decide whether to address learners' mathematical errors based on the majority of struggling learners or to proceed with the lesson and later support learners who face challenges (Alshwaikh and Adler, 2017). This takes into consideration the pressure for teachers to finish the syllabus and be at pace with the lessons as expected by the department.

Teaching episode 1 lesson 2 - teacher questioning causes confusion amongst learners

The teacher wrote the representation below on the board and asked learners questions

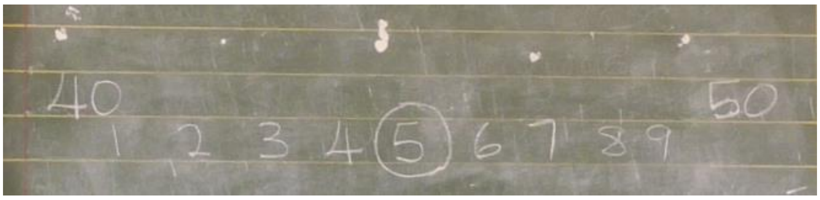

Figure 5- rounding off to the nearest 10

Teacher: *If we are counting in multiples of 10, how many fingers would you use to show the number 40?*

From the teacher's question learners used their fingers to count and showed the teacher 4 fingers. She then moved on and asked learners:

Teacher: "*What is the number between 40 and 50?*"

Learner: "*10*"

The teacher realised that the learner got the answer incorrect and others were not attempting to answer it. This is possibly because the structure of the question was confusing; it may have been confusing because 9 numbers exist between 40 and 50, that being 41- 49. She did not rephrase the question, rather told the whole class to quickly write down all the numbers from 41 to 49, and look at it carefully and then find the number in the middle. It is interesting that the representation was on the board the whole time (see figure 5), but learners did not look at it. Here we see the importance of a teacher framing the questions before asking FP learners, as it might cause confusion (Martino, and Maher, 1999). After the task many learners shouted out the number 45 which was correct. When the teacher asked learners to engage with the task after writing it, they were able to do what she initially wanted them to answer verbally. This illustrates the importance of correct mathematics discourse when questioning learners so that no confusion may occur.

Teaching episode 2 lesson 2- mathematical sign incorrectly represented for lesson on rounding off

The teacher instructed learners to tell her any numbers which fit between 40 and 50 and they replied: "*41, 42, 45, 44 and 46*". She wrote each number on the board (see figure 6 below), then selected individual learners and instructed them to round off the number to the nearest 10, and all learners got the correct answer.

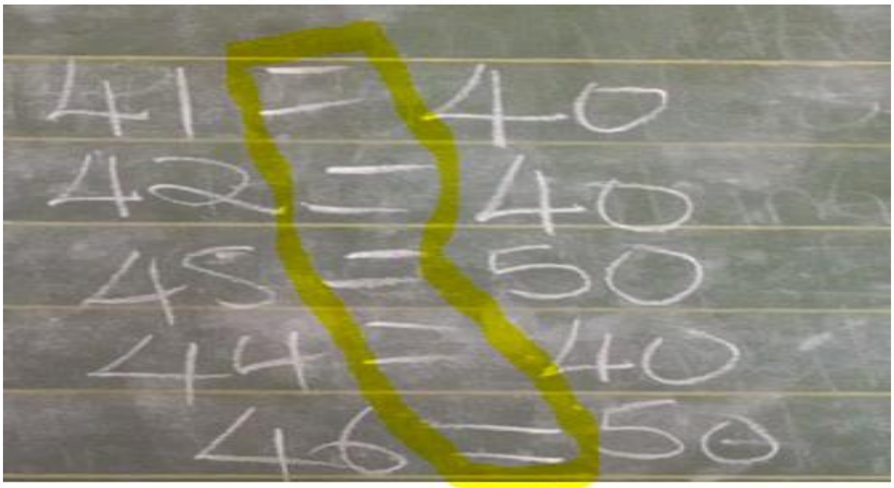

Figure 6 – incorrect representation of mathematical sign during classroom discussion

Although learners got the answer right, it is worth mentioning the incoherence between mathematics content and the representation of content on the board. This was noticed when the teacher did not use the correct mathematical discourse on the board, instead of using the mathematical sign ≈ (approximately equals to sign) she made use of the = sign (equals to sign) to signify rounding off (see figure 6).This is the mathematical routine that Thembiwe used to communicate mathematical ideas to the learners regarding the topic of rounding off, and should not be taken for granted because mathematically the signs do not mean the same thing. When rounding off, the value of the number changes, making it important to use the approximately equal to sign rather than the equal to sign. Regarding this episode, learners in grade 4 use the ≈ to signify when numbers have been rounded off, hence, the importance of words and their uses (Sfard, 2008). FP teachers need to be conscious of the words they use in class to explain mathematics concepts, as mathematics words have their own meaning. It is also imperative for learners to understand the meanings of words and concepts, so that they do not struggle in future grades when the concepts are built upon.

In addition, when asked in an interview if coherent concept connection is important in mathematics, she replied:

> *"Yes, it's very much important because if you're teaching in CAPS, we have ...how can I put it? If we have a grade one teacher, the teacher teaches addition from 1-10, a grade 2 teacher teaches from 50-100, a grade 3 teacher, from 100-500, just like that, so they are building up the content."*

This illustrates that the teacher is aware of the importance of progression in mathematics topics from one grade to another, but factors such as her lack of mathematics content knowledge and discourse as illustrated above, will have an impact on her teaching and this will in turn affect the logical progression of topics from one grade to another as required by CAPS.

The extracts from both lessons by Thembiwe illustrate that her misrepresentation of mathematics content and her usage of mathematics discourse is cause for concern, because it hinders coherent mathematics lessons. While the lesson was concerning, the teacher's response during an interview gives the context for the mistakes. She said: *"…Even some of us, the maths information, we don't know it … Mathematics training workshops are too short … mathematics content is large."* This highlights that the teacher is aware of the complexity of teaching mathematics concepts and realises that the in-service content training is not enough to cover all content that needs to be taught. Jansen and Christie (1999) and Jansen and Taylor (2003) attest to the fact that the training for mathematics and science teachers were far from adequate when it came to Outcomes Based Education (OBE) training, and Thembiwe's statement is a testament to the challenges teachers face with in-service CAPS mathematics content training. This is interesting because it means that in 2017 rural teachers' still experience challenges with adequate mathematics content, which influences effective teaching.

Teacher Carol (Xitsonga medium school)

The following episodes include extracts of two different Mathematics lessons taught by the same Teacher

Teaching episode 1 lesson 1- no clear lesson objective

Teacher Carol had 21 years of teaching experience, and was trained for a 3 year Junior Primary Teaching Diploma (JPTD) at West Minister College of Education in Johannesburg. Carol did not explicitly make the topic of the lesson clear to the learners. Learners are at a disadvantage when teachers do not make the lesson objective clear because they do not know precisely what they will be learning about.

Teaching episode 2 lesson 1- inconsistent representation of mathematical signs

Although teacher Carol did not make the objective of the lesson clear, she taught learners addition using the method of expanding the digits according to place value, adding the tens together, adding the units together, regrouping them and adding to get the final answer (see figure 7 below).

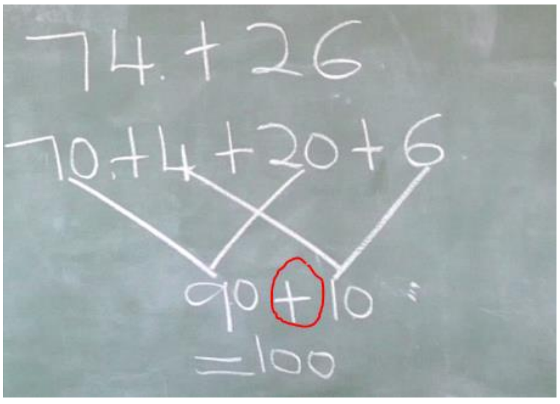

Figure 7 - one of the examples carried out by the teacher

In most cases she did not represent the examples mathematically due to inconsistent use of addition and equals signs (See figure 8 below), according to mathematics rules and principles.

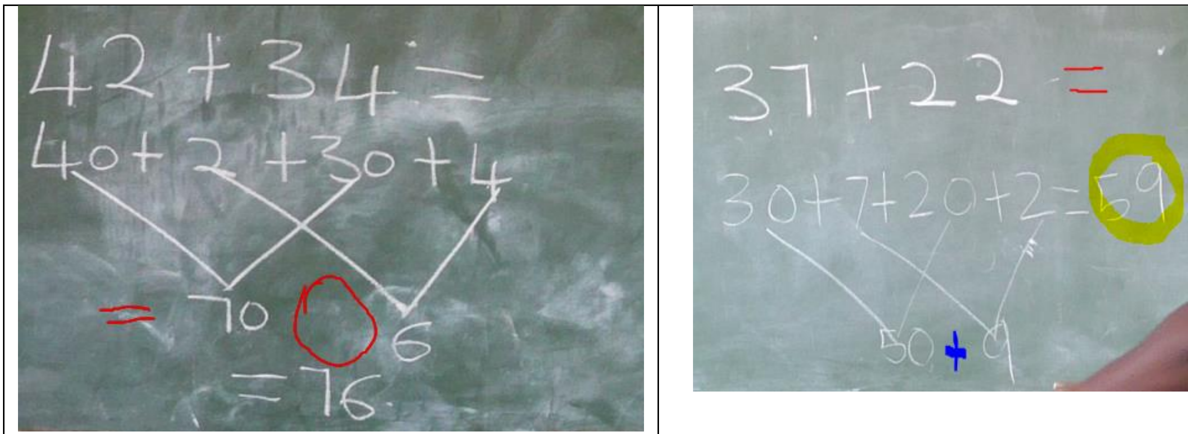

Figure 8 – inconsistent use of mathematical signs and structural incoherence

The above-mentioned may cause confusion amongst learners with regard to structural coherence, as ad hoc representations could negatively affect conceptual understanding in mathematics. The inconsistency on the part of the teacher is the cause for concern because Diezmann, Watters, and English (2002) advocate that when teachers are consistent in using the correct mathematical representations to children in early school years; it acts as a vehicle for developing important mathematical ideas and problem solving processes. Therefore, when teachers are inconsistent when representing mathematics concepts on the board, it may hinder conceptual development and learning of mathematics ideas in the current and future grades. Inconsistent mathematics representations cannot be taken for granted, especially when a teacher is laying mathematical foundations, it is fundamental that correct mathematics structure, rules and words are communicated to learners. This also addresses the importance of quality teacher training in Foundation Phase, to ensure that teachers have appropriate mathematical content knowledge so that mathematics concepts are taught effectively, explicitly and coherently (Hill, Ball and Schilling, 2008).

Teaching episode 3 lesson 1- lower order cognitive demand

The teacher works through these examples: 23+42, 36+24, 42+34 and74+26. During all the examples learners answered by chorusing as a whole class, as the teacher did not question individual learners. It is common for learners in the FP to chorus while working through mental mathematics in the mornings, however, FP teachers need to use other methods of questioning learners so that they are able to identify which learners lack understanding to assist them if necessary. I argue that all the examples illustrate that no higher order thinking skills were accessed, since she only explored numbers with two-digits as opposed to three-digit numbers. According to the FP mathematics CAPS document learners should be able to: "recognise the place value of three digit numbers and be able to decompose three-digit numbers up to 999 into multiples of 100, multiples of 10 and units " (2011, p.20). Furthermore, according to the element of MDI, exemplification, learner tasks require different actions, at different levels of complexity or cognitive demand in order to allow for different opportunities for learning mathematics (Adler and Ronda, 2015). This means that the teacher needs to plan effectively to allow for the different levels of complexity to come to the fore (Venkat and Adler, 2012). Given this, we may assume that teacher Carol does not plan her lessons adequately to enable a higher level of cognitive demand from the learners.

Teaching episode 4 lesson 1 - lack of teacher reflection and mathematics content knowledge lead to incoherence

In this episode the lesson took a different direction when Carol wrote 11+11 on the board, and incoherence was identified when the teacher did not write the = sign after 11+11 (see figure 9 – highlighted in red below).

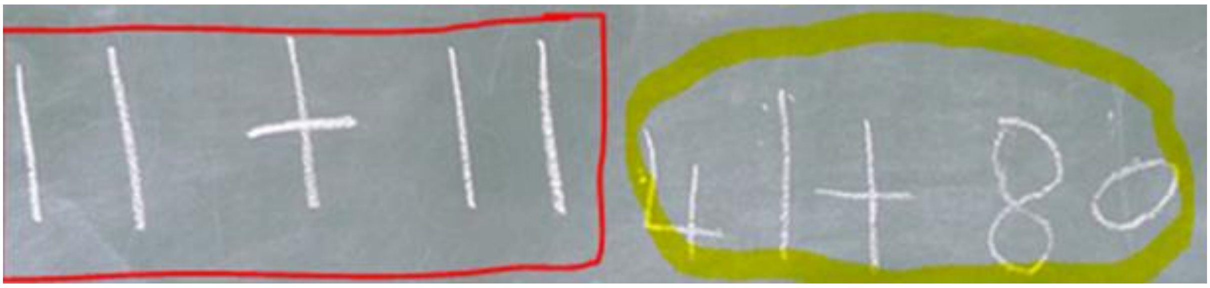

Figure 9- perplexity occurs within this lesson

When Carol did not use the equal (=) sign it illustrated the taken for granted usage of mathematics discourse while teaching her Grade 3 learners. Nonetheless, a learner was called out to the board to **"***complete the sum of 11 + 11".* The teacher was possibly under the assumption that the learner could have inferred from previous examples conducted in the same lesson, and that he would be able to add 11+11 using the method that she taught earlier in that lesson. Nonetheless, the learner wrote random numbers on the board as seen in figure 9 above, highlighted in yellow, and it is unclear how the learner thought of such numbers. It can only be assumed that the learner's random numbers address lack of clear understanding of the topic and the teacher's lack of explicit explanation and usage of mathematics discourse.

Of interest is that the teacher did not try to figure out the reason behind the learner writing those numbers on the board, since they do not relate to the mathematics sum posed on the board. Instead, she immediately erased the learner's wrong numbers and wrote 11+11 on the board again, while it is expected that the teacher could have engaged with the learner to try and understand the reason behind such numbers.

Of interest and concerning is when the teacher tried to help the learner to work out the mathematics problem, and instead she got the answer incorrect. The teacher wrote 11+11 = 24, (see figure 10 below), and surprisingly did not recognise the incorrect answer.

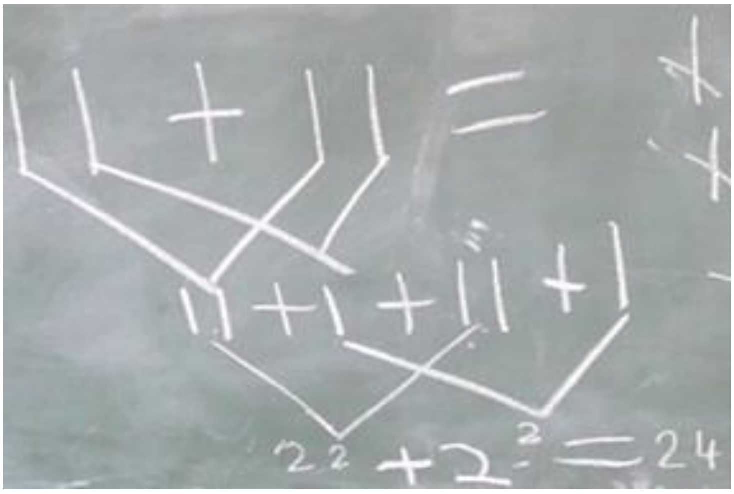

Figure 10 – Mathematical content error by the teacher

The teacher's mistake in the current example may have caused a disconnect in learners' understanding as they observed the teacher writing down the incorrect mathematics content on the board, because she did not follow the method she introduced at the beginning of the lesson (i.e. 'addition' using the method of expanding the digits according to place value, adding the tens together, adding the units together, regrouping them and adding to get the final answer). Considering that the teacher wanted to teach using the method of 'addition' mentioned earlier, it is expected that she would have separated the units from the tens for both 11's [10 +1+10+1]. However, she carried down both 11's, which adds up to 22, and still carried down the units, 1 + 1, which caused her to end up with 24. Without the teacher realising the content error she made, she introduced sticks as a different representation of the same content (see figure 11) to show the learner that was called to do the sum on the board how he could get to the correct final answer by using a different method.

Figure 11 – Second representation of the initial mathematics problem which is mathematically correct

The teacher asked the learner to count every stick and he got the answer correct, with 11+11 being equal to 22 (see figure 11). Interestingly, the teacher became confused because the learner’s correct answer contradicted her erroneous answer of 24 from the previous example (see figure 10), where she made a mistake that was left unattended. I wondered why she did not go back to the initial representation of grouping the tens and units and continue from this to clarify the concept and the manner of engaging with the concept to her learners. Nonetheless, the teacher appeared to be unaware of the mistake she made while trying to help the learner, even when the learner got the answer correct, this addresses the importance of FP mathematics teachers continuously reflecting while teaching to notice such errors (Lucas, 2012).

However, the teacher re-drew 24 sticks, (see figure 12 below- highlighted in red), which matched the answer she got in (figure 10).

