Analyzing pedagogy across number focused Grade 2 numeracy Lessons

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Declaration

I, Gift Cheva, declare that this research report is my own work. It is submitted for the degree of Master of Education (Curriculum Studies and Mathematics and Science Education) in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination in any other university.

Signature

Date: February 2013

Abstract

The purpose of this report is investigating pedagogic practice in a selection of grade 2 number lessons. The study is informed by Bernstein's concept of framing - a key focus in Bernstein's (2000) theory of the pedagogic discourse. The question the report sought to understand was: What is the extent and nature of control teachers have over the selection, sequencing, pacing and evaluation of knowledge in number.

The report is based on empirical data from three number lessons from three different Grade 2 classes in a suburban primary school in Johannesburg in South Africa which now serves a historically disadvantaged population. The three lessons were all based on the topic of number but differing in content. The first lesson involved the teaching of the number 16; the second lesson dealt with the addition of two single digit numbers and the third lesson was premised on the concept of ordinal numbers from 1- 15. The report applied a qualitative research paradigm and the empirical data set was part of baseline data collected for a broader project- the Wits Maths Connect- Primary project (WMC-P). The project aims at improving the teaching and learning of primary mathematics. Videotaped lessons were then transcribed into text and chunked into episodes that were then analysed.

The results of the report showed that teachers had greater control in terms of task selection, sequencing and pacing and task completion on number work pointing to strong framing of these aspects. In terms of teacher evaluation the report notes that criteria ranged across instances of clear and explicit criteria, more implicit criteria and some instances where there were no observable instances of teacher evaluation of mathematical knowledge. The study concludes with some reflections on the implications of the analysis presented.

Dedication

To Rumbidzai and Ruvimbo.

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Abbreviations

CAPS	Curriculum Assessment Policy Statement
C2005	Curriculum 2005
DFS	Derived Facts Strategies
DoE	Department of Education
FFL	Foundations for Learning
HG	Higher Grade
HSRC	Human Sciences Research Council
ID	Instructional Discourse
LO	Learning Outcome
MLA	Monitoring Learning Achievement
NRF	National Research Foundation
OBE	Outcomes Based Education
RNCS	Revised National Curriculum Statements
RD	Regulative Discourse
SACMEQ	Southern and East Africa Consortium for Monitoring Education Quality
T	Teacher
TIMMS	Trends in International Mathematics and Science Study
WCED	Western Cape Education Department
WEC	World Economic Forum
WMC-(P)	Wits Maths Connect Primary- Project

Chapter 1: Introduction

1.1 Setting the scene

The story of the under- achievement of learners in primary mathematics in South Africa has been well documented in both local and international studies. These studies have explored the problems related to poor performance that persist from year to year. Continued poor performance thus makes the South African context of interest to researchers. Eighteen years after the demise of apartheid- South African learners are still performing very poorly in mathematics, despite many curriculum changes taking place.

This discussion starts with an overview of the South African curriculum followed by a brief discussion of the poor performance in mathematics at the Foundation Phase. This is followed by the problem statement of the study and the purpose, the rationale of the study and the research question and sub-questions which this study sought to answer. Towards the end of this chapter a brief summary of the structure of this report was presented.

1.2 An overview of curriculum reforms in South African schools

It is imperative when looking at the poor performance that is endemic to the South African schooling system to review the curriculum documents under which teachers are operating and in some instances have been using. Since 1994, South Africa has undergone through three main phases of curriculum reform, firstly, in 1997, Curriculum 2005 commonly referred to as (C2005) was launched. C2005 was informed by three principles which were outcomes-based education (OBE), learner centeredness and integration. C2005 was implemented in Grade 1 in 1998, Grade 2 in 1999 and Grade 3 in 2000 Chisholm et al. (2005). While ex-model-C schools were able to implement C2005 successfully, disadvantaged schools ' floundered' (Harley & Wedekind, 2004).

Vally and Spreen (1998) argue that many historically disadvantaged schools failed to implement the new curriculum, a situation that has been described by Malcom (1999) as a "voyage of faith" where teachers were sent out with the hope that they could meet the challenges of implementing a new curriculum in an under-resourced system without support (Harley & Wedekind, 2004 cited in Chisholm, 2004).

In 1999, when C2005 was in its second year of implementation, the Minister of Basic education, Professor Kader Asmal appointed a committee to review C2005 to determine whether there was progress and to identify any challenges experienced since the implementation of OBE. The Review Committee recommended that the curriculum be streamlined and strengthened. In November 2000, the Minister appointed a Ministerial Project Committee to manage the streamlining and strengthening of C2005 for grade R-9.The Revised National Curriculum Statement (RNCS) for grade R-9 became policy in April 2002. The basic principles of the curriculum, OBE, learner-centeredness and integration remained constant. It was this policy that was being implemented in the Foundation Phase in 2012, when this study was undertaken. At the time of writing this research report the National Curriculum Statement had been amended resulting in a single comprehensive Curriculum and Assessment Policy Statement commonly referred to as CAPS, (DBE, 2011b). With the changes in curriculum come also changes in the way teachers teach as the different reforms are understood and implemented differently by different schools and in some cases different teachers.

1.3 Background: Performance in mathematics in South African primary schools

That many learners in South Africa struggle in mathematics is not in dispute. What seems to be contentious, however are the reasons why many of our learners continue to fail in their quest to do well in mathematics.

The outlook in research and policy debates in South Africa currently view the state of mathematics education as in a state of 'crisis'(Fleisch, 2008; Taylor, 2006). A number of national and international evaluations in standardized tests over the recent years have shown that South African Foundation Phase learners are performing below age and grade level expectations.

The quality of teaching in South African schools continues to be on a downward trend. The fifth World Economic Forum (WEF) – global competitive index, Schwab (2012), has ranked the quality of teaching in South African primary schools 132th out of 144 countries. The same report has placed South Africa at the bottom of 62 countries in terms of the quality of mathematics and science education. The quality of primary teaching and of mathematics and science education within this continues to be seen as problematic.