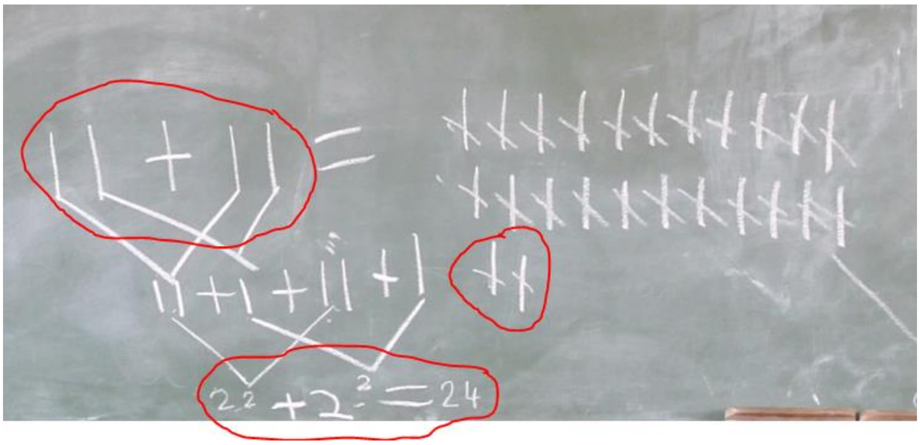

Figure 12 – Teacher makes a content error in the representation on the left and then manipulates the learners in the representation on the right by adding two sticks

She then asked the same learner that was in front to count the sticks and subsequently got 24, and the teacher praised the learner for the wrong answer and showed him that the number of sticks was the same as the answer that she got initially, before asking him to sit down. From this activity it is worrying to realise that the teacher manipulated learners by drawing the incorrect number of sticks in order to appear correct, and it is also unclear whether all learners did not recognise the teacher's mistake because only one learner was involved while others sat quietly while watching. Incoherence between the incorrect mathematics content representation by the teacher, and the correct mathematics content that was practiced by the learner could negatively influence learner understanding and confidence and possibly enforce doubt while engaging with mathematics practice. The teacher seemed to struggle with the method that she wanted to teach the learners, this may be a possible reason for the errors which she made as she was unable to correct the error. The problem is that while the teacher changed the number of sticks to match her answer of 24 in figure 10, it was still a wrong representation mathematically, because 11+11 = 22 not 24. From this we see that the teacher needs to always be consciously aware of the content and what is presented to the learners, whether it is through her talk or representation on the board as it affects what they will learn in future mathematics lessons, and builds on what was learnt in previous grades.

This is cause for concern as Lucas (2012) discusses reflective learning and advocates that the process of knowledge-making should be constructed through active reflection on past and present experiences, because it has an effect on future occurrences. From my observation, the teacher did not have any lesson plan as a guide, and this is problematic as Shen, Poppink, Cui and Fan (2007) posit that when teachers prepare lessons well, it may be used as a tool for personal reflection. This in turn leads to personal development of content knowledge and pedagogical facets of teaching. Unfortunately, because this lesson was recorded on the last day of data collection, I did not have the opportunity to conduct a video-stimulated recall interview to ask questions pertaining to this lesson. It is one of the challenges this study experienced in the rural context, because data collection was disturbed by various incidences that shortened days of data collection.

Teaching episode 1 lesson 2 – incoherence between formal mathematical representation from the textbook and mathematical representation on the board

Teacher Carol instructs the learners to open the textbook to page 80 and look at the blocks in blue, referring to tens (vukhume) and the red blocks, referring to units (vun'we) respectively (refer to figure 13 below).

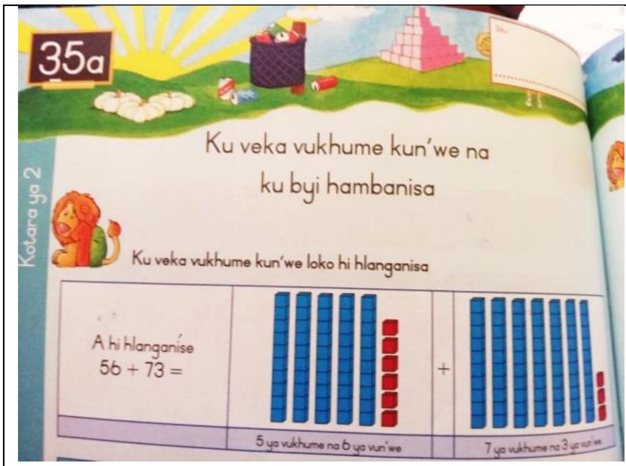

Figure 13 - the blocks in blue refer to tens (vukhume) and the blocks in red, refer to units (vun'we)

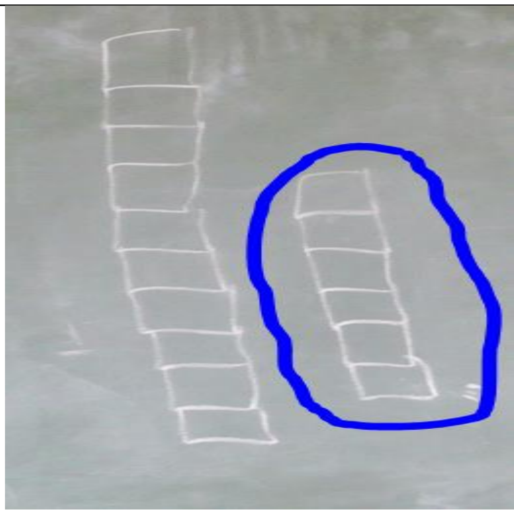

Figure 14- Incorrect representation of unit column- the unit blocks are not supposed to touch each other

Even though the teacher has given the instructions to the learners, she does not explicitly explain the topic or what the lesson is about. As mentioned above in the previous episodes, it is imperative for FP teachers to explicitly state the lesson topic/objective, as DeLong, Winter, and Yackel, (2005) suggest that without learning objectives it is difficult for students to know what they are learning about, because learning objectives direct their attention. When learners are uncertain about what exactly they were supposed to learn in the lesson, the uncertainty causes learners' unnecessary anxiety. Carol then drew the illustration presented in figure 14 above and said that the first column represents the tens and the second column represents the units. Incoherence between the teacher's explanation of what's going on in figure 13 (formal knowledge represented in the textbook) and her misrepresentation on the board in figure 14 (mathematical representation on the board) occurs. According to mathematics rules, the blocks to illustrate units were not supposed to touch each other (see figure 13 as compared to figure 14), to help learners see units as a singular thing (Fuson and Briars, 1990). She then asked learners to count the units drawn on the board and they did in chorus up to 7, even though the correct answer is 6. The teacher stopped them when they got to 7. Although learners were looking at the board while counting, because the teacher did not point at the board, learners may have lost interest. A teacher pointing on the numbers while learners are counting may be seen as one of the important routines in FP to ensure learners' focus (Sfard, 2008).

Regarding the representation of the units together rather than in separate blocks, I asked the teacher's reasoning during the video-stimulated recall interview, she replied: *"I didn't separate them because when you show learners separate squares, they still combine them."* This response is interesting and cause for concern, because a teacher is stating that she misrepresents mathematics content because learners have been doing it, rather than correcting learners' incorrect practices. It is the teacher's duty to correct learners when they are doing something wrong, rather than leave it because it is seen as the 'normal' practice. Another assumption that can be made about this teacher's response would be that teachers in Grades 1 and 2 did not clearly present the mathematics rules and representations pertaining to 'place value', which are needed to understand the progression of concepts in grade 3.

The teacher is trained and knowledgeable and also holds the position of knowledge and authority in class, hence, the importance of drilling information in FP, so that they understand mathematics rules and procedures. FP is about building solid foundations in mathematics content, which affects future knowledge, understanding and representation of mathematics concepts. When I asked the teacher in the interview if she felt that the in-service mathematics Foundation Phase training she received was helpful, she said: *"... there's a lot of training …. The training helps, but not for long, because just when you start to understand and get used to one topic, they move on to the next one and we sometimes forget because we are so busy…"* It is undeniable that mathematics content is large and that some teachers do not have a good grasp of all the mathematics content which they teach, however, teacher Carol's response is cause for concern, because knowledge gained from a workshop should not be left there. A teacher needs to actively re-engage with content learnt in workshops so that she knows the content better, to confidently deliver it to the learners.

Teaching episode 2 lesson 2 – incoherent representations of mathematics knowledge

Teacher Carol drew the following representation (figure 15) on the board

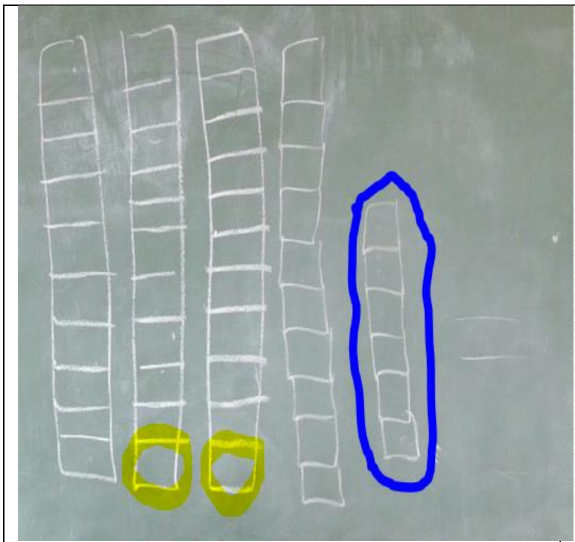

Figure 15 – Mathematically incorrect representation of unit column: The 2nd and 3rd column has incorrect number of blocks in the tens columns.

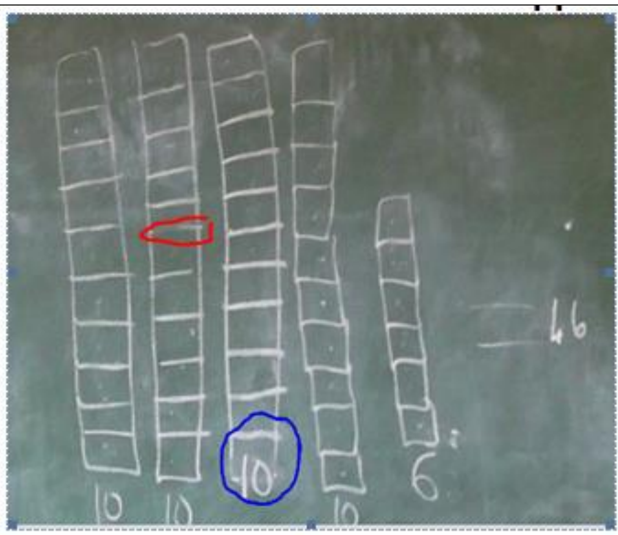

Figure 16- teacher erased a line from column 2 to make it 10 blocks instead of 11- Column 3 still has 11 blocks instead of 10

The teacher used iconic mediators (Sfard, 2008) to explain the difference between tens and units, however, they are incorrectly represented (see figure 15 above), because the six unit blocks highlighted with blue should have been drawn as six separate blocks. The misrepresentation of units by Carol is worrying as she seems to generalise mathematics rules about place value. Venkat and Adler (2012) posit that during the primary years of schooling the use of diagrams is essential for the child, in order to provide strong imaginable foundations for the abstract symbolic mathematical language. Considering the importance of visual representation to mediate mathematics communication of concepts, the continuation of misusing visual mediators was noticed in the yellow highlighted blocks (see Figure 15). The 2^{nd} and 3^{rd} tens column in Figure 15 illustrate that the teacher drew an incorrect number of blocks to demonstrate the tens columns, she drew 11 blocks in both columns rather than 10. Because learners follow what the teacher drew on the board, when they were asked to count each block individually in figure 15 they counted the incorrect additional blocks and got 48, at this point I thought that this made the teacher aware of her mistake.

However, further on in the lesson, in figure 16, incoherence between the diagrammatical representation on the board and the number that the teacher had written below each row occurred. The teacher wrote 10 below each column, she erased the additional block which appeared in figure 15 from the 2^{nd} column (figure 16 highlighted in red). While the blocks in the third column were still 11 (see figure 16 highlighted in blue), and I argue that this teacher is again manipulating learners by writing 10 under the column, while 11 blocks exist. Carol continues to overlook the importance of using mathematical signs and did not use + signs between each column to signify to the learners that they will be adding to get the final answer of 46 written on the board (see figure 16), hence, illustrating another incorrect mathematical routine by Carol (Sfard,2007). Of concern, is that she writes 46 on the board as the final answer, however, because of the extra block (highlighted in blue in figure 16) in the 3^{rd} column, the final answer is actually 47. Such mistakes are alarming because the explicit usage of mathematical signs are part of visual mediators, and are supposed to be used as objects for mathematical thinking and communication (Berger, 2013), given the on-going teacher mistakes, it highlights the importance of reflection during teaching and learning, which Carol does not seem to take seriously.

Scott et al., (2011) states that in order to carry out tasks where effective visual mediators are used, a teacher needs to have a good grasp of mathematics content knowledge, as it is likely to impact pedagogical practice. Bearing in mind Carol's response on the nature of training, the challenges with using visual mediators and effective explanatory talks from all the episodes and lessons, suggests that the influence of insufficient mathematics content knowledge has impacted on her pedagogical practice.

It is worth mentioning at this stage the possible influence of the context for the provision of teaching resources, because it could be possible that the teacher did not have money to prepare additional resources to use to teach the different methods of addition. The drawing of columns on the board suggests the last option for a teacher to explain mathematics concepts, although it does not excuse the misrepresentation.

Teaching episode 3 lesson 2- lower order cognitive demand

Figure 17 below is a snippet of the lesson activity given to the learners by Carol. I argue that in this activity, Carol used lower order questions, just as she did in lesson 1 episode 3.

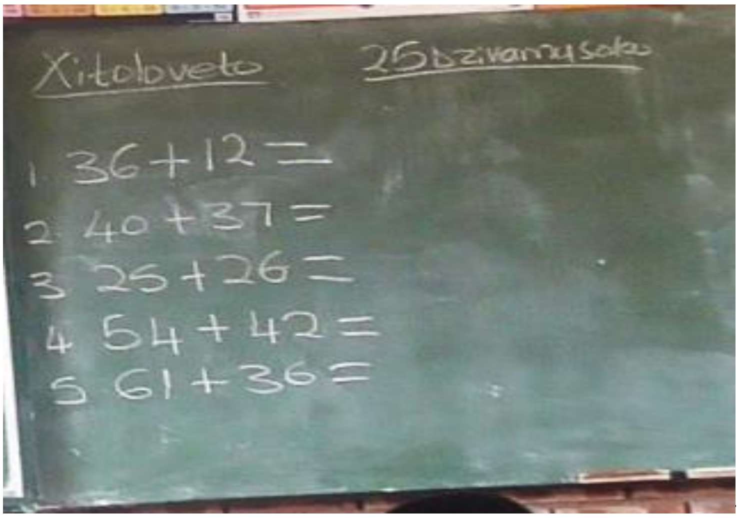

Figure 17 – lesson activity

In a video-stimulated recall interview, I asked the teacher the reason for not using addition examples with three-digit numbers, and she replied: *"Right now, I only want them to use tens and units, I think, the higher they go they will be able to differentiate between hundreds and thousands. We start with small numbers, and the teachers in* *higher grades teach them higher numbers."* Her response suggests that she is shifting the responsibility of introducing learners to higher numbers, and disregarded that delaying the three-digit numbers might disadvantage learners in those higher grades. By only focusing on introducing learners to tens and units does not mean they should be limited to only two-digits numbers, especially when Grade three CAPS requires learners to be able to work with three-digit numbers (2011, P.20). Of interest is that her co-teachers have worked on three-digit number addition with the Grade 3s during my data-collection process, which shows that they follow the policy instructions and prepare learners for higher grades. Notwithstanding the discussion and considering the context of the study, even though the teacher did not mention the knowledge of learners, I cannot oversee the possibility of the teacher's pacing of the lesson due to understanding the type of learners in the classroom. However, the reasoning made me question Carol's confidence with mathematics content knowledge which requires teachers to engage with such mathematics problems. Nonetheless, even with the task that requires learners' low cognitive demand her consistent misrepresentation and continuous manipulation of mathematical content knowledge may cause learners not to grasp correct mathematics concepts Venkat and Adler (2014).

The following table exemplifies the nuances of the different teaching episodes:

Key
Lesson = L
Teaching Episode =TE

Nuances between different teaching episodes by different teachers	Brief explanation
✓ Visual representation errors	✓ All 3 participants discussed under the first sub theme used mathematically incorrect visual representations in various teaching episodes without realising it, addressing the importance of constant reflection while teaching. It also highlights the importance of planning for FP teachers, to enhance their own understanding of content, and may enable them to practice various ways to teach the same concept in different forms using various visuals for learners' development and understanding (Kelchtermans, 2009). Even though the NECT book has structured planned lessons, it doesn't mean that teachers should not plan how they will teach the lesson. ✓ The misrepresentations of mathematics knowledge may lead to major disconnections in learner understanding of rules, meaning of concept(s), practicing and solving mathematics problems, and therefore, has implications for the learning of mathematics in their current and future grades (Arcavi, 2003). ✓ Making use of the correct visuals when representing mathematics content highlights the importance of teacher planning, teachers practicing mathematics before teaching, continuous reflection while teaching and the use of effective visuals which are coherent with the lesson and lesson activities.
✓ Complexity of teaching	✓ Teacher Carol in TE 1 and 2, L 2 and teacher Thembiwe, TE 2, L 1: taught 'place value' which should've been well foregrounded in previous grades as stated in the FP CAPS

	document (p.216) ✓ Considering that 'place value' is introduced in Grades 1 and 2, teachers in those grades did not do justice in foregrounding mathematics concepts to the learners (CAPS, 2011,P.20), because most observed learners in grade 3 cannot distinguish between hundreds, tens and units.
✓ Mathematics Discourse	✓ Teacher Fonky TE 2: definition of symmetry suggests complex language barrier between English proficiency and explaining mathematics content. ✓ Teacher Fonky in TE 4 illustrated insufficient mathematics discourse and mathematics content knowledge due to her inability to use appropriate mathematical terms such as: 'vertical, 'horizontal' and diagonal' in her teaching and instead she used everyday words that might hamper learning in future grades. ✓ Foundation Phase teachers introduce learners to foundational concepts in mathematics; therefore, it is fundamental that they use proper language, words, concepts and rules that should be reinforced in following grades (Sfard, 2007 and Goulding, Rowland, and Barber, 2002). ✓ Of concern is that if FP teachers leave knowledge gaps, learners will struggle to close it resulting in poor performance and negative attitude towards mathematics (Larkin and Jorgensen, 2016). ✓ Without overlooking departmental pressure and contextual complexities, it is expected that Foundation Phase teachers have appropriate mathematics content and pedagogical knowledge (Venkat and Spaull, 2015). ✓ Teacher Thembiwe used unit builder cards to teach place value in TE 2, L 1 that was not labelled correctly to represent mathematical content relevant for the lesson. Visual representation and teacher talk has to be coherent, especially the visual because learners in Grade 3 still rely more on what they see on the board in relation to what the teacher says (Venkat, and Naidoo, 2012). Thus, there is a possibility of learners using information that the teacher used on the board