The Systemic Evaluation of the Foundation Phase - a comprehensive study that sought to measure the learning achievements of primary school learners noted that Grade 3 learners appeared to have a very poor grasp of elementary mathematics (DoE, 2003). This was reflected in the average score of only 30 % on the numeracy tasks. Besides providing important insights into the state of numeracy among Grade 3 learners the report also pointed to general poor performance by primary learners in mathematics. Commenting on the same systemic evaluation results, Fleisch (2008), states that the average Foundation Phase school learner was struggling with numeracy.

In 2005 the Grade 6 Systemic Evaluation was released. According to Fleisch (2008) Grade 6 learners obtained a mean score of 27 % for mathematics. Fleisch, further explains how the Department of Education (DoE) dissected the Grade 6 results according to achievement levels i.e. outstanding, achieved, partly achieved and not achieved to determine the average level at which South African primary learners function. It emerged that only 12 % cent of all learners sampled scored at ‘achieved’ or ‘outstanding’ levels, with 81% scoring at ‘not achieved level in mathematics. In the words of Fleisch (2008 p.8) ‘only one in ten learners was at the standard required by the National Curriculum Statement’.

Then in 2006 the Western Cape Education Department- (WCED, 2006) produced documentation that revealed that 60 % of Grade 3 learners in mathematics were performing below the expected level for numeracy. The same documentation revealed that between 2002 and 2006 numeracy levels for Grade 3 learners dropped from 36.6 % in 2002 to 32 % in 2006 (WCED, 2006). The Western Cape study further disaggregated the results by former departments and quintiles and what emerged was that the majority of learners had not mastered the basics of mathematics (Fleisch, 2008).

A large scale cross-national study- Monitoring Learning Achievement (MLA) testing Grade 4 learners focusing on numeracy and numeration domains reported that the average score for numeracy was 30.1 %, (Strauss & Berger, 2000).

Again, results in the Trends in International Mathematics and Science Study (TIMMS) which was administered by the Human Sciences Research Council (HSRC) to Grade 8 learners reflected that the average score in numeracy was 264 compared to an international average of 467. The TIMMS mathematics score was divided into two dimensions- a *content dimension* and a *cognitive dimension*. South Africa averaged a score of 274 on the number dimension with a standard deviation of 5, 4 compared to Botswana which hold a national average of 384 with a much a lower deviation of 2.2 (Reddy, 2005).

In order to get a sense of how South African learners are learning, Fleisch, (2008) analyzed the questions. In a problem solving question that asked learners to solve a one –step problem involving division of a whole number by a unit fraction, only 7 out of every 100 South African Grade 8 learners got full credit compared to 78 in Singapore, 50 in England ,and 11 in Botswana.

Two mathematics assessment tasks administered to Grade 6 learners by the Southern and East Africa Consortium for Monitoring Education Quality (SAQMEQ) revealed that more than half (3119) of the learners had not reached basic numeracy level. Moloi and Strauss (2005), sought to find out the prevalence of Grade 6 learners who had achieved minimum desired levels of mastery in mathematics in SAQMEQ. They discovered that at a particular school half of the learners tested were at the pre-numeracy stage level, while others achieved only one level up, at the emergent stage.

Schollar (2004) administered standardized numeracy tests to Grade 5 and Grade 7 learners and found that most learners got addition sums correct, but were less confident with multiplication and division, particularly at Grade 5 level. The table below shows the percentage of correct answers on simple arithmetic operations for Grade 5 and Grade 7 learners. The table reveals that while percentage scores for both Grade 5 and Grade 7 learners are high for addition and subtraction they are not so for multiplication and division especially at Grade 5 level, while the score for division at Grade 7 is the lowest.

Table 1: Percentage correct answers on simple arithmetic operations

	Addition	Subtraction	Multiplication	Division
Grade Five	84.5	61.2	50.3	40,8
Grade Seven	74.7	92.6	75.0	59.4

Source: Schollar, 2004

Schollar (2004) also revealed that only 12 % of Grade 5 learners and 31 % of Grade 7 got the items correct on higher order mathematical skills such as word sums suggesting that the performance of the learners on higher- order skills are of great concern.

The SACMEQ data and the national learner evaluation tests show that weak performance in matric originates much earlier; probably in the foundation and or intermediate phases (Louw & Van der Berg, 2006). For example; in the SACMEQ II and III sub-regional tests the local Grade 6 Maths scores were below the regional mean scores(Louw & Van der Berg, 2006).

Thus, one can argue that the Maths problem is also pronounced and extends in the primary grades where learners' Maths scores are consistently amongst the world's worst, with far poorer countries achieving better scores than South Africa and learner achievement scores far below what is expected at all levels of the schooling system (Bloch, 2007; Muller, 2004; OECD, 2008).

However, what is more worrisome is what came out of the analysis of learners' rough workings on basic operations. The analysis showed that many students were not using abstract methods such as carrying, but concrete procedures such as unit counting. In fact, Schollar (2004) noted that 38 % of Grade 5 learners showed evidence of unit counting. An observation made by Schollar earlier on the use of concrete methods to solve addition was also reported by Vinjevold and Crouch (2001) who found out that Grade 3 learners were not proficient on simple addition operations. The majority of Grade 3 learners could correctly add two single-digit numbers (e.g. 9 + 7), but they could not solve problems that required addition of two double digit numbers with carrying (e.g. 16 + 27).

This well-established research evidence suggests that learners were making predominant use of 'concrete', context –specific approaches that may be appropriate at the early stage of numeracy but become impediments to the transition to using abstract methods that depend on a solid understanding of the structure of the base -10 number system (Fleisch, 2008). Thus South Africa's primary education achievement gap begins in the Foundation Phase, at the very earliest days of formal schooling, and continues unbroken to the end of primary education and beyond. Hence, problems in performance in mathematics are evident by the end of Foundation Phase level, and have been noted specifically in the context of early number learning.

The recently introduced large scale standardized national tests taken by all primary grades in mathematics and literacy, generally referred to as the Annual National Assessment (ANA) showed that the national mean performance in the Grade 3 numeracy test stood at 28 % and at 30 % in the Grade 6 Mathematics test as of 2011(DBE, 2011c). The overall performance of learners as mirrored in the ANA 2011 results was very low with average scores of 30 % and lower in languages and mathematics at each grade (DBE, 2011a). The DBE report reveals learners' inability to handle basic numeracy operations of subtraction, multiplication and division that involve whole numbers (DBE, 2011d).