	to make sense of the topic, which makes it important that teachers are conscious of the resources used for teaching and that concepts are well presented. ✓ Teacher Carol in TE1, L 2 showed incoherence between the explanations of the information in the textbook and the incorrect representation of the unit's column on the board. ✓ Furthermore in TE 2, lesson 2, Carol misrepresented content on the board by drawing 11 blocks while talking about the tens column. ✓ While it could also be explained as a teacher mistake, the continuous practice suggests a lack of lesson preparation and critical reflection during teaching (Smyth, 1989 and John, 2006). ✓ All of these issues highlight the importance of a teacher using correct visual representations as it affects their verbal instruction and in turn negatively affects learner understanding and concept continuity in mathematics. ✓ Teachers are showing paucity of mathematics discourse for teaching (Sfard, 2008). ✓ Teachers need to continuously attend professional development that prioritises the enhancement of content knowledge, especially for Foundation Phase teachers that were not properly trained (Kennedy, 2016). It is also important for Foundation Phase teachers to plan the lessons before teaching, to ensure that they understand the topic in relation to the teaching aids they want to use to develop learners understanding.
✓ Lesson topic/objective	✓ The three participants either do not represent the topic in relation to the lesson taught or did not state the lesson topic clearly at the beginning of the lesson. They seem to have taken for granted the importance of explicitly stating the objective of the lesson at the beginning of the lesson, for learners to be aware of it. ✓ Making the lesson objective clear in FP is significant for a teacher and learners, to ensure coherent mathematics teaching (Venkat and Adler, 2012). If taken for granted learners may not know what the lesson is about and hence affect their frame of mind for

	learning in that lesson (Hubley, 1993).
✓ Low cognitive demand When using the words 'low cognitive demand' in this study, I mean that the cognitive demand being put on the child is not up to standard with the CAPS standards and is too easy for the child.	✓ Teacher Carol taught the lesson content at a lower cognitive level as compared to CAPS (2011, P.20) expectation, which might affect learner's thinking about mathematics concepts. ✓ While the teacher might be influenced by the knowledge of learners, it is also important that learners are introduced to higher order thinking, even if they are not ready, because they will be re-introduced to three digit numbers in grade 4. ✓ This also strongly illustrates that she does not plan her lessons to get a higher level of thinking from the learners. ✓ This may also be due to her undertraining of mathematics during college and in-service training.
✓ Mathematical Routines (Sfard, 2007; 2008)	✓ Teacher Carol did not use a pointer to guide learners during the counting of the units column in TE1 L2 ✓ Teacher Fonky did not measure the squares represented on the board and used a solid line to represent symmetry in TE4 and 5 ✓ Teacher Thembiwe used an = sign to represent rounding off as opposed to an ≈ sign ✓ All of the above-mentioned illustrate that teachers follow these routines when teaching mathematics. ✓ Of concern is that they seem to not realise that Mathematical routines are governed by the specialised mathematical words and visual mediators (Sfard, 2008).This raises great concern for mathematics learning because when teachers enact routines which are mathematically incorrect in the FP it may be detrimental to mathematics learning and cause incoherent lessons to be taught.
✓ Critical reflection	✓ The visual verbal content errors by all participants illustrate unawareness of the mistakes made while teaching and the implication to learners' learning of content, as they could not correct those errors. Hence, the importance of critical reflection (Fook, 2007).

5.3.2 Sub theme two - occurrence of macro- coherence

In the introduction of this chapter, I stated that macro-coherence means the coherence that occurs within a full lesson, from the beginning of the lesson, that is, from the lesson topic, to the examples, tasks, teacher talk and teacher and learner interactions. Given this, for the purpose of this sub-theme a lesson will be used to highlight the nature of coherence that was identified in all parts of the lesson rather than specific episodes. From all the classroom observations, Teacher Charlotte's lesson highlighted macro-coherence.

Teacher Charlotte (English medium school)

Teacher Charlotte has 24 years of teaching experience and also studied at studied at the Mapulaneng College of Education and acquired a Junior Primary Teaching Diploma (JPTD). She explicitly wrote "Line of symmetry" as the topic/objective on the board, see figure 18 below.

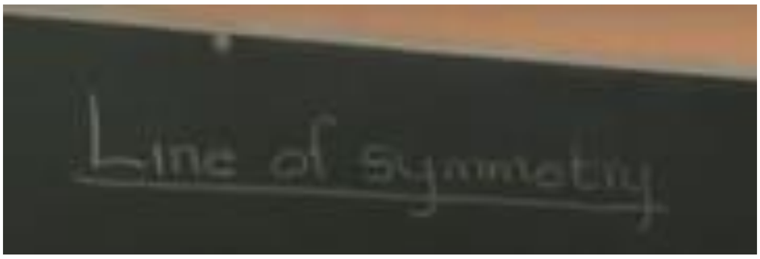

Figure 18: Lesson heading - Teacher Charlotte

According to MDI such action is vital for learners in general but specifically for FP, because it makes the lesson objective clear. Throughout the lesson I watched Charlotte focusing only on symmetry lines as the only concept to be taught as compared to Fonky (episode 1) who wrote symmetry lines and symmetry shape on the board as her lesson objective and only focused on symmetry line. Charlotte did not move off the topic resulting to micro-coherence between the teacher talk and the lesson topic on the board.

Charlotte began the lesson with learners counting backward and forward starting from 5 to 200. According to Angilheri (2006) counting forwards and backwards develops learners' understanding of patterns, which assist in early addition and subtraction. Her response in an interview corroborates her awareness of the importance of mental mathematics, because when I asked the reason for mental maths every morning, she said:

> *"It helps to stimulate their mind when they get stuck while chorusing, I allow learners to help each other, sometimes they count individually for me and sometimes they count in groups."*

This is an interesting response and may be seen as a positive practice for mathematics learning, as different methods of interaction gives learners a better opportunity to understand mathematics concepts. She then asked the learners what they had been learning the day before, and a learner clearly responded and said: *'addition'*. She replied: *"Good, what about addition?"* Another learner said: *"Busi's method of addition".* Charlotte then replied: *"Good, I can't move on to today's work if you didn't understand yesterday's".* She further asked them: *"Tell me, in Grade 2, did you ever learn about symmetry?"* The learners responded in the affirmative and she replied: *"You see, whatever we learn in previous grades is a continuation."* Here we see that she is aware of and makes explicit to learners that mathematical concepts are linked and build on each other from one grade to another. Link-making to promote concept continuity is present as she takes into cognisance that teaching and learning is a process that involves the need for pedagogical links to be made between teaching and learning activities enacted at different points in time (Scott et al, 2011).

She introduces the lesson differently from Fonky, mentioned earlier in this chapter, who also taught line of symmetry. While Charlotte asked learners questions at the beginning of the lesson to check for previous knowledge, Fonky told them what they would be learning about. Thus, it could be argued that Fonky's teaching approach is authoritative, which might have negative implications on learning as learners may be afraid to ask questions or to even respond to questions (Chen, Hand, and Norton-Meier, 2017). Charlotte drew a square on the board and then asked a learner to show what a line of symmetry looks like in a square. The learner drew a solid vertical line in the middle of the shape, and the teacher asked learners in class if that was correct and learners agreed and began applauding. Charlotte replied: *"Stop applauding, it is incorrect."* She then extended the lines out of the shape at the top and the bottom (see figure 19 below) and explicitly told the learners that "…*in order to show symmetry, a dotted line or an extended line is used, you may not use a solid line in the shape to show symmetry. Also, notice how the symmetry line cuts the shape into half and then there are two equal parts."* Charlotte emphasised that learners should not use a solid line within the shape to signify symmetry, a reason she stopped the learner when doing that. The use of illustration and the choice of words to draw learners' attention to a specific aspect *"also notice how…"* suggest effective teaching of a mathematics concept. The detailed explanation demonstrates the teacher's sufficient mathematics content knowledge, and ability to ensure learners' access to mathematics language (Venkat and Adler, 2012).

Charlotte took a piece of paper and cut it into a shape of a rectangle and folded it in different ways to illustrate what is symmetrical and what was not symmetrical (such as diagonally). She made it explicit that in a rectangle all sides are not equal, and then used a square that she had already cut out and showed them symmetry vertically, horizontally and diagonally (although without actually using the mathematical term diagonal). This pedagogical practice differentiates Charlotte with Fonky who didn't show learners what symmetry is in a rectangle. Hence, Charlotte is broadening their knowledge by making the mathematics available to learn. She further drew the square and rectangle on the board and emphasised that one must draw the symmetry line out of the shape, which illustrate awareness of mathematical representation for symmetry line. While learner interaction existed from the beginning of the lesson, and I argue that it was used effectively, at this point Charlotte called learners to the front to complete various examples to show what symmetrical is. She used a smiley face, a heart, a moon, and a cross, and for each one she gestured both vertically and horizontally while asking the learners: *"Will it work like this?"* (See figure 19 below). This allowed learners to make meaning of the concept using different representations and allowed them to think critically about which shapes are symmetrical and which shapes are not.

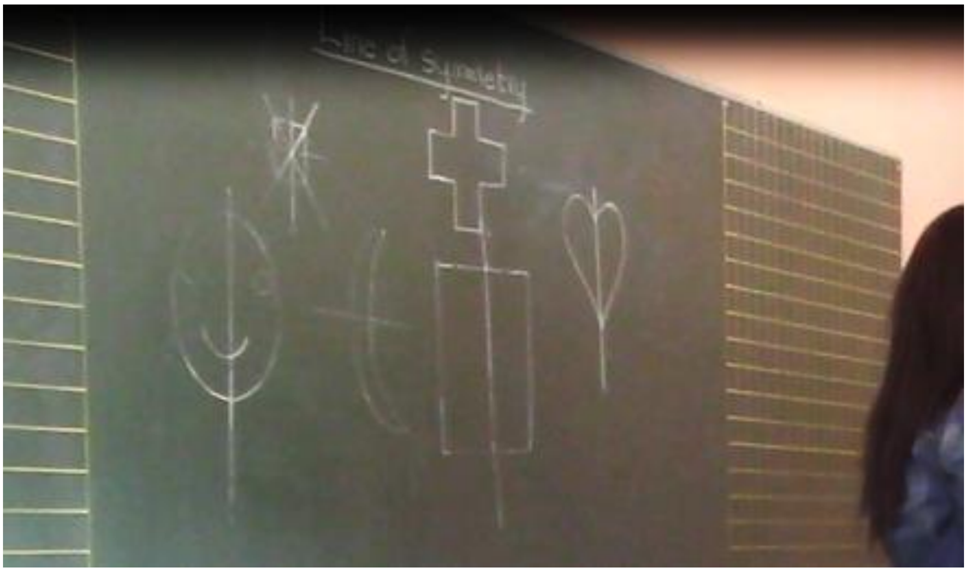

Figure 19 – Symmetry lesson examples

In a video-stimulated recall interview, I asked the teacher what concepts learners should have known before she taught the lesson, to see if she was aware of concept connections. She replied: *"Learners need to know different shapes and understand what symmetrical means, then in this lesson they needed to know how each shape can show symmetry."* From this response Charlotte shows clarity of the notion of concepts and the importance of demonstrating to learners that they build on each other.

The teacher talk and lesson examples clarify the existence of macro coherence in her lesson, because of the links between lesson objective, examples and teacher talk which are also coherent with the lesson activity chosen (see figure three). Without overlooking the great lesson, Charlotte used a protruding line to show symmetry in all her examples on the board, but at the beginning of the lesson, as mentioned above, she did make the learners aware of the fact that symmetry lines may be drawn as dotted lines (because in figure 3, the textbook activity, the symmetry line is drawn as a dotted line). The above discussion highlights the small nuances and occurrences of content knowledge and mathematical representation which cause macro coherence to come to the fore when teaching mathematics to Grade three learners. When asked in an interview what her understanding of coherent concept connection, she replied: *"All mathematics concepts link, even without us realising. Sometimes, I link them without realising. I think it's a good thing, but it will be better if we realise when we making the links".* This might provide insight in her being able to teach this mathematics lesson coherently, it also illustrates that regardless of her training and the context of the school that she teaches in, coherent teaching is possible.

5.3.3 Sub theme three - factors which influence coherent teaching

Given the data generated by this study and the discussion and findings of this chapter, various factors emerge which influence coherent teaching. As mentioned in theme one of this chapter, all four participants indicated that they were undertrained for mathematics content at colleges during apartheid, both the junior primary teaching diploma teachers and the senior primary teaching diploma teachers. In addition, the personal experience and the nature of in-service workshops influenced the complexity of teaching in grade 3 classrooms, as Thembiwe highlighted that: *"…the mathematics workshops are not held often and when we do have them, they only last between two to three hours, mathematics content is a lot so we cannot cover everything in workshops."* This quote illustrates that due to inadequate in-service content training in post-apartheid South Africa, teachers are still in a disadvantaged position with regard to mathematics content knowledge which is needed to teach mathematics effectively (Ball, Thames and Phelps, 2008). The lack of content knowledge affects coherent teaching negatively, because teachers cannot teach what they do not know. I argue that teachers' poor training in colleges influenced the nature of mathematics content knowledge, which further affects the delivery of their lessons negatively. This may cause a lack of motivation amongst teachers because they should be seen as the knowledgeable person in front of the learners (Hashweh, 2005).

In addition to insufficient training on mathematics content and pedagogical knowledge, inadequate teaching resources were identified as one of the factors that shaped specific pedagogical approaches. Thembiwe's usage of unit builder cards to teach a lesson on place value was not well thought through for the purpose of the lesson and therefore, mathematics knowledge was misrepresented, this may also suggest teacher limitation in pedagogy. By Fonky moving on to place-value in the subsequent lesson, it highlights that teachers are influenced by pressure to be aligned with the curriculum, rather than teaching for coherent progression of topics. While Fonky's pace could also be critiqued for not completing the lesson, it is possibly because of inadequate training and workshops for professional development that resulted in incomplete topics and inconsistency in the teaching of the lesson. The lack of mathematics content and pedagogy hinders the continuity and progression of topics in mathematics because if a teacher does not have the knowledge to teach a topic (to the required CAPS, 2011 standard), they are likely to under teach or bypass certain topics and this has implications for coherent teaching and topic continuity in future grades (Alshwaikh, and Adler, 2017).

Furthermore, as mentioned above, this study found that some teachers did not critically reflect during teaching, especially in both of teacher Carols lessons (Fook, 2007). This demonstrates that they are not reflecting for their own growth, to better their mathematics content knowledge and pedagogy which also affects coherent teaching negatively. Three out of the four participants taught incoherent mathematics lessons, the fact that teachers are unaware of such an imperative issue (coherence) pertaining to mathematics teaching for effective learning is a cause for concern, and illustrates that teachers need effective training pertaining to mathematics content, pedagogy, critical reflection and the skill to plan and enact lessons with the notion of coherence in mind.

5.4 Conclusion

This chapter added to the existing body of research as it illuminated the crisis in South African mathematics education as teachers illustrated a serious lack of coherent teaching and a deficit in content and pedagogy in mathematics. Three out of four teacher's lesson episodes highlighted incoherent teaching. This chapter used MDI by Venkat and Adler (2012) and Sfards (2008) concepts to interrogate and discuss issues such as: incoherence between what the teacher writes on the board and what she actually enacts, incoherence between what is displayed on the board and what appears in the textbook (formal mathematics), incoherence between the lesson objective and the lesson being carried out as well as major issues pertaining to the incorrect usage of mathematics visual representation. This highlighted the importance of teacher critical reflection during and after teaching mathematics topics as incorrect visual representation of mathematics concepts, may have seemed small and overlooked by educators but when discussed in detail above , it illustrates that what the teacher represents to the learners in the mathematics classroom cannot be taken for granted. Teacher discourse plays an essential role in giving learners the correct meanings of mathematics concepts. Therefore, when teachers are not aware of everything they say, write and do in the mathematics classroom, incoherent teaching and learner confusion is the result. Furthermore, in order for teachers to enable a coherent progression of mathematics topics it is necessary to get the basics right when introducing mathematics concepts. Teachers within a grade and across grades should collaborate and plan in-depth lessons and have discussions about coherence and mathematics discourse so that learners may receive the correct mathematics discourse as they progress so to bridge the gap that may occur when learners progress from one teacher to the next.

Chapter 6

Conclusion - the culmination of the research journey

6.1 Introduction

The main purpose of this study was to critically explore and understand grade 3 rural teachers' mathematics content knowledge and coherent teaching in Acornhoek classrooms, Mpumalanga province. To address this, the study focused on three sub-questions:

- What mathematics content knowledge do grade 3 teachers portray?
- How do grade 3 teachers teach mathematics lessons coherently?
- What factors shape teachers' approaches when teaching mathematics?

As discussed in chapter one and two, the scarcity of research that focused on FP rural teachers' mathematics content knowledge and particularly coherent teaching, motivated the conceptualisation of the current study. To date, the paucity of rural mathematics education research in South Africa (Balfour, Mitchell and Moletsane, 2008) has not been able to offer an account of the nature of coherent and incoherent teaching in FP rural classrooms. This study was therefore conducted in order to contribute to the existing knowledge in mathematics education and research, to present rural grade 3 teachers' voices and experiences of teaching mathematics coherently.

This study used Mathematics Discourse in Instruction (MDI) by Adler and Ronda (2014); Adler and Ronda (2015) and Venkat and Adler (2012) as the main lens to make sense of the data and concepts from Sfard's (2008) commognitive theory. The MDI theory and Sfard's concepts allowed the study to make sense of what teachers say, do, and write during mathematics lessons in grade 3 classrooms. The CDA framework was used to analyse the way teachers talk about their training and nature of their mathematics content knowledge, their MDI and the selection and usage of words and endorsed narratives. Considering that participants used language to describe their experiences of teaching mathematics, it was essential to recognise their choice of words during interviews and lesson observations to comprehend their understanding of mathematics content, the practice of teaching coherently or not, and their experiences regarding their FP mathematics training.

This chapter begins by presenting a summary of the findings in relation to the research questions as described in chapter one. The limitations associated with this study are discussed. Finally, the chapter concludes by making recommendations for future research, stressing a need for more research with rural teachers within rural communities.

6.2. Summary of the findings

6.2.1 Foundation Phase mathematics training

All participants indicated that they were undertrained and under-prepared to teach mathematics content in FP, and the mathematics workshops that were organised by the Education department for professional development, focused on policy rather than prioritising and enhancing teachers' mathematics content knowledge. This leaves teachers with mathematics gaps, therefore, being unable to teach some topics, leaving them concerned regarding learner understanding.