1.4 Problem statement

As already referred to performance in mathematics at all levels of the schooling system continues to be described in terms of a ‘crisis’ (Fleisch, 2008). Low–levels of attainment in mathematics continue to be seen in the Foundation Phase (Grade 1 -3) and Intermediate Phase (Grade 4-6).

Research findings on the teaching of number in South African primary schools by Ensor et al. (2009), show that whilst there is a trajectory of counting to more abstract ways of working with number across Grade 1 to 3, students still remain highly dependent on concrete strategies for solving problems at Grade 3 level. Similar findings which suggest the predominance of unit counting and repeated addition have been reported by (Schollar, 2008).

The poor performance of learners in mathematics in South African primary schools has been attributed to a multiplex of reasons. Some of the reasons include inter alia- curriculum coverage, coherence, cognitive demand and pacing. Reeves argues that learning gains are proportional to the degree of curriculum coverage, and the extent to which the level of cognitive demand at which the material is presented approaches the levels specified by the official curriculum. Pupils perform better in mathematics when the teacher gives explicit feedback in response to pupil knowledge displays and makes clear the criteria for judging a good display (Reeves, 2006).

Some researchers have attributed the poor performance in primary mathematics to the whole matter of control by teachers over the selection, sequencing and pacing of tasks (Jacklin & Hardman, 2008; Scmitt, 2009).

Given these problems associated with numeracy teaching I am interested in analyzing the extent and form of control teachers have in the teaching of numeracy. According to Bernstein (2000) control regulates how meanings are to be made public within a context- i.e. control refers to relations between teachers and learners over selection, sequencing, pacing and criteria for establishing mathematical knowledge.

1.5 Purpose Statement

The purpose of this study is to explore and analyze the pedagogic practice of teachers in terms of how they select, sequence, pace and evaluate mathematical knowledge in Grade 2 classes. The focus of this study is to analyze pedagogy; specifically the nature and extent of control over the discursive rules of selection, sequencing, pacing and evaluation of knowledge across number focused lessons in Grade 2 numeracy lessons within one school that falls within the Wits Maths Connect – Primary project – detailed later in this chapter.

1.6 Research question and sub-questions

Against the background of low performance in mathematics by primary school learners, the overarching focus that I sought to respond to was to analyze the framing of mathematical knowledge across a set of number lessons in Grade 2 numeracy. Specifically, and based on Bernstein's definition of framing of knowledge by teachers which I present later in this report, the key question can be divided into the following sub-questions:

a) What is the nature and strength of control over what counts as valid mathematical knowledge?

b) What is the nature and strength of control over sequencing of mathematical knowledge?

c) What is the nature and strength of control over pacing of mathematical knowledge?

d) What is the nature and strength of control of evaluative criteria in teaching numeracy?

1.7 Rationale

Literature on the teaching and learning of numeracy is rich, but does not deal specifically with analyzing pedagogic structure in the teaching of numeracy at the grade 2 levels using the concept of framing (Bernstein, 1975, 2000). Research work done by Ensor et al. (2009) suggest that teachers use strategies that do not shift learners from using concrete to abstract strategies and consequently these strategies 'freeze' learners' understanding of numeracy.

The other reason that has driven my impetus to investigate pedagogy has to do with my personal experience as a primary school teacher over the past eight years. I have taught primary mathematics for more than eight years and as I now look back during my teaching years I have grown an interest in understanding what inhibits primary school learners from acquiring competence in the more abstract ways of symbolic forms of mathematics. I am curious to analyze the nature and extent of control relations between teacher and learners in the teaching and learning of early numeracy. This research which focuses on analyzing pedagogy across number focused lessons, investigates the control relations in terms of Bernstein's categories of selection, sequencing, pacing and evaluative criterion.

Currently studies that seek to analyze pedagogy across number focused lessons at the Foundation Phase are very few especially at grade specific levels, and more so if in terms of selection, sequencing, pacing and evaluation of mathematical knowledge.

Also, currently I am a masters' fellow who is part of a research and developmental project being run by the Wits Maths Connect-Primary (WMC- P) Project. The broader project specifically seeks to formulate a developmental trajectory within the teaching of numeracy in ten primary schools in Gauteng district. My work within the WMC-P has awakened in me a curiosity to analyze the structure of pedagogy in the teaching of numeracy.

I also believe that my involvement with teachers who are engaged with teaching Foundation Phase (Grade 2) numeracy will help me to understand pedagogy in terms of the discursive rules of selection, sequencing, pacing and the evaluative criteria. In order to this, I have focused on video data of single lessons of number teaching drawn from one of the WMC-P schools. Out of the four baseline lessons observed in this school, three were focused on number teaching, and these lessons form the empirical dataset for my study.

1.8 Outline of remaining chapters

Chapter Two – The literature review engages and synthesizes a wide range of literature on the areas of teaching of early number, the possible problems in the teaching of numeracy in South African primary schools. It also reviews policies such as the Revised National Curriculum Statement (RNCS) and Foundations for Learning (FFL) in the teaching of number.

Chapter Three - The conceptual framework I developed for this investigation is presented in chapter 2. Bernstein's concept of framing has been operationalized for the analysis of teacher's pedagogic discourse.

Chapter Four– The Research Methods chapter initially defines and explains the key tenets of the qualitative research method. The chapter also presents how I gathered data through classroom observations- video- recording of lessons. I then explain the sampling techniques used and how ethical considerations were complied with in the methodology and in the compilation of this report. The chapter concludes with an explanation of the data analysis strategies and how I addressed issues of rigor in the research report.

Chapter Five – Data analysis and Discussion, in this section of the research report I analyze the data using the construct of framing as posited by Bernstein. I also explain key research findings which are interpreted alongside pertinent literature from the concept of framing in relation to numeracy teaching. The chapter concentrates on the central issues of the nature and control of selection, sequencing, pacing and evaluation of number content to foundation learners.

Chapter Six– Conclusion recaptures the main points, arguments and concerns raised in this research report. Selection and sequencing of mathematical knowledge is strongly framed in Grade 2 numeracy lessons. In terms of pacing there are variations - in some instances learners determine the pacing of the lesson although largely pacing of numeracy lessons is determined by the teachers. Lastly, the evaluative criteria was in some instances absent and strongly framed in one lesson while in two of the lessons the evaluation criteria was largely unclear and not explicit. The chapter shows that and discusses possible implications for the learning of early number. Lastly I discuss the limitations of the study, make recommendations which are key to numeracy teaching and outline topical areas and issues of the research that need further investigation**.**

References follow thereafter.

Chapter 2: Literature review

2. 1 The concept of numeracy

Achieving consensus in terms of definitions has always been a contentious issue, particularly in the social sciences. As such, the definition that I have adopted in this report defines numeracy as proficiency with number concepts and skills, and their application (DfEE, 1998). This broad definition encompasses the notion of numeracy as being a life skill that is important for achievement in mathematics in the school life. Number concept is one of the most important concepts established in the foundation phase of primary education. Children love to say rhymes and learn from an early age how to "count to ten".

As Steen (2001) puts it:

> "considering the deluge of numbers and their importance in so many aspects of life, one would think that schools would focus as much on numeracy as on literacy, on equipping students to deal intelligently with quantitative as well as verbal information …'(p.58).

The importance of numeracy is further highlighted by Steen, who argues that to 'develop an informed citizenry and to support democratic government, schools must graduate students who are numerate …' (Steen, 1999, p. 8). I agree that the development of numeracy is crucial for children's meaningful access to basic education, and beyond. By the time learners leave primary school they should have a confident grasp of number which will provide a solid platform for engagement with mathematics at secondary school level. Teachers then need to 'school' their learners in practices that ground them sufficiently to deal with abstract principles of mathematics.

2. 2 International literature on number teaching

Basic number skills such as addition, subtraction, division, multiplication set within 'number sense' are important for the development of further mathematical knowledge. I have mentioned the overarching importance of focusing on early numeracy skills for learning of basic mathematics skills (i.e., addition, subtraction, multiplication, division) and the development of further mathematical knowledge.

2. 2. 1 Early introduction to number

There is ample research evidence which shows that children begin schooling with some knowledge of numbers. However, their knowledge of number is usually limited to 'reciting conventional counting sequences' or rote counting (Aubrey, 1997). Rote counting is reciting numerals in order from memory, for example, "1, 2, 3, 4, 5, 6, 7, 8, 9, and 10".

According to Aubrey (1997) rote counting does not necessarily have a direct relationship with adding and subtracting. While Aubrey argues that adding and subtraction rely on linking quantities to a list of names she concedes that rote counting does still provide learners with access to talk about number. However, Aubrey discovered that the wealth of experience in rote counting that learners bring to school was often ignored by teachers.

Askew and Brown (2003) have attributed the low valorisation attached to the experience of numbers that children bring to school to the low status that is sometimes given to rote counting. Similar findings into children's knowledge on early number have been documented by Gelman and Gallistel (1978). They also revealed that most children often do make a very satisfactory start on number knowledge before coming to school.

Some British research into young children's use of number symbols discovered that children invent idiosyncratic symbols. In this research some pre-scholars were able to represent small quantities by annotating tins to represent small quantities (Hughes, 1986). Contrary to the above findings Munn (1984) found that when children used their own idiosyncratic notation they were less successful at solving simple problems than those children who used conventional numerals.

The teaching implications of number emerging from the above literature findings point to the fact that knowledge that children bring to school needs to be built upon and teachers need to encourage learners to feel free to use a variety of ways, including conventional numerical symbols, to support simple problem solving. Teachers need to build on learners' experience of number. This is so because counting is an effective basis for early numeracy learning and teaching. Literature suggests that while young children can use idiosyncratic symbols to record small quantities, standard numerals are more helpful in solving problems. These findings direct my attention towards teachers' selections of tasks that indicate building on learners' experiences of number.

2. 2. 2 From counting to number operations

Gray (1991) argues that 'initially children will simply be reciting numbers as a rhyme, without attaching any number (idea of "how many") significance to them'. This is called counting. We say "counting out" to signify that a child can count out a number of items correctly. Gray (1991) suggests that the operation on numbers up to 20 is underpinned by a developmental trajectory, and progresses through a sequence of, count all, count on from the first number, count on from the larger number, use known number facts and derive number facts. In view of this, teachers can teach learners to gain proficiency through this sequence.

The idea of counting is often recognized through the rehearsal of counting names 'but is, more precisely, the co-ordination of a countable item with a number name (Maclellan, 2001p. 6) . Counting then involves learners assigning objects a number word. The essential thing about counting is making sure that all items are included when counting. In fact, the order of counting does not matter - what matters according to Maclellan (2001) is keeping the list of counting 'referents stable' and not repeating the same referent. In view of this well-developed sequence of development in counting research evidence teachers need to teach learners the sequence. Learners then need to be taught to shift from counting to calculation based methods of dealing with number.

2. 2. 3 Counting methods

Askew, Bibby, and Brown (2001), worked with low-attaining Year 3 (equivalent to the South African Grade 3) learners who were relying heavily on counting methods. Teachers identified the few number facts that these learners did know (most often small doubles) and worked to help them to derive unknown number facts. In assessing the learners after this intervention the learners out-performed a control group with three times as many using known or derived facts. Askew and Brown (2003) caution that if low-attaining children over-depend on counting for calculation this may lead to their not 'committing number facts to memory' (p.6). However, Thompson (1995) argues that children who know many number facts and have developed a range of calculation methods still sometimes combine these facts and methods with counting techniques in order to derive unknown facts.