6.2.2 Paucity of mathematics discourse and concepts

The findings show that some teachers experienced inadequate mathematics discourse, which may cause learners to struggle with mathematics concepts which were not well foregrounded in future grades. This study found lack of coherent teaching in different lessons, from three of the four participants, only Charlotte's lesson was macro-coherent. Even though Charlotte was teaching mathematics in English, this study cannot conclude that teaching mathematics in English is a means for coherent teaching, because incoherent teaching was observed in other lessons that were taught in English. I do not ignore that mathematics is a discourse on its own (Sfard, 2007) and that English and Xitsonga are languages in their own right, hence the complexity of teaching the subject of mathematics since it has its own specialised discourse.

6.2.3 The role of clear lesson objectives

The majority of lesson episodes illustrated that teachers took for granted the notion of making the lesson objective clear to the learners. They did not explicitly write the lesson topic/objective on the board, or simply wrote a topic which was not fully covered or aligned with the actual lesson, and did not inform learners what the lessons would be about at the beginning of the lessons. This pedagogical error caused incoherencies in the majority of the lessons. This cannot be overlooked in FP because learners may not know what the lesson is about, and this will influence their frame of mind for learning in that lesson, while at the same time negatively affecting coherent teaching (Venkat and Adler, 2012).

6.2.4 Mathematically incorrect visual representations

Three of the four teachers represented mathematics content incorrectly in different forms. A few examples include: Thembiwe used unit-builder cards to represent a lesson on place value, while Carol showed learners' informal maths on the board, then referred learners to formal maths in the textbook. In her place value lesson, she showed learners how to identify the difference between the tens and units columns in the textbook and then misrepresented the same information on the board. All three participants misrepresented mathematics content, which may have been due to teachers' insufficient content knowledge or the notion that they did not know how to present mathematics knowledge effectively. When teachers failed to use the correct visual representations of mathematics content, it led to incoherent teaching and major disconnections in learner understanding of rules, meaning of concept(s), practicing and solving of mathematics problems. This therefore has implications for the learning of mathematics in their current and future grades (Kaldrimidou and Ikonomou, 1992).

6.2.4.1 Visual representations and critical reflection

As mentioned in chapter 5, it is alarming that when teachers were given the opportunity to critically reflect on their mathematical visual and pedagogical errors during VSRIs, they stated that they would not change the manner of teaching that topic. This is major cause for concern as the study hoped that with VSRIs teachers would take heed of their errors and a subsequent change in mathematical learning would occur. Nonetheless, this calls for teachers to plan effectively, practice the mathematics to be taught before teaching and continuously reflect while teaching to ensure that the chosen visual is coherent with the lesson and lesson activities. This study suggests that teachers should reflect on the coherence of the artefacts used during teaching and the coherence of the discourse used during teaching as a lesson includes both discourse and mathematical artefacts.

Given that visual representation and teacher talk are generally important, they have to be used coherently to support learners' mathematics conceptual development. The findings show that visual representation is especially important because learners in Grade 3 still rely more on what they see on the board in relation to what the teacher says. Thus, learners use the information that the teacher puts on the board to make sense of the topic, which makes it important for teachers to be conscious of the resources used while teaching so that mathematics concepts are well presented. The importance of critical reflection while teaching is highlighted through the 'visual verbal content errors' by all participants who could not correct their errors due to their unawareness of the mistakes made while teaching, which suggests serious implications to learners' learning of content (Fook, 2007).

6.2.6. The importance of engaging and understanding lesson plans

During classroom observations, I noticed that teachers did not have their lessons to guide them while teaching, a possible reason for incoherencies; instead, they used the NECT programme lesson plans. The 'usage', from the observed lessons suggests that teachers did not engage with the NECT-provided lesson plans to make sense of how to teach the topic and main concepts, rather, they 'consulted' with them as they were teaching. This study argues that even though some teachers do not design their lesson plans, it is still important for them to engage and practice topics and concepts which they are going to teach in order to familiarise themselves with the lesson content. Engaging with lesson plans helps teachers' to strategize the manner in which they present topics and concepts, and identify when to do more research if necessary, this was not identified with the majority of teachers, albeit with the exception of Charlotte. It is important for FP teachers to plan lessons before teaching to ensure that they understand the topic in relation to the teaching aids which they want to use to develop learners' understanding. However, teachers need to plan their own lessons with the notion of coherence in mind so that when they are teaching, they can enact the correct lesson objective, examples and task effectively in order to achieve macro coherence. Carol taught the lesson content at a lower cognitive level as compared to CAPS (2011, P.20) requirements, hence, addressing the importance of planning lessons to ensure that different cognitive levels are attended to.

6.3 Limitations and challenges faced during the study

Only three weeks were spent at the research site which resulted in insufficient time to observe the context in-depth or to conduct more observations and VSRIs. Nevertheless, because this is a Masters dissertation, the period might also be considered enough to collect data. I made good use of the whole three weeks and engaged with the generated data as quickly as possible. This was so that I could attend to any issues that may have been needed to be revisited and clarified with the participants. The language barrier was another limitation, as I went to Mpumalanga with the assumption that the schools that I will be working with were English medium, believing that the data collection process would be easier for me as English is my home language. This limitation was overcome through the assistance of my peer researcher who is a Xitsonga speaker; every day after school, we would collaborate and examine the data collected while he would assist by translating and helping me understand what had occurred in those lessons. However, the use of a translator may also be seen as a limitation as it may cause the meaning of the data to be lost. Moreover, the availability of teachers with whom I could conduct interviews was limited as many refused to remain behind after school for interviews. To counter this, I managed to interview the teachers during lunch breaks.

6.4 Recommendations for future research

1) Considering the continuing in-service professional development that is not useful for rural teachers pertaining to mathematics content knowledge and pedagogy, this study recommends in-depth studies using VSRIs to be continuously conducted, to make sense of teacher's pedagogical reasoning with them rather than for them.

2) This study recommends that with regards to in-service training, the Provincial Department of Education in Mpumalanga should realise that a balance between policy training and content training need to occur.
3) The nature of Foundation Phase mathematics courses and training at universities need to be specified for FP learning. Thus, the study recommends the need to receive pre-service training which is not only about mathematics content but essentially, the different methods of delivering the mathematics content to FP learners.
4) Pre and in-service training should enable teachers to be able to plan lessons for coherent teaching. This is essential as teachers need training in planning lesson sets in order to assist them in working on coherence within a lesson and across lesson sets. Lesson plans should be available to the teacher while teaching so that it may be used as reference to guide the coherence in the lesson. If a teacher plans for coherence then the lesson examples and tasks will fit into the logical structure of the lesson and this may enable coherent teaching.
5) The study recommends that FP mathematics teachers should receive quality training to create their own lesson plans and properly enact the use of visual mediators within the FP classroom, so that it may enable coherent teaching. When teachers misuse visual mediators it causes incoherence and learner confusion, as discussed in chapter 5, and this may also be the reason why teachers need to see themselves teach so that they can become aware of the implications of misrepresenting mathematics content through the misuse of visual mediators.

These recommendations are essential, especially if the dream of providing equitable democratic education for all children in South Africa is taken seriously, regardless of their geographic location.

6.5 Crossing borders to understand the nature of rural mathematics teaching

This study's aim was not to criticise Acornhoek FP mathematics teachers, but rather the findings of this study shed light on the lack of quality teacher training which influenced mathematical content and coherent pedagogical practices in rural mathematics classrooms.

Reference List

Adler, J., and Ronda, E. (2014). An analytic framework for describing teachers' mathematics discourse in instruction. *Psychology of Maths Education (PME)*, *38*.

Adler, J., and Ronda, E. (2015). A framework for describing mathematics discourse in instruction and interpreting differences in teaching. *African Journal of Research in Mathematics, Science and Technology Education*, *19*(3), 237-254.

Adler, J., and Ronda, E. (2017). Mathematical discourse in instruction matters. *Research for educational change: Transforming researchers' insights into improvement in mathematics teaching and learning*, 64-81.

Aguilar, M. S., and Zavaleta, J. G. M. (2012). On the links between mathematics education and democracy: A literature review. *pythagoras*, *33*(2), 1-15.

Allahyar, N., and Nazari, A. (2012). Potentiality of Vygotsky's sociocultural theory in exploring the role of teacher perceptions, expectations and interaction strategies. *WoPaLP*, *6*, 79-92.

Alshwaikh, J., and Adler, J. (2017). Researchers and teachers as learners in Lesson Study. *SAARMSTE Book of Long Papers*, 2-14.

Anghileri, J. (2006).Scaffolding practices that enhance mathematics learning. *Journal of Mathematics Teacher Education*, *9*(1), 33-52.

Annual National Assesments (ANA) – Department of Basic Education

Aploon-Zokufa, K. (2013). Locating the difference: A comparison of pedagogic strategies in high and low performing schools. *South African Journal of Childhood Education*, *3*(2), 112-130.

Arcavi, A. (2003). The role of visual representations in the learning of mathematics. *Educational studies in mathematics*, *52*(3), 215-241.

Arnold, M. L., Newman, J. H., Gaddy, B. B., and Dean, C. B. (2005). A look at the condition of rural education research: Setting a direction for future research. *Journal of research in Rural Education*, *20*(6), 1-25.

Askew, M., Venkat, H., and Mathews, C. (2012, July). Coherence and consistency in South African primary mathematics lessons. In *Proceedings of the 36th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 27-34). Taipei, Taiwan: PME.

Atchoarena, D., and Gasperini, L. (2003). *Education for Rural Development towards New Policy Responses*. International Institute for Educational Planning (IIEP) UNESCO. 7-9 rue Eugene-Delacroix, 75116 Paris, France.

Attorps, I. (2006). Mathematics teachers´ conceptions about equations.

Babbie, E. R. (2011). *Introduction to social research*. Wadsworth Cengage learning.

Babbie, E., and Mouton, J. (2007). Qualitative methods of Data sampling. *The practice of social research*, *7*, 187-193.

Balfour, R. J. (2012). Rurality research and rural education: Exploratory and explanatory power. *Perspectives in Education*, *30*(1), 9-18.

Balfour, R. J., Mitchell, C., and Moletsane, R. (2009). Troubling contexts: Toward a generative theory of rurality as education research. *Journal of Rural and Community Development*, *3*(3).

Ball, D. L., and Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. *Multiple perspectives on the teaching and learning of mathematics*, 83-104.

Ball, D., Thames, M. H., and Phelps, G. (2008). Content knowledge for teaching: What makes it special?. *Journal of teacher education*, *59*(5), 389-407.

Baxter, P., and Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report*, *13*(4), 544-559.

Ben-Zvi, D., and Sfard, A. (2007). Ariadne's thread, Daedalus' wings and the learners autonomy. *Education and didactique*, *1*(3), 117-134.

Berger, M. (2013). Examining mathematical discourse to understand in-service teachers' mathematical activities. *pythagoras*, *34*(1), 1-10.

Bernstein, B. (2000). *Pedagogy, symbolic control, and identity: Theory, research, critique* (No. 4). Rowman and Littlefield.

Bless, C., Higson-Smith, C., and Kagee, A. (2006). *Fundamentals of social research methods: An African perspective*. Juta and Company Ltd.

Boston, M. D. (2013). Connecting changes in secondary mathematics teachers' knowledge to their experiences in a professional development workshop. *Journal of Mathematics Teacher Education*, *16*(1), 7-31.

Bot, M., and Schlemmer, L. (1986). *The classroom crisis: Black demands and white responses*. Indicator Project South Africa, Centre for Applied Social Sciences, University of Natal.

Bove, P. A. (1990). Power and freedom: Opposition and the humanities. *October*, *53*, 78-92.

Brent, D., and Simmt, E. (2006). Mathematics-for-teaching: An ongoing investigation of the mathematics that teachers (need to) know. *Educational studies in mathematics*, *61*(3), 293-319.

Bryman, A. (2004). Qualitative research on leadership: A critical but appreciative review. *The leadership quarterly*, *15*(6), 729-769.

Brysman, H., and Burgess, R. (1999). Qualitative research methodology: A review.

Bunting, I., Sheppard, C., Cloete, N., and Belding, L. (2010). *Performance indicators in South African higher education 2000-2008*. African minds.

Cai, J., Ding, M., and Wang, T. (2014). How do exemplary Chinese and US mathematics teachers view instructional coherence?. *Educational Studies in Mathematics*, *85*(2), 265-280.

Chen, Y. C., Hand, B., and Norton-Meier, L. (2017). Teacher roles of questioning in early elementary science classrooms: A framework promoting student cognitive complexities in argumentation. *Research in Science Education*, *47*(2), 373-405.

Cloke, P. (2006). Conceptualizing rurality. *Handbook of rural studies*, 18-28.

Cohen, L., Manion, L., and Morrison, K. (2007). Validity and reliability. *Research Methods in Education. London: Routledge*, 133-164.

Cooperation, O. E. (2008). Development (OECD). 2003. *Environmentally Sustainable Buildings: Challenges and Policies*.

Creswell, J. W. (2009). Mapping the field of mixed methods research.

Creswell, J. W. (2012). Collecting qualitative data. *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. Fourth ed. Boston: Pearson*, 204-35.

Creswell, J. W., Hanson, W. E., Clark Plano, V. L., and Morales, A. (2007). Qualitative research designs: Selection and implementation. *The counseling psychologist*, *35*(2), 236-264.

De Lange, Naydene, Khau, Mathabo., and Athiemoolam., Logan.(2014). Teaching practice at a rural school?'And why should we go there?' Part 1: exploration of the critical relationship between higher education and the development of democracy in South Africa. *South African Journal of Higher Education*, *28*(3), 748-766.

DeLong, M., Winter, D., and Yackel, C. A. (2005). Student learning objectives and mathematics teaching. *Problems, Resources, and Issues in Mathematics Undergraduate Studies*, *15*(3), 226-258.

Demi, M. A., Coleman-Jensen, A., and Snyder, A. R. (2010). The rural context and secondary school enrollment: An ecological systems approach. *Journal of Research in Rural Education (Online)*, *25*(7), 1.

Department of Basic Education. (2011). Curriculum and Assessment Policy Statement (CAPS): Foundation Phase Mathematics, Grade R-3.

Department of Education. (2001). Early Childhood Development Education (White Paper 5).Pretoria: Department of Education.

Diezmann, C. M., Watters, J. J., and English, L. D. (2001). Difficulties confronting young children undertaking investigations.

Diezmann, C. M., Watters, J. J., and English, L. D. (2002). Teacher behaviours that influence young children's reasoning.

Dixon, K., Excell, L., and Linington, V. (2014). “We are workshopped": Problematising Foundation Phase teachers' identity constructions. *South African Journal of Childhood Education*, *4*(1), 139-155.

Dörfler, W. (2002). Formation of mathematical objects as decision making. *Mathematical Thinking and Learning*, *4*(4), 337-350.

Dossey, J. A. (2002). *Mathematics Modeling for Today's Mathematics Classroom: A Contemporary Approach to Teaching Grades 7-12*. Brooks/Cole.

Dossey, J., McCrone, S., Giordano, F. and Weir, M. (2002). Mathematics methods and modeling for today’s mathematics classroom. A contemporary approach to teaching grade 7-12. Pacific Grove, California : Brooks/Cole.

Fairclough, N. (1995). Critical discourse analysis. The critical study of language. Language in social life series.

Fairclough, N., and Wodak, R. (1997). Critical discourse analysis. In van Dijk, TA (ed.) Discourse as Social Interaction (Discourse Studies: A Multidisciplinary Introduction, vol. 2).

Fiske, E., and Ladd, H. (2006). Racial equity in education: How far has South Africa come?. *Perspectives in Education*, *24*(2), 95-108.

Fleisch, B. (2008). Primary education in crisis. *Cape Town: Juta*.

Fook, J. (2007). Reflective practice and critical reflection. *Handbook for Practice Learning in Social Work and Social Care, Basingstoke, Palgrave*, 363-375.

Foucault, M. (1989). Foucault live. *New York: Semiotext (e)*.

Foucault, M. (1997). *The politics of truth*. Semiotext.

Frankenstein, M. (2009). Using real real-life problems in teaching critical mathematical literacy. *Words and worlds: Modeling verbal descriptions of situations. Rotterdam: The Netherlands: Sense Publications*.

Fuson, K. C., and Briars, D. J. (1990). Using a base-ten blocks learning/teaching approach for first-and second-grade place-value and multidigit addition and subtraction. *Journal for research in mathematics education*, 180-206.

Garfinkel, P. E. (1974). Perception of hunger and satiety in anorexia nervosa. *Psychological medicine*, *4*(3), 309-315.

Gaventa, J. (2003). Power after Lukes: an overview of theories of power since Lukes and their application to development. *Brighton: Participation Group, Institute of Development Studies*.

Goulding, M., Rowland, T., and Barber, P. (2002). Does it matter? Primary teacher trainees' subject knowledge in mathematics. *British Educational Research Journal*, *28*(5), 689-704.

Grant, C., and Osanloo, A. (2014). Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your "house". *Administrative Issues Journal*, *4*(2), 4.

Green, W. (2011). Foundation Phase teacher provision by public higher education institutions in South Africa. *South African Journal of Childhood Education (SAJCE)*, *1*(1).

Greenberg KH 1990. Mediated learning in the classroom. International Journal of Cognitive Education and Mediated Learning, 1:33-43.

Guo, Y., Li, X., and Sherr, L. (2012). The impact of HIV/AIDS on children's educational outcome: A critical review of global literature. *AIDS care*, *24*(8), 993-1012.

Gutstein, E. (2006). *Reading and writing the world with mathematics: Toward a pedagogy for social justice*. Taylor and Francis.

Hamiloğlu, K., and Temiz, G. (2012). The impact of teacher questions on student learning in EFL. *Journal of Educational and Instructional Studies in the world*, *2*(2).

Hashweh*, M. Z. (2005). Teacher pedagogical constructions: a reconfiguration of Pedagogical Content Knowledge. *Teachers and Teaching*, *11*(3), 273-292.

Hattie, J. (2003). Teachers Make a Difference, What is the research evidence?.

Heaton, R. M. (1992). Who is minding the mathematics content? A case study of a fifth-grade teacher. *The Elementary School Journal*, *93*(2), 153-162.