Learners approach counting tasks using a variety of approaches. The sequence of development alluded to above by Gray (1991) begins when learners *'count-all'*: counting each collection and then counting the combination of two collections starting from one (that is, 2 + 5= 1,2. . .1,2,3,4,5. . .1,2,3,4,5,6,7). Teachers need to teach learners according to the sequence. Thus teachers need to encourage those learners who 'count-all' to 'count-on' - accept one set as a given and count on the number of the second set (so, 2+5= (2), 3, 4, 5, 6, 7) as this allows more effective counting. But, successful *'counting-on'* requires the correct coordination of the sets being counted to keep track of what has been, and what is still to be counted (Maclellan, 2001). Counting becomes even more efficient through determining the larger collection and 'counting-on ‘the number of times indicated by the smaller set (e.g. 2+5= (5), 6, 7, (Maclellan, 2001, p.7)

According to Gelman and Gallistel (1978), learners’ earliest abilities in addition and subtraction are based on their experiences of combining and separating sets of objects in the real world. Although this is most readily observed in counting tasks, nonverbal calculation is typically evidenced in a task in which an initial quantity is displayed to the child, and then screened from view. The learner watches as the teacher alters the initial quantity through adding or removing items. Understanding of addition or subtraction is confirmed when the child matches the transformation by counting out the appropriate result with countables (Levine, Jordan, & Huttenlocher, 1992). Successful non-verbal calculation gives insight into the learners’ quantitative representations without the intervening variables of language (as occurs in story problems) and number combinations which may have been developed by rote (as discussed in section on early introduction to number above 2.4 1). Levine et al. (1992) argue that non- verbal calculation is an ability that typically precedes both. The importance of non-verbal calculation is further highlighted by Gray, Pitta, and Tall (2000) who argue that non-verbal calculation is an important achievement for learners. Non-verbal calculation marks some understanding of ‘counting-on’ and ‘counting back’. And more so, it makes learners to appreciate counting as an abstract activity.

To facilitate the improvement of children's counting skills time must be spent on each lesson counting orally using structured materials. Hence, teachers can offer learners repeated opportunities to practice counting, integrating counting with other dimensions of number.

Learners use a variety of mental methods for calculating numbers greater than 20. Askew and Brown (2003) posit that there is less agreement about strategies involving the addition and subtraction of numbers from 20 to 100. Denvir and Brown (1986) suggest that there is no unique sequence, and that, moreover, there is no clear relationship between order of teaching and learning. Thompson (1999b) argues that more recent research suggest two particularly common approaches, the first involves partitioning or splitting both numbers, and the second involves sequencing or jump methods. In the next section I present the two approaches involving addition and subtraction that learners may apply.

Partitioning/ split method

47 + 36 is calculated as 40 +30= 70; 7+6 = 13; 70 + 13 = 83.

Sequencing or jump method

A subtraction such as 57 – 34, solved using the ‘jump method’ would be calculated as 57- 30 = 27; 27 – 4 = 23. A key procedure common to both strategies is ‘partitioning’- the splitting of two digit numbers into the quantities represented by the number names. So 47 [forty-seven] is partitioned into 40 [forty] and 7 [seven] and not into ‘4 in the tens column and 7 in the units column or even ‘4 tens and 7 units’. In the split method both of them are partitioned, whereas in the jump method only one of them is, and chunks of this partitioned number are added to or subtratcted from the other number in a seqential manner.

According to Askew and Brown (2003), studies carried out in Holland suggest that while learners may tend to prefer to use the partitioning method, they should be encouraged to use the sequencing method as it lends itself more readily to subtraction, for example, [83 -47 as 83 - 40 = 43; 43 – 7 = 36]. Ruthven (1998) agrees that despite such methods being used by children there is no evidence of what is normally understood by place value [tens and units] in fact; Thompson (1999a) argues that mental calculation strategies use what has been described as the quantity value aspect of place value [56 seen as 50 and 6], whereas standard written algorithms draw on the column value aspect for instance, 56 is seen as 5 tens and 6 units.

Commutative property

Research evidence suggests that learners’ understanding of commutativity of multiplication develops later than that of addition and is also influenced by the type of problem (Nunes & Byrant 1996) . This is so because understanding the commutativity of number (a + b = b + a) is related to the use of more efficient computation strategies. Thus, given learners’ mental strategies it makes sense for teachers to delay the teaching of algorithms that focus on a digit’s column value in developing mental strategies. Teaching needs to attend to the structure of number operations as much as to the structure of numbers.

2. 2. 4 Counting principles

Gelman and Gallistel (1986) posit that most children come to school with the idea that numbers are embedded in the counting principles and related activities of addition and subtraction. For Gelman and Gallistel the following five principles govern and define counting:

1. The one-one principle

Marmasse, Bletsas, and Marti (2000) note that this principle emphasizes the importance of assigning only one counting tag to each counted object in the array. For example, the child should never state "one, two, and two." To follow that principle, a child has to coordinate two processes, partitioning and tagging. According to Marmasse et al. (2000) this simply means that every item being counted needs to be transferred from the to-be-counted category to the counted category (partitioning) while a distinct tag must be set aside, not to be used again in the counting sequence (tagging).

2. The stable-order principle

Marmasse et al. (2000) argues that counting involves more than the ability to assign arbitrary tags to the items in a collection. In fact counting tags chosen must be arranged in stable (i.e. repeated) order. For example, the child might count three objects stating "one, three, and four" and four objects by stating "one, three, four, and five." Gelman and Gallistel comment that the human mind "has great difficulty in forming long, stably recallable lists of arbitrary names (words)" (1986, p.79). They argue that much of a child's first engagement with learning number is rote learning the first 12 or 13 number words, and the rules that generate subsequent words.

3. The cardinal principle

According to Marmasse et al. (2000) the last tag represents the whole set, e.g., if five objects have been counted "1, 2, 3, 4, 5" the last tag, "5" describes the whole set. This principle reflects that the learner understands that the last number word of an array of counted items has a special meaning- it represents the set as a whole and the numerosity of this set of items. Siegler (2003) argues that it seems likely that the cardinal principle presupposes the one-to-one principle and the stable-order principle and therefore should develop after the learner has some experience in selecting distinct tags and applying those tags in a set.