Herbert, S., Vale, C., Bragg, L. A., Loong, E., and Widjaja, W. (2015). A framework for primary teachers' perceptions of mathematical reasoning. *International Journal of Educational Research*, *74*, 26-37.

Hiebert, J. (1984). Children's mathematics learning: The struggle to link form and understanding. *The elementary school journal*, *84*(5), 497-513.

Hill, H. C., Ball, D. L., and Schilling, S. G. (2008). Unpacking Pedagogical Content Knowledge: Conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal for research in mathematics education*, 372-400.

Hill, H. C., Blunk, M. L., Charalambous, C. Y., Lewis, J. M., Phelps, G. C., Sleep, L., and Ball, D. L. (2008). Mathematical knowledge for teaching and the mathematical quality of instruction: An exploratory study. *Cognition and instruction*, *26*(4), 430-511.

Hirson, B. (1979). *Year of fire, year of ash: the Soweto revolt, roots of a revolution?* (Vol. 3). Zed Press.

Hlalele, D. (2012). Exploring rural high school learners' experience of mathematics anxiety in academic settings. *South African Journal of Education*, *32*(3), 267-278.

Hoadley, U. (2010). Tribes and territory: Contestation around curriculum in South Africa. In *Curriculum Studies in South Africa* (pp. 125-176). Palgrave Macmillan, New York.

Hoadley, U., and Ensor, P. (2009). Teachers' social class, professional dispositions and pedagogic practice. *Teaching and Teacher Education*, *25*(6), 876-886.

Human, A., Van der Walt, M., and Posthuma, B. (2015). International comparisons of Foundation Phase number domain mathematics knowledge and practice standards. *South African Journal of Education*, *35*(1), 01-13.

Iqbal, J. (2007) Learning from a doctoral research project: Structure and content of a research proposal. The Electronic Journal of Business Research Methods, 5(1),11–20.

Janks, H. (2010). Language, power and pedagogies. *Sociolinguistics and language education*, 40-61.

Jansen, J. D. (2004). Race and education after ten years: conversations. *Perspectives in Education*, *22*(1), 117-128.

Jansen, J. D., and Christie, P. (1999). *Changing curriculum: Studies on outcomes-based education in South Africa*. Juta and Company Ltd.

Jansen, J., and Taylor, N. (2003). *Educational change in South Africa 1994-2003: Case studies in large-scale education reform*. The World Bank.

Jeynes, W. H. (2003). A meta-analysis: The effects of parental involvement on minority children's academic achievement. *Education and urban society*, *35*(2), 202-218.

John, P. D. (2006). Lesson planning and the student teacher: re-thinking the dominant model. *Journal of Curriculum Studies*, *38*(4), 483-498.

Kaldrimidou, M., and Ikonomou, A. (1992). High school graduates' ability in using graphical representations. *Cahiers de Didactique des MatheÂmatiques, 10*, *11*, 21-43.

Kanyongo, G. Y., and Brown, L. I. (2013). Relationship between pedagogical strategies and teachers' content knowledge of mathematics. *African Journal of Research in Mathematics, Science and Technology Education*, *17*(1_2), 106-112.

Kazemi, E. (1998). Discourse that promotes conceptual understanding. *Teaching Children Mathematics*, *4*(7), 410.

Kelchtermans, G. (2009). Who I am in how I teach is the message: self-understanding, vulnerability and reflection. *Teachers and Teaching: theory and practice*, *15*(2), 257-272.

Kellner, H. (1989). *Language and historical representation: Getting the story crooked*. University of Wisconsin Press.

Kennedy, M. M. (2016). How does professional development improve teaching?. *Review of Educational Research*, *86*(4), 945-980.

Khuzwayo, B. (2005). A history of mathematics education research in South Africa: The apartheid years. *Researching mathematics education in South Africa: Perspectives, practices and possibilities*, *234*, 286.

Kim, D. J., Choi, S., and Lim, W. (2017). Sfard's Commognitive Framework as a Method of Discourse Analysis in Mathematics. *Language*, *115*, 10008173.

Larkin, K., and Jorgensen, R. (2016). 'I Hate Maths: Why Do We Need to Do Maths?'Using iPad Video Diaries to Investigate Attitudes and Emotions Towards Mathematics in Year 3 and Year 6 Students. *International Journal of Science and Mathematics Education*, *14*(5), 925-944.

Leinhardt, G. (2001). Instructional explanations: A commonplace for teaching and location for contrast. *Handbook of research on teaching*, *4*, 333-357.

Leinhardt, G., Zaslavsky, O., and Stein, M. K. (1990). Functions, graphs, and graphing: Tasks, learning, and teaching. *Review of educational research*, *60*(1), 1-64.

Loughran, J. (2010). Seeking knowledge for teaching teaching: Moving beyond stories. *Studying Teacher Education*, *6*(3), 221-226.

Lucas, P. (2012, November). Critical reflection. What do we really mean. In *2012 Australian Collaborative Education Network National Conference* (p. 163).

Lysaght, Z. (2011). Epistemological and paradigmatic ecumenism in" Pasteur's Quadrant": Tales from doctoral research. In *The Third Asian Conference on Education Osaka, Japan, Official Conference Proceedings* (pp. 567-579).

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Lawrence Erlbaum Associates.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Lawrence Erlbaum Associates.

Madhavan, S., and Townsend, N. (2007). The social context of children's nutritional status in rural South Africa 1. *Scandinavian Journal of Public Health*, *35*(69_suppl), 107-117.

Martino, A. M., and Maher, C. A. (1999). Teacher questioning to promote justification and generalization in mathematics: What research practice has taught us. *The Journal of Mathematical Behavior*, *18*(1), 53-78.

Marton, F., and Pang, M. F. (2006). On some necessary conditions of learning. *The Journal of the Learning sciences*, *15*(2), 193-220.

Marton, F., Tsui, A. B., Chik, P. P., Ko, P. Y., and Lo, M. L. (2004). *Classroom discourse and the space of learning*. Routledge.

Masinire, A. (2015). Recruiting and retaining teachers in rural schools in South Africa: Insights from a rural teaching experience programme. *Australian and International Journal of Rural Education*, *25*(1), 2-14.

Masinire, A., Maringe, F., and Nkambule, T. (2014). Education for rural development: Embedding rural dimensions in initial teacher preparation. *Perspectives in Education*, *32*(3), 146-158.

Mason, J. (2006). Mixing methods in a qualitatively driven way. *Qualitative research*, *6*(1), 9-25.

Mathews, C. (2014). Teaching division. *Exploring Mathematics and Science Teachers' Knowledge: Windows Into Teacher Thinking*, 84.

Mbatha, T. (2014). Experiences of Foundation Phase teachers qualified in a dual medium programme. *Per Linguam: a Journal of Language Learning= Per Linguam: Tydskrif vir Taalaanleer*, *30*(2), 37-50.

Mbatha, T. (2014). Experiences of Foundation Phase teachers qualified in a dual medium programme. *Per Linguam: a Journal of Language Learning= Per Linguam: Tydskrif vir Taalaanleer*, *30*(2), 37-50.

McMillian, H. J., and Schumacher, S. (2010). Research in education (7. Baskı).

Mhlolo, M. K., Schafer, M., and Venkat, H. (2012). The nature and quality of the mathematical connections teachers make. *pythagoras*, *33*(1), 1-9.

Minnaar, L. (2006). *Causes of school dropout among learners in a rural farm school* (Doctoral dissertation).

Minnaar, L. (2006). *Causes of school dropout among learners in a rural farm school* (Doctoral dissertation).

Mishra, P., and Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A framework for teacher knowledge. *Teachers college record*, *108*(6), 1017.

Mji, A., and Makgato, M. (2006). Factors associated with high school learners' poor performance: a spotlight on mathematics and physical science. *South African journal of education*, *26*(2), 253-266.

Moletsane, R. (2012). Repositioning educational research on rurality and rural education in South Africa: Beyond deficit paradigms. *Perspectives in Education*, *30*(1), 1-8.

Mouton, N., Louw, G. P., and Strydom, G. L. (2012). A historical analysis of the post-apartheid dispensation education in South Africa (1994-2011). *The International Business and Economics Research Journal (Online)*, *11*(11), 1211.

Muijs, D. (2010). *Doing quantitative research in education with SPSS*. Sage.

Murris, K., and Verbeek, C. (2014). A foundation for Foundation Phase teacher education: Making wise educational judgements. *South African Journal of Childhood Education*, *4*(2), 1-17.

Naidoo, D., and Green, W. (2011). Semiotic mediation through coherent discourse in science classrooms. *African Journal of Research in Mathematics, Science and Technology Education*, *15*(1), 34-50.

Naidoo, J. P. (2005). Educational Decentralization and School Governance in South Africa: From Policy to Practice. *International Institute For Educational Planning (IIEP) UNESCO*.

Nguyen, N. T., McFadden, A., Tangen, D. J., and Beutel, D. A. (2013). Video-stimulated recall interviews in qualitative research.

Nightingale, D. J., and Cromby, J. (2002). Social constructionism as ontology: Exposition and example. *Theory and Psychology*, *12*(5), 701-713.

Niss, M. (2003, January). Mathematical competencies and the learning of mathematics: The Danish KOM project. In *3rd Mediterranean conference on mathematical education* (pp. 115-124).

Nkambule, T. C. (2017). Student teachers' perceptions of a Wits rural teaching experience project: What to learn and improve. *South African Journal of Higher Education*, *31*(1), 191-206.

Nkambule, T., Balfour, R. J., Pillay, G., and Moletsane, R. (2011). Rurality and rural education: Discourses underpinning rurality and rural education research in South African postgraduate education research 1994-2004. *South African Journal of Higher Education*, *25*(2), 341-357.

North, D., and Zewotir, T. (2006). Introducing statistics at school level in South Africa. In *Proceedings of the 7th International Conference on Teaching Statistics*.

Nunan, S. L. (2005). Forgiving ourselves and forging ahead: Teaching grammar in a new millennium. *English Journal*, 70-75.

Pilcher, J. J., Nadler, E., and Busch, C. (2002). Effects of hot and cold temperature exposure on performance: a meta-analytic review. *Ergonomics*, *45*(10), 682-698.

Pillay, J. (2016). Problematising child-headed households: The need for children's participation in early childhood interventions. *South African Journal of Childhood Education*, *6*(1), 1-8.

Powell, A. B., and Brantlinger, A. (2008). A pluralistic view of critical mathematics. In *Proceedings of the fifth International Mathematics Education and Society conference* (pp. 424-433).

Rubin, A., and Babbie, E. R. (2011). Qualitative research: General principles. *Research methods for social work*, 436-455.

Sayed, Y. (2004). The case of teacher education in post-apartheid South Africa: Politics and priorities. *Changing class: Education and social change in post-apartheid South Africa*, 247-265.

Scott, D., and Morrison, M. (2005). *Key ideas in educational research*. AandC Black.

Scott, D., and Usher, R. (Eds.). (1996). *Understanding educational research*. Psychology Press.

Scott, P., Mortimer, E., and Ametller, J. (2011). Pedagogical link-making: A fundamental aspect of teaching and learning scientific conceptual knowledge. *Studies in Science Education*, *47*(1), 3-36.

Setati, M. (2005). Teaching mathematics in a primary multilingual classroom. *Journal for research in Mathematics Education*, 447-466.

Sfard, A. (2007). When the rules of discourse change, but nobody tells you: Making sense of mathematics learning from a commognitive standpoint. *The Journal of the Learning Sciences*, *16*(4), 565-613.

Sfard, A. (2008). *Thinking as communicating: Human development, the growth of discourses, and mathematizing*. Cambridge University Press.

Sharron, H. (1987). *Changing Children's Minds: Feuerstein's revolution in the teaching of intelligence*. Souvenir PressLtd.

Shen, J., Poppink, S., Cui, Y., and Fan, G. (2007). Lesson planning: A practice of professional responsibility and development. *Educational horizons*, *85*(4), 248-258.

Shepherd, D. L. (2011). Constraints to school effectiveness: What prevents poor schools from delivering results. *Programme to support pro poor policy development programme. Department of Economics, Stellenbosch University. PSPPD Project–April*.

Shneiderman, B., and Plaisant, C. (2006, May). Strategies for evaluating information visualization tools: multi-dimensional in-depth long-term case studies. In *Proceedings of the 2006 AVI workshop on BEyond time and errors: novel evaluation methods for information visualization* (pp. 1-7). ACM.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard educational review*, *57*(1), 1-23.

Sikes, P. (2004). Methodology, procedures and ethical concerns. *Doing educational research*, 58-72.

Simon, M. A. (2006). Key developmental understandings in mathematics: A direction for investigating and establishing learning goals. *Mathematical Thinking and Learning*, *8*(4), 359-371.

Simons, H. (2009). *Case study research in practice*. SAGE publications.

Siyepu, S. (2013). The zone of proximal development in the learning of mathematics. *South African Journal of Education*, *33*(2), 1-13.

Siyepu, S. W., and Ralarala, M. K. (2014). Making sense of mathematical discourse: implications for success in the learning of differentiation in a university classroom.

Skovdal, M., and Daniel, M. (2012). Resilience through participation and coping-enabling social environments: the case of HIV-affected children in sub-Saharan Africa. *African journal of AIDS research*, *11*(3), 153-164.

Smarick, A. (2014). A New Frontier: Utilizing Charter Schooling to Strengthen Rural Education. *Bellwether Education Partners*.

Smith, J. A. (Ed.). (2015). *Qualitative psychology: A practical guide to research methods*. Sage.

Smith, N. (2012). *Recognition Theory as Social Research*. London, Palgrave Macmillan.

Smyth, J. (1989). Developing and sustaining critical reflection in teacher education. *Journal of teacher education*, *40*(2), 2-9.

Spaull, N. (2013). South Africa's education crisis: The quality of education in South Africa 1994-2011. *Johannesburg: Centre for Development and Enterprise*, 1-65.

St. Pierre, E. A. (2000). Poststructural feminism in education: An overview. *International journal of qualitative studies in education*, *13*(5), 477-515.

Stelmach, B. L. (2011). A Synthesis of International Rural Education Issues and Responses. *Rural Educator*, *32*(2), 32-42.

Stylianou, D. A., and Grzegorczyk, I. (2005). Symmetry in mathematics and art: An exploration of an art venue for mathematics learning. *Problems, Resources, and Issues in Mathematics Undergraduate Studies*, *15*(1), 30-44.

Tabach, M., and Nachlieli, T. (2011). Combining theories to analyse classroom discourse: A method to study learning process. In *The Seventh Congress of the European Society for Research in Mathematics Education, University of Rzeszów, Poland*.

Taylor, N., and Vinjevold, P. (1999). Getting learning right.

Thembela, A. (1986). Educational obstacles to black advancement. *Black advancement in the South African economy*, 73-80.

Thompson, J. B. (2013). *Ideology and modern culture: Critical social theory in the era of mass communication*. John Wiley and Sons.

TIMMS 2015 study results - HSRC

Torrance, H. (2007). Assessment as learning? How the use of explicit learning objectives, assessment criteria and feedback in post-secondary education and training can come to dominate learning. *Assessment in Education*, *14*(3), 281-294.

Tyson, L. (2014). *Critical theory today: A user-friendly guide*. Routledge.

Van der Berg, S., Burger, C., Burger, R., de Vos, M., du Rand, G., Gustafsson, M., ... and van Broekhuizen, H. (2011). Low quality education as a poverty trap.

Van der Kolk, B. (2014). *The body keeps the score: Mind, brain and body in the transformation of trauma*. Penguin UK.

Van Dijk, D., and Van Driel, F. (2012). Questioning the use-value of social relationships: Care and support of youths affected by HIV in child-headed households in Port Elizabeth, South Africa. *African Journal of AIDS research*, *11*(3), 283-293.

Van Dijk, T. A. (2008). Discourse and context. *A sociocognitive approach. Cambridge*.

Venkat, H., and Adler, J. (2012). Coherence and connections in teachers' mathematical discourses in instruction. *Pythagoras*, *33*(3), 1-8.

Venkat, H., and Naidoo, D. (2012). Analyzing coherence for conceptual learning in a Grade 2 numeracy lesson. *Education as Change*, *16*(1), 21-33.

Venkat, H., and Spaull, N. (2015). What do we know about primary teachers' mathematical content knowledge in South Africa? An analysis of SACMEQ 2007. *International Journal of Educational Development*, *41*, 121-130.

Vygotsky, L. S. (1987). *The collected works of LS Vygotsky: Volume 1: Problems of general psychology, including the volume Thinking and Speech* (Vol. 1). Springer Science and Business Media.

Vygotsky, L. (1978). Interaction between learning and development. *Readings on the development of children*, *23*(3), 34-41.

Walker, V. S. (2000). Valued segregated schools for African American children in the South, 1935-1969: A review of common themes and characteristics. *Review of Educational Research*, *70*(3), 253-285.

Wang, J. (2006). Questions and the exercise of power. *Discourse and Society*, *17*(4), 529-548.

Wessels, H. M., and Nieuwoudt, H. D. (2010). Teacher knowledge and confidence in Grade 8 and 9 data handling and probability. In *Proceedings of the 8th International Conference on Teaching Statistics*.

Wessels, P. L., and Steenkamp, L. P. (2009). An investigation into students' perceptions of accountants. *Meditari Accountancy Research*, *17*(1), 117-132.

Williams, P. (2008). Independent review of mathematics teaching in early year's settings and primary schools.

Appendix A

Information sheet for principals:

05 January 2017

Dear Principal

My name is Kharoon Nisha Rasool. I am a Master of Education by Dissertation student at the University of the Witwatersrand, School of Education. I am interested in conducting research at your school in order to explore and understand Grade 3 rural teachers' nature of mathematics content knowledge and coherent teaching in Acornhoek classrooms, Mpumalanga province. The information generated will be used for the purpose of research report for degree purposes.

My research participants will include teachers from two schools in Acornhoek. I kindly request your permission to make use of grade 3 mathematics teachers from your school as my research participants, and intend to observe two mathematics lessons per teacher. Additionally, one semi-structured interview per teacher will occur, subject to change depending on classroom observation. The teachers may withdraw from participating in this study at any time without any penalty. There are no foreseeable risks in participating in this study and no form of payment involved in participating.

My research will make use of a qualitative research approach. Semi-structured, one-on-one interviews with Grade 3 mathematics teachers will occur. With regard to observations, I will take on the role of non-participant observer and will conduct semi-structured observations during grade 3 mathematics lessons. Video-recording and audio-recordings will be used during data collection. The interviews will take approximately 35 - 45 minutes and will take place after school.

Confidentiality with regards to the teachers' names and the schools name is guaranteed throughout the writing of my research project. All research data will be destroyed within three- five years after completion of the project. Please use the contacts below should you require any further information.

Thanking you for all your assistance in making this project a reality.

Kind Regards

Kharoon Nisha Rasool

9 Side Road Chrisville 2091, Johannesburg

Cell phone: 0790694073

Email: khairoonrasool@yahoo.com

Dr. Thabisile Nkambule

Curriculum Division

School of Education

Tel:+27-11-717-3049

Email: Thabisile.nkambule@wits.ac.za

Appendix B

Information sheet for teachers:

05 January 2017

Dear Teacher

My name is Kharoon Nisha Rasool. I am a Master of Education by Dissertation student at the University of the Witwatersrand, School of Education.

I would like for you to voluntary participate in my study by allowing me to observe your lessons while teaching mathematics to your grade three learners. The information will be used to understand Grade 3 rural teachers' nature of mathematics content knowledge and coherent teaching in Acornhoek classrooms. If you refuse to participate, or discontinue participation at any time, no penalty or loss of benefits to will occur. The information generated will be used for the purpose of research report for degree purposes.

My research will make use of a qualitative research approach. Semi-structured, one-on-one interviews with Grade 3 mathematics teachers will occur. With regard to observations, I will take on the role of non-participant observer and will conduct semi-structured observations during grade 3 mathematics lessons. Video-recording and audio-recordings will be used during data collection. The interviews will take approximately 35 - 45 minutes and will take place after school.

The reason I chose to videotape is because it is necessary to gain as much information from the observations as possible given the time constraints when collecting data, that being three weeks. The video playback will enable me to gain insight on the nature of the teachers mathematics content knowledge as well as the way in which/if at all teachers make coherent concept connections in the mathematics classroom. Failure to make use of a videotape, may lead to me missing essential information which may assist me in understanding the teaching and learning process in grade three mathematics classrooms.

I will not disrupt your classroom routine in any way. You should feel free to ask me to leave the classroom at any time, without penalty. There are no foreseeable risks in participating and no payment will be made to you for participating in this study.

Your identity will be kept confidential at all times and in all academic writing or publications of this study. All research data will be destroyed within three- five years after completion of the project. Please do not hesitate in contacting me should you require any further information.

Thanking you for all your assistance in making this project a reality.

Kind Regards

Kharoon Nisha Rasool

9 Side Road Chrisville 2091, Johannesburg

Cell phone: 0790694073

Email: khairoonrasool@yahoo.com

Dr. Thabisile Nkambule

Curriculum Division

School of Education

Tel:+27-11-717-3049
Email: Thabisile.nkambule@wits.ac.za

Appendix C

Consent form for teachers:

05 January 2017

Please fill in and return the reply slip below indicating your willingness to allow me to engage with you during interview sessions and to observe your class while you are teaching mathematics to your grade 3 learners, for the study titled: Exploring and understanding grade 3 rural teachers' nature of mathematics content knowledge and coherent concept connections in Acornhoek classrooms, Mpumalanga province

I, ____ give my consent for the following:

Circle one

- **Permission to observe you in class**

I agree to be observed in class. YES/NO

- **Permission to be audiotaped**

I agree to be audiotaped during the interview or observation lesson YES/NO

I know that the audiotapes will be used for this project only YES/NO

- **Permission to be interviewed**

I would like to be interviewed for this study. YES/NO

I know that I can stop the interview at any time and don't have to answer all the questions asked. YES/NO

- **Permission to be videotaped**

I agree to be videotaped in class. YES/NO

I know that the videotapes will be used for this project only. YES/NO

Informed Consent

I understand that:

- I am free to withdraw from the study at any time without prejudice.
- My name and information will be kept confidential and safe and that my name and the name of my school will not be revealed.
- I can ask the researcher to leave the classroom at any time.
- I can ask for my class not to be videotaped or for an audio recording not to take place during interviews.
- All the data collected during this study will be destroyed within five years after completion of the project.
- I do not have to answer every question and can withdraw from the study at any time.

Sign______________________________ Date____________________________

Appendix D

The Approval Letter from Mpumalanga Department of Education

APPROVAL TO CONDUCT RESEARCH FOR DR T. NKAMBULE

education
MPUMALANGA PROVINCE
REPUBLIC OF SOUTH AFRICA

Building No. 5, Government Boulevard, Riverside Park, Mpumalanga Province
Private Bag X11341, Mbombela, 1200.
Tel: 013 766 5552/5115, Toll Free Line: 0800 203 116

Litiko le Temfundvo, Umnyango we Fundo | Departement van Onderwys | Ndzawulo ya Dyondzo

Enquiries: A.H. Baloyi
Tel: (013) 766 5476

Dr T. Nkambule
2307 Oasis Security Estate
Cnr Pyp Avenue and Orange rivier Drive
Kempton Park West
1619

RE: APPLICATION TO CONDUCT RESEARCH: DR T. NKAMBULE

Your application to conduct research was received on 25 February 2015. The title of your study is: "Conditions of teaching and learning that facilitate and/or constrain learning in rural high Schools." The research objectives, significance and overall design of your study give an impression that the outcomes of the study will be useful and valuable in improving teaching and learning in rural schools. Your request is approved subject to you observing the content of the departmental research manual which is attached. You are required to discuss with the principals of the sampled schools regarding the approach to your observation and data collection as no disruption of tuition will be allowed. You are also requested to adhere to your University's research ethics as spelt out in your research ethics document.

In terms of the attached manual (2.2. bullet number 4 & 6) data or any research activity can only be conducted after school hours as per appointment. You are also requested to share your findings with the department so that we may consider implementing your findings if that will be in the best interest of the department.

MPUMALANGA
THE PLACE OF THE RISING SUN

For more information kindly liaise with the department's research unit @ 013 766 5476 or a.baloyi@education.mpu.gov.za. The department wishes you well in this important project and pledges to give you the necessary support you may need.

APPROVED/~~NOTAPPROVED~~:

MRS MOC MHLABANE
HEAD OF DEPARTMENT

07 / 3 / 15
DATE

Appendix E - transcription of interviews

University of the Witwatersrand
Time of interview: 10:30 AM
Date: 2 May 2017
Place: Impumelelo Primary School
Interviewer: Mrs Rasool
Interviewee: Teacher Thembiwe
Introductory questions:
Where did you attend primary and secondary schools? Welverdien primary school in Mpumalanga. I attended Mahlahle high school.
Please tell me a bit about yourself, why did you choose to be a teacher? I chose to become a teacher because I have the passion and love for it and the other reason is because there were scarce jobs for black people in our communities. ….like us blacks we only knew you could become a teacher, you can become a policeman, during our years we had no opportunities.
Where did you train to be a teacher? (only ask 'when' if they don't mention it) At Mapuleng college in Bushbuckridge Mpumalanga
Were you trained as a Foundation Phase teacher? / If you still remember, can you briefly talk about the way you were trained? I trained for three year to get a JPTD; it was called a junior primary teaching diploma. They taught me numeracy, literacy…….everything. I think they trained me well. It was good at the time.
How long have you been teaching Foundation Phase? For about 12 years …. *laughs* The other day you were telling me that you went to work at Eskom as vendor selling electricity because there were no teaching jobs available, and then you came back into teaching. How long did you work for? Uhmmm….. I completed my diploma in 1995, I worked at eskom until 2003 and then in 2004 I was employed by the department of education.

Okay, thanks for that ma’am
Have you received any training to teach Foundation Phase – workshops and/or qualification, please tell me about this? The workshops are helpful. The only problem is that our department is changing the curriculum every time. If you try to grasp the content that you’ve been work shopped, about after a year or after some months, the department changes the curriculum and then you have to learn another curriculum. But…. the workshops are useful: the only problem is that the department changes now and then. Now were having a programme that is called NECT, it’s not long ago that we were work shopped about CAPS Is NECT different to CAPS? There is not that vast difference but they work hand in hand. The only thing is when you grasp this, and then you have to go to another workshop. Do they ever give you training for mathematics content? Yes, they do give us, but, the period is too short, because they have to train you for maths in a couple of hours; like 2-3 hours.so you can’t get everything because the content is large.
Do you think it’s important to reflect as a Foundation Phase teacher? It is important because you will see where you are backward and where you are forward and where your children can’t understand, so you can repeat the lesson to make it a success.in this programme, the NECT, you can reflect, but you don’t have much time to reflect because each and every day there’s some time to follow. The tracker tells you what to do for that particular day.it doesn’t give you a day to go back and revise the lesson so that the children can grasp. No! You need to go forward each and every time.

<u>Research questions:</u>
According to you, is it important for Foundation Phase teachers to have mathematics content knowledge? Why? Yes because when a child comes to school, he/she is empty and then we build the

foundation, the concrete materials in that child's life.
Do you think your training prepared you enough to teach mathematics in FP or grade 3, How/Why? My training at the college? Yes. It did because I can teach, I have that knowledge. And ma'am when you were trained there, you said it was during apartheid – were there only black lecturers training you? Yes, mostly blacks, there were a few whites but not many. Did they have different subjects? Yes, they had subjects like maths, English etc. and that's how they trained us.
From your experience, is it important to teach mathematical concepts coherently and connected? Please explain briefly. Yes, it's very much important because if you're teaching; in CAPS, we have the…. How can I put it? If we have a grade 1 teacher, the teacher teaches addition from 1-10, a grade 2 teacher teaches from 50-100, a grade 3 from 100-500, just like that, so they are building up the content; when we start teaching multiplication. We start them by repeated addition. You start them from what you know to the unknown. Because multiplication is difficult for them, but if you start by the repeated addition, they understand that 10+10, it means multiply 2 by 10.
What is your understanding of coherent concept connection in mathematics? Well… we teach from the known to the unknown, yes if grade 1 teaches up to 10, grade 2 teaches take it from ten to the next set of numbers, and from there they build on it.
According to your experience, what challenges, if any, do learners experience with mathematical content? What is challenging for them, the first one is division, and they can differentiate between division and multiplication, that's where they got the difficult part. And then

like for instance in geometry, there are some shapes and what so ever – we're pushing so that they can understand. Even us; some of us; the information; we don't know it; for instance, calculating distance. As a teacher I don't understand, so what can happen to the learner?
What do you think a child needs to know before they start learning to **"add and combine?"-** I saw how you taught Busi's method of addition today, what do you think a child needs to know before they are able to answer this type of addition activity? - They have to know how to count. - They've got to know the place value - Its then that they'll be able to answer - Because at the first time, you write the numbers there and then the 2nd step you break it down - Yes and then if you break it down , both the numbers - Then the following step- they have to pack according to the place value - Yes 100s, 10s, and units, neh…. - Its then that they will be able to add to find the answer - And then you have to know that if were talking about 100s, were talking about 3 numbers, units is one number, tens is 2 numbers - If you saw me writing 70072, that's what they'll write instead of 772 – so you have to tell them, every now and then when we're talking about a hundred, were looking at only three numbers. When you have four numbers, it means thousands When teaching using the NECT programme, it has taught us that when you get into the class in the morning, you have to count, and they have to do mental maths – that's why you have seen me making them count. uhm….. do the…., uhm, its mental maths, 142+10+20, what what…. that's what we need to do each and every day.
You've already told me about the challenges they face while teaching

mathematics, do you think the problem is multiplication and division or are there outside factors that affect a child's learning? Yeah there may be outside factors because in the community that were working in, it's very much rural; even the HIV epidemic has affected a lot in this area. we've got a lot of families that are led by children, of the grade 3 age as well one has to take her pill for HIV in the morning and the pill has to do its own work, while she is here at school , you will find that the child doesn't even understand what you're saying because they're so tired., while the pill is doing its own work , the child cannot work Then we've got families that are led by children. These kids are orphans. The HIV has done a lot of damage in this community. So…… if a child comes to school being tired, she has been cooking, cleaning, washing. the other factor is that , its half the class that can do my homework because they need to help their parents at home mostly their parents are working from 4 am until 6pm – they go to some farms in the Hoedspruit area – some of them work shifts, some are going in the morning , some are going in the afternoon So, nobody is giving them the parental support. those are the factors that are affecting them And the other factor is myself as a teacher, because I've told you that there are concepts that I myself, I don't know. I can calculate the distance or whatsoever. So yes the department has to do more workshops. Yes, the department doesn't teach us 'content', they teach us how to 'implement policy.'
Why do you make the learners count every morning? I make them count each and every morning so that they should have more knowledge about counting and it's linked to what I'm going to teach so I have to prepare them first.
So after you've prepared them with mental maths, do you tell them what your lesson topic for the day is and what previous topics do they need to know in order to understand what you're teaching them today? Today, I was going to teach them about this addition …… adding hundreds, tens,

and units. They have to understand the place value first and through that I can bring the method of adding through place value.

Okay, how do you ensure that when you teach, you make sure that the concepts are connected?

To make sure that the concepts of…..the maths concepts? Yes. They're connected, because if I'm teaching them, they are counting: they are adding, they know their place value – that's how all things come together

Please tell me about teaching mathematics in your home language Tsonga?

We teach maths in Tsonga from grade R-3. We should be saying these numbers in our home language but because it creates a problem when the child goes to grade 4, and the grade 4 teacher has to start teaching from 1 again, the grade four teacher, telling them, what is this, what is this, because in FP we teach them in our home language and then they go to grade 4 and it's a problem because the grade 4 teacher has to start from scratch. We talk about place value in Tsonga, he has to start/ introduce the term in English, for example dzana is a 100 and it consumes a lot of time. That is why there's a huge problem in the intermediate mathematics results, because they have to start from one. They are good or the best learners in FP when they learn mathematics in their mother tongue, but the problem comes in when they have to learn everything in English in grade 4. I think the system is failing our kids badly. This is why the results from intermediate to senior are not good.

And this language barrier is contributing to even matric results. You'll find even in matric that a child cannot express himself well in the English language.

English in FP is not emphasised upon, as it is the FAL. We emphasise Tsonga , our HL

If you were given the opportunity to teach in an urban school, would you?

Yes, I would, but I'd struggle to use technology.

University of the Witwatersrand
Date: 2/05/2017
Place: Imfundo Primary school
Interviewer: Mrs Rasool
Interviewee: Teacher Fonky
Introductory questions:
Where did you attend primary and secondary schools? I did not attend high school. I studied only at primary. And after primary, what did you do? I first worked as an unqualified teacher, and then I went to a training college 'Mapuleng college of education'. In Mpumalanga, I trained for three years, for a SPTD. So you trained for a high school, but you came to teach in a primary school? Yes
Please tell me a bit about yourself, why did you choose to be a teacher? It was my calling.
Ma'am, how long have you been teaching FP? 18 years 1999 – Today
Have you received any training to teach Foundation Phase – workshops and/or qualification, please tell me about this? We were always having the workshops. In-service training, so they were always preparing us to go for workshops so that we can come back and implement everything. I taught while I was unqualified in 1987 during apartheid, 1988, and 1990. In 1991, I went to the training college. Then I started in 94 after apartheid.
What do you like about teaching Foundation Phase in a rural school? You know what ma'am, when I look toward the rural schools, most of them, most of the learners, they need more attention. Some of them are coming from different families, they need different attention, and they need different attention. Some of

them, they are coming from, what can I say “disadvantaged homes”. These learners in rural schools. They need more attention.
Do you think it’s important for teachers to reflect after lessons? Yes, it’s important, because you must think about what you have implemented to the kids.is it effective or not. Because, if the learners can maybe not understand, you suppose to go back and re do it.
Do you think this blue book makes your life easier? if you had your own choice, would you plan your own lessons, or do you think this book is good enough? Sometimes, the blue book is very much helpful because some of the things, if I can use my own lesson, not referring to the blue book, you’ll find that the learners won’t know anything. So this book brings the broad things in, because, some of the things, they’re still new. If I give them my own activities. It’s going to be easy. And this blue book makes them think more.

Research questions:
According to you, is it important for Foundation Phase teachers to have mathematics content knowledge? Why? Yes ma’am, they must have content knowledge because you cannot teach without knowing anything.so you must have the knowledge of everything in maths.
Do you think your training prepared you enough to teach mathematics in FP or grade 3, How/Why? My training was not enough. I was trained in a lot of things, methods, what what, but coming to the field is different to college. That’s why I was used to go to some of the workshops that helped me.
From your maths teaching in grade 3, where do learners struggle most? They struggle most in division and multiplication. Why do you think they struggle in division? Like when you say 52-3, because sometimes, when it comes to a ‘remainder’, it becomes a problem.

From your experience, is it important to teach mathematical concepts coherently and connected? Please explain briefly. It is very important because the learner needs to know that multiplication goes hand in hand with division. They're all connected. When I say 5×2 = 10.Then when I come to division. I say 10÷2= 5, or I say 10÷5 = 2. So they're all connected. In the beginning, they all learn to count, and throughout future learning in maths, they need to be able to count. counting forward and backward, counting of 10s, 5s etc.
Ma'am, you were teaching a lesson on Busi and Dumis method of addition, can you tell me what concepts a child needs to know before you can teach Busi and Dumis method? A child needs to know the 10s, the units, the place value, how are you going to add them or minus them. Firstly, learners must know about the signs, I'm using addition and subtraction, they must know, these signs are going hand in hand. They must first count the 10s, then the units, thereafter they can add.
When you're teaching breaking down and combining in addition, why is it important to connect the concepts? Some of the learners cannot see the link between the terms. So as the teacher, I must show them the 10s are this one and they know that in 100s they must have 2 numbers. In units the numbers are only one.
ma'am, I noticed in your class that when they're counting, you give them counters, you show them to use their fingers, what else do you do to help them to count. We give them the counters, some use a scribbler, then you count, maybe I can say the grade ones in FP use sticks, however, and some in grade 3 are still using sticks.
Ma'am, before you told me that learners struggle with multiplication and division, but why do they struggle? What factors affect a Childs learning?