4. The abstraction principle

Marmasse et al. (2000) argue that there is no restriction on the number or type of items that can be counted. Steffe, Von Glasersfeld, Richards and Cobb (1983) argue that there are five different types of countable item, progressively difficult for the child to manage: perceptual units To understand this principle, learners need to appreciate that they can count non-physical things such as sounds, imaginary objects or even the counting words – as is the case when 'counting on'. The realization of what is counted is reflected in this principle.

5. The order-irrelevance principle

For Marmasse et al. (2000) the learner has to learn that the order of enumeration (from left to write or right to left) is irrelevant. It does not really matter whether the counting procedure is carried out from left to right, from right to left or from somewhere else, so long as every item in the collection is counted once and only once. In other words, a set of objects may be properly counted by starting with any object and going in any order.

Ensor et al. (2009 p. 10) argues that 'once these principles have been mastered (and this usually happens over a protracted period), children have developed the ability to work with numbers as representations of numerosity'. As Gelman and Gallistel put it: "counting provides the representations of reality upon which the [numerical] reasoning principles operate. That is, counting serves to connect a set of reasoning principles to reality" (1986, p.161).

2. 2. 5 Teaching for recall and derivation of number facts

Derived facts strategies (DFS) are strategies in which a learner uses a small set of known number facts to find or derive the solution to unknown number facts. That is, learners figure out ways to build on their own knowledge to determine more complex facts. Instruction that encourages children to use DFS strategies and reinforces spontaneous DFS activities can lead learners to abandon the simple counting strategies. According to Steinberg (1985) teaching addition and subtraction DFSs results in increased achievement.

The retrieval from memory of basic number combinations of single-digit addition and related subtraction has long since been considered desirable. Baroody, Bajwa, and Eiland (2009) and colleagues argue that that learners who do not master number combinations experience considerable difficulty. They further argue that retrieval of numbers reduces cognitive overload when such knowledge is needed in more advanced operations. Teachers need to consciously and deliberately teach number combinations in early numeracy classes.

According to Maclellan (2001) number combinations develop in three phases firstly, *counting* as I have discussed in the section on counting methods, secondly, *reasoning from known facts* and *relations to deduce a new combination* and thirdly through *mastery* that is by retrieving the answer from memory. Maclellan (2012) states that:

> If teachers can encourage learners to use their own knowledge through counting and reasoning, there can be an almost seamless mutating into automatic recall which reflects a well-integrated network of conceptual and procedural knowledge, and equips learners with knowledge with which they can reason abstractly with in number work. (p. 9).

2. 2. 6 Description of Derived Fact Strategy

Instruction that encourages Derived Facts Strategies builds on students' own reasoning strategies to help them move from familiar to more complex addition and subtraction facts. According to Steinberg (1985) there are two main components of Derived Facts Strategies: *decomposing* and *compensating*.

Decomposing is breaking the number into its pieces – the key is that the learner decides how to break up the numbers according to their own understanding. For example, many learners are able to add most easily to 10, so they might reason that 6 + 7 can be solved by "making a ten." For example, a learner might think, "If I start with 6, I need 4 more to make 10. Then I still have 3 left from the 7, so it is 13; (6 + 7 □ 6 + 4 + 3)."

Compensating is when learners shift to an easier or known fact and adjust or compensate to find the needed fact. For example, to find 16 – 9, a learner may reason that 16 – 10 is 6, but since "I've taken away one more than I need to, I'll compensate and add it back on to 6 and get 7."

This does not however mean that number combinations should be drilled at the expense of meaning. In fact, Baroody, Lai, Li, and Baroody (2009) argue that if number combinations are drilled at the expense of meaning learners end up recalling number combination in familiar contexts but face difficulties in unfamiliar tasks. The teaching implications arising from Baroody and colleagues' research findings are that teachers need to expose learners to multiple ways of counting and reasoning tasks and to facilitate learners to use 'use their own strategic knowledge with increasing efficiency such that they themselves discern the value of fluent number combinations'(Maclellan, 2012 p. 9).

However, Geary, Hoard, Byrd-Craven, Nugent, and Numtee (2007); Gersten, Jordan, and Flojo (2005) argue that this does not in any way distract from the expectation that learners need to demonstrate mastery in number combinations. Rather, the implication I draw from Baroody and colleagues focuses teachers' attention on teaching the structure of number to learners.

2. 2. 7 The importance of meaning in numeracy teaching and learning

Teachers need learners to understand that each number can be associated with a variety of possible meanings. This understanding is important for both calculation and application.

Understanding number as repeated addition and multiplication

> Askew and Brown (2003) posit that calculations can be identified with different types of interpretations and contextual problems.
>
> To illustrate, 6 × 3 can be linked to:
>
> - Repeated sets (e.g. 6 boxes each with 3 sweets);
> - Multiplicative comparison (scale factor) (e.g. 6 sweets and 3 times as many chocolates);
> - Rectangular arrays (e.g. 6 rows of 3 sweets)
> - Cartesian product (e.g. the number of different possibilities for eating a sweet and a chocolate from 6 sweets and 3 chocolates) (p.10).

Askew and Brown (2003) argue that of these possible interpretations multiplication as repeated addition and division as sharing appear to be widely used by primary school learners. In fact, Hart (1981) suggests that such early ideas- multiplication as repeated addition and division as sharing have an enduring effect and can limit learners' later understanding of these operations. Hart (1981), notes that if learners understand multiplication only as repeated addition this may lead to misconceptions 'such as multiplication makes bigger' and 'division makes smaller'. Anghileri (1999) alerts us to the fact that even older children may persist with using primitive methods such as repeated addition or repeated subtraction with larger numbers.

2. 2. 8 The use of appropriate language in numeracy teaching

Askew and Brown (2003) posit that teaching learners the appropriate language is important as different expressions are apt to influencing children's solution methods. For instance, interpreting 52 × 3 as '52 lots of 3' may lead to a less efficient calculation method than 'reading' the symbols as ' 52 multiplied by 3' or '3 fifty –twos'. Fuson, Perry, and Kwon

(1998) argue that in teaching number words primary school learners should be taught numbers as chants or unbreakable chains first, then as a breakable chain. Initially, the child always has to start at 1 and only later can the child start at other points before being able to move up and down the chain with fluency. Hence, learners need to be exposed to the experience of the variety of meanings that can be associated with calculation sentences and teachers need to encourage children to ‘read’ calculations in a variety of ways and to select the ‘reading’ that makes carrying out the calculations most efficient.

2. 2. 9 The use of questioning in teaching numeracy

Research findings from early studies generally agree that teacher questioning at a high cognitive level is a key factor in learners’ attainment (Bennett, 1976; Galton & Simon, 1980).

Clarke (2000) also suggest that:

> ‘greater use of open-ended questions; giving learners more time to explore concepts; providing more chance for learners to share strategies used in solving problems; offering greater challenge to children; having higher expectations of children; having a greater emphasis on ‘pulling it together’ at the end of a lesson; more emphasis on links and connections between mathematical ideas and between classroom mathematics and ‘real life mathematics’; less emphasis on formal recording and algorithms; and allowing a variety of recording styles are the hallmarks of good numeracy teaching.’ (p.5).

The above empirical research evidence by Clarke suggests questioning at higher cognitive level is a key factor in learners’ attainment. These findings are supported by Blöte, Klein, and Beishuizen (2000) who also contend that teachers’ instruction in numeracy should allow learners to explore, discuss, and justify their strategies and solutions.

In other words, challenging learners with high level cognitive questions may have more impact on standards than styles of lesson organization. However, findings by Askew and Brown (2003) about lesson organisation that contributed to this were more ambivalent: while high level questioning was often associated with higher proportions of whole class teaching this was not always the case.

2. 2. 10 The use of games in teaching numeracy

Several researchers have documented the use of games to improve learners’ basic numeracy skills. They argue that games enhance learners’ motivation during number learning.Young-

Loveridge, Carr, and Peters (1995) conducted a study involving early childhood teachers' professional development which demonstrated that when awareness of numeracy was enhanced, teachers extended children's mathematical knowledge and thinking during games. For instance, dice games can be used to develop children's counting skills and produce significant improvements in enumeration and the construction of collections (Hughes, 1986).

Peters (1998) argue that learners who play number games in small groups supervised by teachers make greater improvements in enumeration, knowledge of number sequence, and recognition of number patterns than learners who do not play games. In addition, Peters (1998) argue that games have potential advantages over other means of instruction in that they are highly motivating and they occur within a meaningful social context.

2. 3 A review of the Revised National Curriculum Statement and Foundations For Learning Curriculum documents

The teaching and learning of early number draws my focus to the curriculum documents that were in place at the time of my data collection. At this time (2011) the Revised National Curriculum Statement (RNCS) (DoE, 2003) was the mandatory curriculum in place, but the Foundations for Learning campaign DoE (2003) had also been introduced in 2010 as further support in 'unpacking' this mandatory curriculum.

In this section I analyse the curriculum documents in relation to the concept of framing-that is in relation to the sequencing, selection, pacing and evaluation of mathematical knowledge in numeracy teaching and learning. I engage with the documents to see whether the curriculum is highly stipulated and explicit, or whether weak framing predominates, whether there could be implicit suggestions of how knowledge is organized for transmission, and greater discretion for the teacher and learner in teaching numeracy. I begin by examining the organizing principle of the RNCS because it is the curriculum that was in use at the time the research report was undertaken and thereafter delve into analysis of the curriculum documents.

2. 3. 1 Organizing principle

The Revised National Curriculum Statement document is organized around a set of five learning outcomes and associated assessment standards. Assessment standards specify the minimum requirements for each grade. The learning outcome that forms the basis of my research is learning outcome (LO 1) - numbers, operations and relationships.

2. 3. 2 Selection/Content/skill weighting

The primary focus in both curricula is on the concept of number, which includes the development of number concept, mental strategies, and word problems involving the four basic operations. Further, priority in the two curricula is given to counting and calculating. The focus is appropriate at this level as the initial learning of ‘number’ forms the basis for all subsequent learning in mathematics. RNCS and FFL curriculum documents specify number ranges up to at least 34 at Grade 1; at least 100 in Grade 2; and at least 1,000 for Grade 3.

The RNCS curriculum is more weakly specified, and attempts to cover skills, knowledge, values, and attitudes in the assessment standards. The strength of framing is much stronger in the Foundations for learning document to the topic of number. 55% of teaching time is allocated to numeracy teaching in the RNCS. Although the RNCS document mentions word problems frequently and views them as integral part of the development of understanding of the four basic operations, no explanation were given in the document as to how they should be used.

In providing a week by week specification of coverage in order to cover termly milestones (details of the knowledge and skills a child should possess in each grade), the FFL differs from the yearly outline of content provided in the RNCS. The FFL programme carried material that intended to clarify the goals of the RNCS by mapping topics and sequencing out in more detail. FFL takes the format of a lesson planning folder with daily lesson plans for the entire academic year- each lesson plan includes what is to be taught, how to structure the lesson, what materials to use to facilitate learning and gives ideas on how to assess the learning once complete. The progression through the year is made up of milestones comprehensive sequencing and integration of topics as well as detailed notes to the teacher to explain how to teach each topic. Thus, strength of framing is greater in pacing, sequencing and evaluation of knowledge in the FFL in comparison to the RNCS.

The two curricula according to Hoadley, Murray, Drew, and Setati (2010) differ markedly on the way assessment is projected. The FFL has milestones per assessment task for each grade and each term. On the contrary, the RNCS emphasizes that learners should work at their own pace and privileges learners’ individual needs taking into account, encouraging reasoning, negotiating meaning, and discussing their understanding of concepts with each other and their teacher. Group work is also emphasized in the RNCS, but is not a focus of the Foundations for Learning.

Hoadley et al. (2010) argues that framing over pacing is weak in the RNCS curriculum document and is largely left to the discretion of the teacher. However, according to the same authors the FFL documents indicates strong framing over pacing.

The RNCS documents sets out the skills and content for each grade in terms of learning outcomes and assessment standards. These are broad statements of what is expected at the end of each grade. Grade content is set out according to the same content topic across all three grades (Grades 1- 3).