Well, some learners have problems at home. Some don't have a good concentration, when you look at him/her; they look at you and start thinking. I'm in the class
What is your understanding of coherent concept connection in mathematics? I don't know. I haven't heard of this term before

University of the Witwatersrand
Date: 26/04/5017
Place: Impumelelo Primary School
Interviewer: Mrs Rasool
Interviewee: Teacher Carol
Introductory questions:
Where did you attend primary and secondary schools? Chewe primary school situated about 15 KM's from here in Mpumalanga.
Please tell me a bit about yourself, why did you choose to be a teacher? My mum was a teacher. I love children so I want to teach them like the way I was taught when I was young.
Where did you train to be a teacher? (only ask 'when' if they don't mention it) I trained at West Minister College of education in Johannesburg for a 3 year Diploma.
Were you trained as a Foundation Phase teacher? I was trained as a primary teacher because I didn't choose the high school level. I did the primary school level because I love kids. It was called JPTD – Junior Primary Teaching Diploma , I did not do a SPTD
If you still remember, can you briefly talk about the way you were trained? They taught us all the subjects : maths, English, Afrikaans, Natural Science, Tsonga, PE I studied from 1995-1997 There were LOLT lecturers for African languages such as Zulu, Sotho, Tsonga
How long have you been teaching Foundation Phase? I'm teaching Foundation Phase from 2004 - today
Have you received any training to teach Foundation Phase – workshops and/or qualification, please tell me about this? Yes, there were a lot of training; things are changing all the time. They trained us through workshops. There was RNCS , CAPS and now NECT

The training helps, but not for long because just when you start to understand and get used to it, it changes.

<u>Research questions:</u>
According to you, is it important for Foundation Phase teachers to have mathematics content knowledge? Why? Yes because you groom the child from the Foundation Phase, so it's more important so if they go to higher primary and high school they will be developed much better
Do you think your training prepared you enough to teach mathematics in FP or grade 3, How/Why? By then it was okay, but now a lot of things have change and the government is trying to train us more often. They're always giving us skills development; they take all Foundation Phase teachers and train us in English, Tsonga, Maths and Life Skills. So we are learning more often.
Can you please tell me about your mathematics teaching experiences in Foundation Phase? The teacher didn't know how to answer this question, even after probing differently
From your experience, is it important to teach mathematical concepts coherently and connected? Please explain briefly. Some learners are connected, some are slow learners that are why if you teach, I mustn't use my own method. I must teach according to these kids; he or she is so slow, I must use the simplest method and the middle and the difficult method. She said: When I teach them addition, I teach them how to add. When I teach them subtraction I teach them how to subtract, and subtraction means division, because when you subtract it's the same like when you divide. You take some to the other one and you see that it links. Even with multiplication, if you multiply things , it's the same as adding
What is your understanding of coherent concept connection in mathematics? I've never heard about it before

According to your experience, what challenges, if any, do learners experience with mathematical content? Us were teaching them in Tsonga.in Tsonga, it's much more difficult than in English because in English we say one plus one, in Tsonga we say nwe plus nwe.
What do you think a child needs to know before they start learning to **"add and combine?"** They must know addition and they must know subtraction and they must know subtraction because after sometime they must add and after subtraction, there's and activity on multiplication.so the children must know all the signs
Before working on mathematics problems with regards to **"the different methods of doing addition"**, which other mathematics concepts should a child already know? Counting, they can add up to 400 and 10s, units, hundreds
What are some of the challenges you have experienced while teaching "addition" topics? The problem comes with multiplication. learners mix the signs You'll find that instead of writing the multiplication, the child writes the addition sign and then they get confused. But then you go long and long and re teach them Others don't even know how to count or add in grade 3 Most kids forget what they learnt from grade 1 and 2 Now it's the 2nd term, you must start with the same numbers from the previous quarter so that they can be through. Slow learners easily forget, so you start with the numbers, you come; you come with the signs so that they can relate.
What do you think are the reasons for such challenges? The poverty thing; others they're like….. You asked me about the feeding scheme. Most of the parents are working at farms, when they eat here at school, there will be no food at home. When he wakes up in the morning, he comes here

being hungry and he will come and eat here. So you'll find most of the learners, with maths, they don't eat anything; they can't concentrate before we feed them and we are requested to teach mathematics in the morning. Most of the learners take treatment for the diseases such as TB/HIV. You can't ask the learners details, others they come and told us, my son is having this problem and this problem and I will come once a month a month for the hospital for the check-up. But other parents don't come and explain to us. Sometimes you will find a child with cramps, they're weak, you'll ask them when last did they eat, she will told you yesterday at school.it is difficult in our rural schools, rather than Imfundo, there's a big difference.
Please describe how you would go about teaching a lesson on addition when teaching them a specific method? From adding I will first say, you start from the simple one (assumingly, she meant numbers'), then you go higher and higher. I won't say 506+702 =.I must start with, let's say…… here's, I'm giving you 20 sweets and I've given that one 30 sweets. Then we combine the sweets. How many sweets do we have? Or maybe, I'll take out the crayons; we use crayons, take out the crayons and add. Or they can add using themselves, mostly I use these lines in the classroom, there's a division. I tell them to count themselves this side and count themselves that side and then we count the numbers For activities, we use the pink department workbook, even the activity book. I use the planner and tracker
General: Other learners they have learning problems, other learners they don't, its normal in the class. You have the brilliant one, the middle one and the slower one, so what can I say, it's for me to help those who can't understand. It's just that our classes were having more kids, I'm having 40 learners. If I was having 20, it would be much easier.so the learners suffer. With these workbook things and the paperwork, there are a lot of things to do. It's a primary school. You can't detain a learner, 3 of them use common transport, even those walking home. I can't detain them because they're too young. I can't help them, even for 20-30 minutes

after school because it’s dangerous for them to walk alone. At break a child must eat and play. But we try, we give the brilliant ones more jobs, then those who are struggling, we assist them.

University of the Witwatersrand
Time of interview: 9am
Date: 3 May 2017
Place: Imfundo Primary School
Interviewer: Mrs Rasool
Interviewee: Teacher Charlotte (Imfundo Primary School)
Introductory questions:
Where did you attend primary and secondary schools? For lower primary, I attended Rivulet in Nelspruit. I then came this side with my family, doing grade 4 upwards.
Please tell me a bit about yourself, why did you choose to be a teacher? The love of teaching came when I was taught at school. I enjoyed what I see educators doing; the way they were going all the way to make us understand, all the way to see us pass and succeed. That's why I ended up loving teaching.
Where did you train to be a teacher? (only ask 'when' if they don't mention it) Mapuleng college of education, it's about 30 KMs from here. It's in Bushbuckridge. I studied for 3 years and completed a JPTD, junior primary teaching diploma – from 1991-1993
If you still remember, can you briefly talk about the way you were trained? We were having a main subject, it was called 'education'; that's where we were taught everything about this field and education and I did well on that one because it uses a lot of notes like history. I was also good at history at high school. So we were taught how to handle learners, how to be a good teacher. Actually it was taking us out of the previous education system; where most teachers; if I have a grudge with you at home and then I have to teach your child. I will hate your child; treat the child differently, why because we are fighting. At the college level we were taught to treat each and every learner the same, doesn't matter what happened between me and the parents. I have to forget that and concentrate on the learner. On what I went to school for. Ma'am, with regards to math, how did they train you? Do you remember? I was not that good in maths, we were not doing maths. There was the STD

senior teaching diploma, those ones were the maths students, and because they had to do pure maths. With us they didn't cover maths as well as STD students. Not everybody can do maths.
Ma'am, how long have you been teaching FP? I can say forever because I only taught in a high school before college – for me after college, it was primary all the way.
Have you received any training to teach Foundation Phase – workshops and/or qualification, please tell me about this? The only training are the department workshops. They are helpful. I think the NECT has a lot of work.it gives you exactly what you must do. Though I didn't attend yesterday's workshop, but with the 1st term I was …… Now we are just doing counting, what we've been doing in the previous years. This term we haven't received the NECT material.im sure they received it yesterday. You can see what in doing is not in the tracker
What do you like about teaching Foundation Phase in a rural school? You know the rural people; we have this thing about 'ubuntu', that respect we are taught at a younger age, so this thing just comes from home. When I come here, I know what I'm here for. And these FP learners, they are from families where they were taught respect. For me, it's just to come in as a teacher, give them class rules. But, it's something that they know from home, that respect. For me, I just need to tell them that in class, you don't do this, you do this. Working here at FP level is a very nice thing. I respect my learners, they respect me back.im sure you've seen how we interact. All is well. The slow learners, I don't want to leave them behind. There is this bond. I like them. Even those who are in grade 7, those who are in high school, they come greet me. There's something good that I'm doing because they don't forget me. Even the parents, they call me to say, I remember you. I treat them the same.
Do you think it's important for teachers to reflect after lessons? Yes, as you see me. but I don't go deep because there is no time.im sure that you've realised that every time I teach my lesson , we have to go back to what I taught in the previous lesson. Yes…to check if…I didn't want to go on, leaving

them behind, without understanding the previous work. That's where I see if they didn't understand like yesterday, I was concerned that these learners are not the same like the other days, maybe, it's the holidays. But today when I asked them about the previous work, they were at least able to show me that they understand. I think that is the good thing. **Though, with a lot of workload, you tend to ignore reflection.**
Do you think this blue book makes your life easier? if you had your own choice, would you plan your own lessons, or do you think this book is good enough? Yes, hmm, the bluebook is good, I don't see anything wrong with it, because I'm having the lesson plans, then actually when I do it, you find that its space and shape and the activities are there in the blue book. All topics are there, it's easy to work with it.

Research questions:
According to you, is it important for Foundation Phase teachers to have mathematics content knowledge? Why? Yes, it is important because if you have the knowledge, it will be easy to impart it to the learners. And you know there are grade ones who go to grade 2and then grade 3, so then I must teach them everything in maths to understand so that the grade four teachers must not struggle and ask the learners , what were you doing in grade 3?they must go to grade 4 fully knowledged.
I explain that the study is about CCC
What is your understanding of coherent concept connection in mathematics? Yes, as you were saying all mathematics concepts link, even without us teachers realising. Sometimes I link them without realising. I think it's a good thing, but itll be better if we realise when we are making the links.
Have you heard about these concepts before? I've never heard about these concepts before.
According to your experience, what challenges, if any, do learners experience with mathematical content? A Word problem, the division part is also a problem. Dealing with money

according to my experience, telling time is also a problem. You teach it, repeat it, and explain yourself empty about time: but when it's time to write, they can't give you the answer.so time and word sums are the most difficult. Money problems aren't easy too. Mary bought an apple for R2.10, when they have to add or subtract problems with 'cents', they have problems.
What do you think a child needs to know before they start learning to **"add and combine?"** They must know counting, and one other thing I've realised - like us, *** we use whatever is working to help them**, like if the number is less than 10 or maybe 25+5; we already have the 25, so we can do our hands like this (shows me how they'd count using their hands), we are counting, so they will say 26, that way it works. We use whatever to get them to understand. When they write exams, starting in grade 3, I must go and invigilate in another class. But if I know that I have taught them well enough, all the skills to calculate. It won't be a problem
What are some of the challenges you have experienced while teaching **"mathematics"** topics? We have a lack of resources, though we have the 'maths kit', it doesn't have enough for all learners. Like the 'counters', we don't have enough for all learners, therefore, we depend on the learners to be able to use their hands to count. If we had more resources, it would make teaching easier. What I have realised… like today, the way the slow learners were responding, those who are slow in English are good in maths…..I don't know why. I prefer to do homework with them in class because you find that at home there is a granny who doesn't know English – there's a huge language barrier. Things are forever changing at schools. Parents can't keep up, even in grade 1, we don't use letters of the alphabet, and we use sounds.
Please describe how you would go about teaching a lesson on adding and combining using place value? Before we go to the real work of that day? I'm sure you saw yesterday as I recapped, someone refereed me to the 100s, 10s and units – that one is very

important. Before we can even get into the lesson, they must know where does the unit stand. Actually, we start with the units, they must know where the 10s is, the 2nd one and then the 100s.Sometimes maybe 50+11.Always they must know that we start from the units , then we add them, then we go to the 10s and then we go to the 100s, and always we play around with that first before we play with Busi's method. They must always know that we start with the units and we end with the 100s, if the units are more; we carry it to the 10s, if the 10s are more, we carry it to the 100s….. At the end we get the answer.
How do you ensure coherent concept connections when teaching? As I am saying, we are doing it without realising it. But the way it is in one thing, you find that they are all linked. Even in data handling, there's addition, subtraction, multiplication, all of them, they come together; if I do number operations, the counting is there, sometimes you even find that your answer must be in that box – there is a shape there where you leave the box for them to fill in the answer. They're all connected.

Appendix F- transcription of video stimulated recall interviews

University of the Witwatersrand – Video Stimulated Interview
Date: 3 May 2017
Place: Impumelelo Primary School
Interviewer: Mrs Rasool
Interviewee: Teacher Carol
1. What do you think is the purpose of the lesson on pg. 80? What did you want the learners were supposed to know at the end of the lesson? I wanted them to count in 10s and units So by the end of the lesson, you wanted them to count in 10s and units? Yes
2. How did you come to use nwe + nwe (from my understanding new means one and it also means unit) , how do you think it's going to affect the child in grade four when the teacher uses the word 'unit' instead of new? Yes, it's going to affect the learners because now the know new, but at least I mix a little bit with English , they must know that new is a unit
3. @ 02:45 , And then ma'am, here where you are teaching, why did you show them the units, on the board the way that you did, you drew them together, instead of separate as the text book illustrates. You tell them, these are units , but why do you draw them together and not separate to signify units Yeah, I didn't separate them, but later on I draw them a circles to show units I use the circles because others, when you show them separate squares, they still combine it. At first when I started teaching , I was showing them not separated , but as the years went by and through the lessons I decided that showing them units as circles are better for their understanding
4. @ 05:48, Ma'am here, when you were making them count , im interested

understanding why did you make them count 1,2,3,4 instead of starting by counting 10s , like 10,20,30,40 , then units , 1 2 3 4 5 6 . I want to understand why you made them count from one until the last block?

I wanted to help the slower learners, so that they can even get the final answer if they don't know the method. I think the clever ones can count 10 20 30 40 50 , so I was accommodating the weaker learners.

Because if I can say 10 20 30 40 50 , to the slower ones , they won't be able to understand , so if we are counting the boxes , 1,2,3,4,5 , those ones that are more accurate , they can know to count 10, 20, 30, 40, 50 , so the slower ones , they must know that they must start from 1,2,3,4,5 and if they understand they will realise that 10 blocks make up a ten

5. @ 10:03, Then ma'am, on pg. 80 here, it's showing 56, but then on the board you drew 46 – I'm trying to understand was it just an example that you were showing them , or were you doing the whole thing?

No , it was just an example, if I like, when I'm busy with the lesson , from the book and use the numbers , like mixing the numbers, not exactly in the textbook, because when they write exams , you we use different numbers from those in the textbook.

So, when you wanted to show them this 46, it was not linked to the example in the textbook?

No

@ 13:53, Ma'am , I'm trying to understand , further in this lesson , you did an addition problem , now where they add the two sets of blocks to get an answer , so what is you reason for not following thru with the example in the textbook?

Sometimes I do the example in the textbook, but sometimes, I do my own numbers , yes , so with this its addition examples , then I will come to subtraction examples and then ill build from there.

so that's why you didn't do the 56+73 Yes
Ma'am, yesterday, we spoke about reflection and after this, if you could teach this lesson differently, how will you teach it differently for coherence? Like now I taught addition , later on I will teach them subtraction, and the multiplication and the division as well So ma'am, when you were showing them those blocks in the beginning of the lesson to show units, do you think you'll still teach them that units are shown with the blocks joined together? Yes, I won't do it differently; I just need them to get the correct answer. Unless if I get to higher primary or high school, then ill change the method because high school students calculate faster. When I was doing the example, I didn't separate it because I wanted them to see, these are the units and 10s.
With regard to the grouping according to place value, which maths concept's come after this, when they get to higher grades, how will they use these concepts? They will be able to differentiate between hundreds and thousands, here we are doing units and tens, I think the higher they go, they will be able to differentiate between hundreds and thousands. Because here we start with the small numbers and the teachers in higher grades teach them higher numbers. Do you think, as grade 3 teachers, it's enough to only know the concepts that you teach in grade 3 or do you need to know more? think it's important for myself to know the higher numbers / better maths

University of the Witwatersrand – Video Stimulated Interview
Date: 4/05/2017
Place: Imfundo Primary School
Interviewer: Mrs Rasool
Interviewee: Teacher Charlotte
What do you think was the purpose of the lesson on symmetry lines? What objectives did you want the learners to reach? Since we know that symmetry lines are a part of the mathematics curriculum , I wanted them to know that symmetry lines , how are they done .it was space and shape that day it was on Wednesday, you can even do it on alphabets , but that day we were concentrating on space and shape. The learners must know how symmetry lines are done , and it must be a straight line and the other shape the rectangle , where they can't be done diagonally because it doesn't have equal sides , only the square can give you all the whatever lines you want , even if u fold it , you can fold it in all those corners. It's for them to know how lines of symmetry are done on shapes
Video 0012 1. Please explain the reason behind learners counting in 5's in the beginning of the lesson? In maths, every time you start a lesson, though I don't do it much, you must have 10 minutes to do mental maths, mental maths is counting in whatever numbers , it can be the even numbers , ordinal numbers, od numbers. also mental maths is the … if you can just do the quick multiples actually , where they must write 5 times , they write at the back of the book fast , it's just mental maths is a short period which helps to stimulate their mind. Do you think it helps them to count, like 5, 10 , 15… like a song chorusing We only get to chorusing when they know it, if they get stuck I realise theres a problem , then I stop them and ask , who can do it alone so the learners can help

each other , sometimes they work individually , sometimes they work in groups
MVI 0079 01:14 2. Is there a particular reason why you did not complete the symmetry lines on ‘cross’ example on the board? It just happened, but I was trying to, what I wanted with the cross is that they can do it to show them that they can do it going down , also like that, but it can’t be done like the square. I don’t even remember why I didn’t tackle the cross
03:57 3. How/What between the time when you asked the question and said “I’ve exhausted myself, I think you understand”, made you realise that the learners really understand? When I started the lesson, I told them that its things they learnt in grade 2, so here is... when I was busy with the lesson , I was able to see that they do understand , and when they take it to the book, they wrote it in the book , though I haven’t marked it yet , I was able to see that they understand
4. What concepts should learners have known before you taught this lesson? I think they must know the different shapes, as I said with the line of symmetry; it’s actually like, when you look into the mirror, you see yourself, and you see your double, that’s how it is then. Then they must know which ones they can do symmetry for all the sides, which one can show symmetry for 2 sides and which one can’t show symmetry. Yes….
5. If you could’ve taught this lesson differently, how could you sequence it to show ‘coherence’ to previously learnt concepts and concepts to follow? There are many ways to do symmetry , as I said , that day I was concentrating on shapes , we are having a lesson on letters or alphabets where they are going to do it there then they will see that it is not done the way it is done on shapes , for instance A, it can only be half , it can’t be diagonal Actually I think everything we teach in maths is important

Why ma'am? For instance, after they learn about time they can use it at home when they see the clock, when they learn addition, they can use it at the tuck shop when they are purchasing something. You can ask them how many people can you see, they will say three, everything in maths is helping, when they see a ball, they can be able to say this is a circle. these things will go with them forever (PLM – to actual representations and real life)
6. Ma'am, do you think critical reflection is important, now that I've shown you this video? Yes , it is , I was able to pick out my errors and also see where I'm doing good – my strengths and my weaknesses.

<u>University of the Witwatersrand – Video Stimulated Interview</u>
Date: 4/05/2017
Place: Imfundo Primary School
Interviewer: Mrs Rasool
Interviewee: Teacher Fonky
1. What do you think was the purpose of the lesson on symmetry lines – What objectives should learners have reached? The purpose of the lesson was , I can say the learners must know how to cut a thing to make it equal so that they can know the other part is the same with the other part
10:05 2. Madam, in the textbook, I noticed that they used a dotted line to signify symmetry, please tell me why you used a solid line to show symmetry, is there a specific reason for this? I thought maybe when I'm using a solid line they will easily understand, that by doing the solid line, that means that you cut it. They will easily understand that the other part is the same with the other part. When you do the dotted line, it's also the same as the solid line. There's no difference.
3. What concepts should learners have known before you taught this lesson? They were supposed to know , maybe I bring the orange in class, when I bring the orange then I take the two kids , then I put them in front, then I use the orange and then I must cut it in the middle , then ask the learners , is the other part equal to the other one. Then they must look at the other one and then the other one says yes And then ma'am, which maths concepts, do they have to know in order to understand this? In order to understand this, sometimes you can use a mirror

No ma'am, before you got to the mirror, like when you started the lesson, you said, what is this? Oh, you start by asking them the names of the shapes, they give you names of the shapes, sometimes they say heart, sometimes they say circle, and then they must come and write a circle.
14:47 4. What was the purpose of using a mirror to show symmetry? – Where were the learners supposed to look and why? The purpose was that, when I show them that eh part of the shape, they must be able to see when you put it in the middle, then they look this side, they're able to see the other part and the other part is just equal to that one, then they know that okay, my line is supposed to be exactly here, it'll be the same part of the other one. So you're saying, when you put the mirror in the middle, the learner must look into the mirror and see the same thing that's reflecting on the other side? Yes What is the significance of using the mirror? The important thing is that they won't forget , when they make a symmetry line , they will think of the mirror and think 'I must put the line' because they still remember the mirror that was in the middle, then showing the other part as the same to the other part
5. Given that in the previous lessons, they learnt about 'shapes'-Do you think it was important to explain the difference between symmetry lines and symmetry shape – Why? It is very important, because with symmetry lines, they are going to draw the line. Then the symmetry shapes, we will give them the other part, then the will finish up the other part to be the same as the other part. So are symmetry lines and shapes different?

I can say they are different because with the shape, they are supposed to finish it and the line just shows that the shape is cut in half.
6. If you could've taught this lesson differently, how would you sequence it differently to ensure coherence? I won't change , I will just tell them to draw their own shapes, after drawing their own shapes , then they draw the symmetry lines in the shapes, maybe this will be my first question, then the 2nd one I'll say , you just draw the symmetry shape , that means the half of the shape that you like, thereafter you finish up.
7. Do you think you reached the objective of the lesson? Yes when I was marking the books, some of the learners understood, but a few didn't understand, but I worked with those few and now they're on the right track.

University of the Witwatersrand – Video Stimulated Interview
Date: 3 May 2017 Place: Impumelelo Primary School Interviewer: Mrs Rasool Interviewee: Teacher Thembiwe
1. What was the purpose of the lesson? The purpose of the lesson is because when we start teaching on our weekly program, with the programme of NECT, we have to do the counting, the counting has to be related to what NECT is asking for. If NECT tells us to count in 10s, it's likely that the lesson will be about counting in 10s.
2. @ 03:36 Why did you write 10 214 + The way that you did on the board, why did you write the '10' on top on the board? and 3. @ 03:53 Why did you write it as 10 282 - I wanted to highlight it more clearly on the board Are you aware of the topic 'exponents 'which the learners learn about in higher grades? No ma'am, I'm not.
4. Ma'am, when they were counting, adding 10s in each case, however after 294 +10, they suddenly got lost, when it came to 304, they struggled. Why do

you think they struggled?

They struggled because , isn't it they were on a level, the level was okay, when they were counting 214+10= 224,its easy, but most learners , when the have to reach for the 100s, its problematic and then you have to help them to go to the other hundred.

So you're saying, when they count in 10s, it's easier for them? But the moment they move from a 100 to another hundred, it becomes difficult for them?

Yes, moving from 100 to another 100 is more difficult, so you have to help them to move from the one hundred to the next one.

Why did you lead them to get to the next hundred? Why didn't you leave them?

I have to lead them in order to count properly, because they don't pronounce the numbers properly yet – I need to lead them in order to pronounce the numbers properly

And if you don't lead them, how can they go about finding the correct answer?

They will for example carry 294 on their head and then count the additional 10 using their fingers. And for subtracting , they will use their fingers as well

5. @ 05:03 you said 222 -10, then you lead them again saying 212, why did you do this? (202,192,182)

the target for the numbers is that they have to know how to count forward and backwards , and backward is a little more difficult, yes…

6. What is the purpose of learners chorusing while counting?

It helps because at the end of the day, they can count, but it's a disadvantage to those who just keep quiet, but at the workshop that we were in yesterday, they advised us that we should reduce the chorus/ rote learning. if it is a pattern of 5 we should make them use their fingers as well to see 1,2, 3, 4, 5……they have to know where the 5 comes from

7. If you could teach this lesson differently to make kids understand adding and subtracting 10 while counting mentally, how would you do it?

Well if they know the place value of the numbers, they know that from a unit, I'm going to the 10, from the 10s I'm going to a hundred – that's how they could fix their mistakes. I'll teach only addition in one lesson, and then move to subtraction in the next lesson and not do both at once.
Yesterday, they were saying something about , it's good to reflect, I did ma'am, but with NECT and CAPS, there's no time to reflect. The only time that we will have to actually do remedial is when you mark the homework, you do the corrections for the homework that you gave them in the previous day.
I wanted to know, the maths lesson that you taught, counting forward and back, which maths concepts come after that. I'm actually not sure.

Appendix G - overview of the lessons discussed in chapter 5

Teacher Fonky – (English medium school)

Topic: Symmetry

- The writing of the topic on the board, *symmetry line and symmetry shape.* See (figure 1).
- During the whole lesson Fonky foregrounded symmetry lines and did not mention anything about symmetry shape, even though both concepts were still on the chalkboard.
- She asked the learners: "*Before we get deeper, what is a symmetry line?"*
- Without giving learners the opportunity to respond, the teacher said: "*A symmetry line is a line that shows two pieces, that the one is the same with the other one."*
- Fonky continued with the lesson and called a learner in front of the class; she then placed a long ruler vertically down the middle of the learner to demonstrate the concept of symmetry.
- The teacher then said: "*When you cut him in half, you find symmetry. On this side there's an ear, on that side there's an ear, on this side there's a hand and on that side there's a hand, and the ruler is the symmetry line."*
- To illustrate the concept further, she introduced a mirror.
- The teacher used a flash card with the number 50 and placed the mirror between the five and the zero in the middle of the card to show learners that the 0 appears on the flash card and it also appears on the mirror.
- Fonky then drew a 'square' on the board, (see yellow highlighted square in figure 2):
- The teacher asked the learners: *"What is this shape called?"* (See yellow highlighted square in figure 2)
- Learner: *"It's a square''*.
- Teacher (probes learners): *"Who can tell me why it's a square?"*
- Learner: *"It's a square because it has four corners."*
- The teacher immediately went back to the board and drew a rectangle (see red highlighted rectangle in figure two) and said:

- Teacher: "*This also has four corners".* She waited for a while until one learner raised her hand.
- Learner: "*Teacher, it is a square because it has four equal sides."*
- Of concern with the usage of the rectangle drawn on the board is that the teacher didn't address what symmetry is in a rectangle
- To continue with the lesson, Fonky took a ruler and 'estimated' the middle of the square (see figure 2 highlighted in yellow) and drew a solid line in the middle of the square.
- The teacher told learners to draw a 'straight line' to show symmetry rather than a 'vertical line'. She did not show learners that the square can be symmetrical if a line was drawn horizontally in the square, and this might hamper learner foundations which should be built well for future grades.
- Fonky drew another square on the board, and drew a diagonal line from the top left corner to the bottom right corner (see blue highlighted square in figure 2) and asked the learners if it was symmetrical. The learners exclaimed in the affirmative.
- Of concern with the manner in which Fonky drew 'squares' on the board is the taken- for- granted assumption that all shapes in the top row of figure 2 were 'squares', even though she did not measure all 4 sides to be equal to ensure proper presentation of knowledge.
- Learners were then asked to open to page 110 of their Department of Basic Education (DBE) books to complete the activity. See Figure 3

Teacher Charlotte (English medium school)

Topic: Line of Symmetry

- She explicitly wrote "Line of symmetry" as the topic/objective on the board, (see figure 18).
- Charlotte began the lesson with learners counting backward and forward starting from 5 to 200.
- She then asked the learners what they had been learning the day before, and a learner clearly responded and said: *'addition'*. She replied: *"Good, what about addition?*"
- Another learner said: *"Busi's method of addition".* Charlotte then replied: *"Good, I can't move on to today's work if you didn't understand yesterday's".*
- She further asked them: *"Tell me, in Grade 2, did you ever learn about symmetry?"* The learners responded in the affirmative and she replied: *"You see, whatever we learn in previous grades is a continuation."*
- Charlotte drew a square on the board and then asked a learner to show what a line of symmetry looks like in a square. The learner drew a solid vertical line in the middle of the shape, and the teacher asked learners in class if that was correct and learners agreed and began applauding.
- Charlotte replied: *"Stop applauding, it is incorrect."* She then extended the lines out of the shape at the top and the bottom (see figure 19) and explicitly told the learners that "…*in order to show symmetry, a dotted line or an extended line is used, you may not use a solid line in the shape to show symmetry. Also, notice how the symmetry line cuts the shape into half and then there are two equal parts."*
- Charlotte emphasised that learners should not use a solid line within the shape to signify symmetry, a reason she stopped the learner when doing that.
- Thereafter, Charlotte took a piece of paper and cut it into a shape of a rectangle and folded it in different ways to illustrate what is symmetrical and what was not symmetrical (such as diagonally).
- She made it explicit that in a rectangle all sides are not equal, and then used a square that she had already cut out and showed them symmetry vertically,

horizontally and diagonally (although without actually using the mathematical term diagonal).

- At this point Charlotte called learners to the front to complete various examples to show what symmetrical is. She used a smiley face, a heart, a moon, and a cross, and for each one she gestured both vertically and horizontally while asking the learners: *“Will it work like this?”* (See figure 19).
- Learners were asked to complete the lesson activity (see figure three).

Teacher Thembiwe (Xitsonga medium school)

Topic: place value

- At the beginning of the lesson, Thembiwe did not mention the lesson topic to the learners.
- The teacher took out number builder cards and placed them on a desk in front of the class. She selected a learner and verbally instructed: *"Use the number builder cards to build the number 329 according to place value"*. The learner did what the teacher asked by placing what he believed to be the relevant cards on the board, to which the teacher commented: *"Good"* (see figure 4).
- A mathematical content error occurred because the number cards were all units.
- The numbers are not correctly represented in the number cards, because they were supposed to show 300, a 20 and a 9 according to place value.
- Thembiwe then pointed at the 329 representation on the board and said: *"Thinking of place value, what does the 9 stand for?"*
- Learners: "*vun'we*" (units in English).
- The teacher pointed at the 2 and asked the learners what it stands for and learners responded "*vun'we*" (units). She looked at them and further asked:
- Teacher: *"Are you sure?"*
- Learners: Only a handful of learners realised the right answer and said **"***vukhume***"** (tens in English)
- Teacher: she pointed at 3 and asked what it represented.
- Learners: shouted out in a chorus "*vun'we*".
- Teacher: She then asked the same question again.
- Learners: once more a handful replied **"***dzana*" ('hundreds' in English).
- Teacher: *"very good"*
- There is a gap between the representation on the board (see Figure 4) and the place value questions the teacher asked.

Teacher Thembiwe (Xitsonga medium school)

Topic: rounding off

- The teacher wrote the representation seen in (figure 5) and asked learners questions.
- Teacher: *If we are counting in multiples of 10, how many fingers would you use to show the number 40?*
- From the teacher's question learners used their fingers to count and showed the teacher 4 fingers. She then moved on and asked learners:
- Teacher: "*What is the number between 40 and 50?*"
- Learner: "*10*"
- She did not rephrase the question, rather told the whole class to quickly write down all the numbers from 41 to 49, and look at it carefully and then find the number in the middle.
- After the task many learners shouted out the number 45 which was correct.
- When the teacher asked learners to engage with the task after writing it, they were able to do what she initially wanted them to answer verbally. This illustrates the importance of correct mathematics discourse when questioning learners so that no confusion may occur.
- Thereafter, the teacher instructed learners to tell her any numbers which fit between 40 and 50 and they replied: "*41, 42, 45, 44 and 46*".
- She wrote each number on the board (see figure 6), then selected individual learners and instructed them to round off the number to the nearest 10, and all learners got the correct answer.
- The teacher did not use the correct mathematical discourse on the board, instead of using the mathematical sign ≈ (approximately equals to sign) she made use of the = sign (equals to sign) to signify rounding off (see figure 6).

Teacher Carol (Xitsonga medium school)

Topic: Addition using the method of expanding the digits according to place value, adding the tens together, adding the units together, regrouping them and adding to get the final answer

- Carol did not explicitly make the topic of the lesson clear to the learners.
- She taught learners addition using the method of expanding the digits according to place value, adding the tens together, adding the units together, regrouping them and adding to get the final answer (see figure 7).
- In most cases she did not represent the examples mathematically due to inconsistent use of addition and equals signs (See figure 8).
- The teacher works through these examples: 23+42, 36+24, 42+34 and74+26. During all the examples learners answered by chorusing as a whole class, as the teacher did not question individual learners.
- The lesson took a different direction when Carol wrote 11+11 on the board, and incoherence was identified when the teacher did not write the = sign after 11+11 (see figure 9 – highlighted in red).
- Carol did not use the equal (=) sign.
- Nonetheless, a learner was called out to the board to **“***complete the sum of 11 + 11”.*
- Nonetheless, the learner wrote random numbers on the board as seen in figure 9, highlighted in yellow, and it is unclear how the learner thought of such numbers.
- The teacher immediately erased the learner’s wrong numbers and wrote 11+11 on the board again and answered it herself.
- The teacher tried to help the learner to work out the mathematics problem, and instead got the answer incorrect.
- The teacher wrote 11+11 = 24, (see figure 10), and surprisingly did not recognise the wrong answer.
- She then introduced sticks as a different representation of the same content (see figure 11) to show the learner that was called to do the sum on the board how he could get to the correct final answer by using a different method.

- The teacher asked the learner to count every stick and he got the answer correct, with 11+11 being equal to 22 (see figure 11).
- Interestingly, the teacher became confused because the learner’s correct answer contradicted her erroneous answer of 24 from the previous example (see figure 10), where she made a mistake that was left unattended.
- However, the teacher re-drew 24 sticks, (see figure 12 - highlighted in red), which matched the answer she got in (figure 10).
- She then asked the same learner that was in front to count the sticks and subsequently got 24, and the teacher praised the learner for the wrong answer and showed him that the number of sticks was the same as the answer that she got initially, before asking him to sit down.

Teacher Carol (Xitsonga medium school)

Topic: place value

- Teacher Carol instructs the learners to open the textbook to page 80 and look at the blocks in blue, referring to tens (vukhume) and the red blocks, referring to units (vun'we) respectively (refer to figure 13).
- Carol then drew the illustration presented in figure 14 and said that the first column represents the tens and the second column represents the units.
- She then asked learners to count the units drawn on the board and they did in chorus up to 7, even though the correct answer is 6.
- The teacher stopped them when they got to 7.
- Teacher Carol then drew (figure 15) on the board.
- The teacher used iconic mediators (Sfard, 2008) to explain the difference between tens and units, however, they are incorrectly represented (see figure 15), because the six unit blocks highlighted with blue should have been drawn as six separate blocks.
- She continued to misuse visual mediators – see the yellow highlighted blocks (Figure 15).
- The 2nd and 3rd tens column in Figure 15 illustrate that the teacher drew an incorrect number of blocks to demonstrate the tens columns, she drew 11 blocks in both columns rather than 10.
- When learners were asked to count each block individually in figure 15 they counted the incorrect additional blocks and got 48.
- Further on in the lesson, in figure 16, incoherence between the diagrammatical representation on the board and the number that the teacher had written below each row occurred.
- The teacher wrote 10 below each column, she erased the additional block which appeared in figure 15 from the 2nd column (figure 16 highlighted in red). While the blocks in the third column were still 11 (see figure 16 highlighted in blue).
- Carol continues to overlook the importance of using mathematical signs and did not use + signs between each column to signify to the learners that they

will be adding to get the final answer of 46 written on the board (see figure 16).

- She then writes 46 on the board as the final answer, however, because of the extra block (highlighted in blue in figure 16) in the 3rd column, the final answer is actually 47.
- Figure 17 is a snippet of the lesson activity given to the learners by Carol.