Hoadley et al. (2010) claim that progression and sequencing in the RNCS document is difficult to read from grade to grade both in terms of skills development and the increasing complexity of content. What makes sequencing and progression to be difficult to discern is that learning outcomes are the same from grade to grade. Hoadley et al. (2010) further claim that progression of content and development of concepts and skills is, insufficiently developed across grades.

The content of the FFL document prioritizes the learning of counting and calculation skills. Hoadley et al. (2010) observed that in relation to counting and calculation, both sequencing and progression are much clearer. In both documents, the same learning outcomes for different grades are dispensed with in favour of specific knowledge stipulation per grade. However, Hoadley et al. (2010) notes that while weaknesses in the stipulation of progression in the RNCS have been remedied in the Foundations for Learning; the remedy has only been piecemeal as it is only in relation to the topic of number.

2. 3. 3 Evaluation Criteria

Hoadley et al. (2010) argues that assessment guidelines in the RNCS are largely generic. The possible levels of achievement are not clarified using examples, for instance, the RNCS talks about 'partial achievement'. This then leaves assessment guidelines being largely opaque to teachers. The RNCS document does not unpack learners' levels of responses. The FFL document does, however, provide content-specific assessment activities and examples, with less emphasis on approach and more on content to be covered and assessed (DoE, 2008). The FFL documents describe quarterly milestones for each grade together with three assessment tasks per quarter, followed by rubrics and checklists for the assessment tasks. Only the FFL curriculum documents give an indication of number and type of assessment tasks, specifying twelve assessment tasks per grade per year.

2. 3. 4 Concluding remarks

Hoadley et al. (2010) argues that the RNCS lacks a sufficient and coherent theory of learning that is linked to a set of pedagogical principles that are likely to be recognized by teachers. Although the curriculum has been substantially changed the RNCS remains the official statement of the curriculum for South Africa at the time of data collection.

Hoadley et al. (2010) argues that in its present form the curriculum lacks specification of knowledge and an inadequate indication of progression across grades in terms of knowledge and cognitive requirements of learners. In fact, they note that its assessment procedures focus on generic and bureaucratic aspects of assessment, rather than a subject specific explanation of what to assess and suggestions for how assessment should take place in a particular subject. I tend to find resonance with Hoadley et al. (2010)'s assertion that curriculum cannot and should not eclipse pedagogy, but should be underpinned by a notion of the average teacher and school addressed by the curriculum, and what classroom practices and understandings of knowledge and its transmission prevail. In the next section I review the teaching of numeracy in South African primary schools.

2. 4 The South African land scape -what are the problems?

The debate surrounding the poor performance of learners in mathematics draws my attention to an in-depth overview of the teaching of numeracy in South African primary schools. Classroom- based research literature on the teaching of number suggests that the problematic in the teaching at the Foundation Phase is linked to problems with selection, sequencing, pacing and evaluating criteria of mathematical knowledge.

A study carried by Ensor et al. (2009) suggests that Foundation Phase teachers spent much of the pedagogic time on whole class teaching and all the tasks selected for group work were of low mathematical level. In fact,Ensor et al. (2009) note that the mathematical requirements of the tasks selected by the teachers were 'trivial' (p.29). Further, the same authors while observing individual tasks in a Grade 2 class noted that learners reproduced almost the exact content that had already been taught on the chalkboard.

In Ensor et al. (2009) 's study, all teachers in Grade 1 through 3 spent some time reading out the problems set, highlighting component parts and breaking tasks into subtasks before learners were able to proceed. Another observation made by Ensor is the amount of time devoted to task completion. They reveal that in Grade 1 and Grade 2 classes a great deal of time was devoted to the completion of tasks by one learner while the rest looked on without contributing anything.

Ensor et al. (2009) also links problems of poor performance to selection of forms of representations used by the teachers in all the Grade 1 through to Grade 3 classes. She noted that across Grade 1- Grade 3, teachers selected concrete apparatus for counting and calculating- by –counting tasks over use of indexical marks. As a result they argue that "in general the use of apparatus anchors experience in the local and particular …" (p.22).

In terms of pacing, Ensor's findings resonate with Schollar (2008) who found similar patterns- a lack of differentiation and an extremely slow pace of learning. Ensor et al. (2009) observed that empirical counting had the tendency of 'holding back' learners from using more abstract , grouped principles of number that are required for learners to move into what has been described as "calculation" orientation by Schollar (2008). Similar findings detailing slow pacing have been reported by (Reeves & Muller, 2005). Their findings indicate that learners spend more time on subtopics that they were expected to have covered in earlier grades.

Hoadley (2007) considers the question of classification in relation to the knowledge made available to learners, drawing attention to the distinction between school knowledge and everyday knowledge. Her study shows that different learners are given access to different forms of knowledge as a result of the selection of certain types of tasks by teachers. Hoadley's study reveals that in terms of task selection learners were exposed to the same tasks despite their differing abilities. Teachers required all learners to work on the same tasks despite their differing abilities.

Morais (2002 p.568) contends that strong framing of the evaluative criteria enhances optimal achievement and is 'the most crucial aspect of a pedagogic practice to promote higher levels of learning of all students'. Making the evaluative criteria explicit consists of 'clearly telling children what is expected of them, of identifying what is missing from their textual production, of clarifying concepts, of leading them, to make synthesis and broad concepts…'(Morais, Neves, & Pires, 2004). Teachers' selection of tasks may be hampered by the National Curriculum Statement (NCS) and its associated recommendations which do not specify in detail tasks to be covered and the period of time the tasks need to be covered.

Hoadley (2007) found an extremely slow pace in poorer schools and teachers providing little or no response to learners' errors. Schools were characterized by the dominance of everyday knowledge and concrete methods of solving problems. Hoadley (2007) argues that both this dominance of everyday knowledge and the concrete methods referred to above result in a very low conceptual level in the classroom (confirmed in Schollar's 2008 study of Grade 6 classrooms, where concrete methods for solving problems persisted). Hoadley's findings were also confirmed by studies by Taylor (2008) whose findings suggested 'the snail's pace' at which teachers' progress through the curriculum, sometimes spending a whole lesson talking about two or three Maths problems.

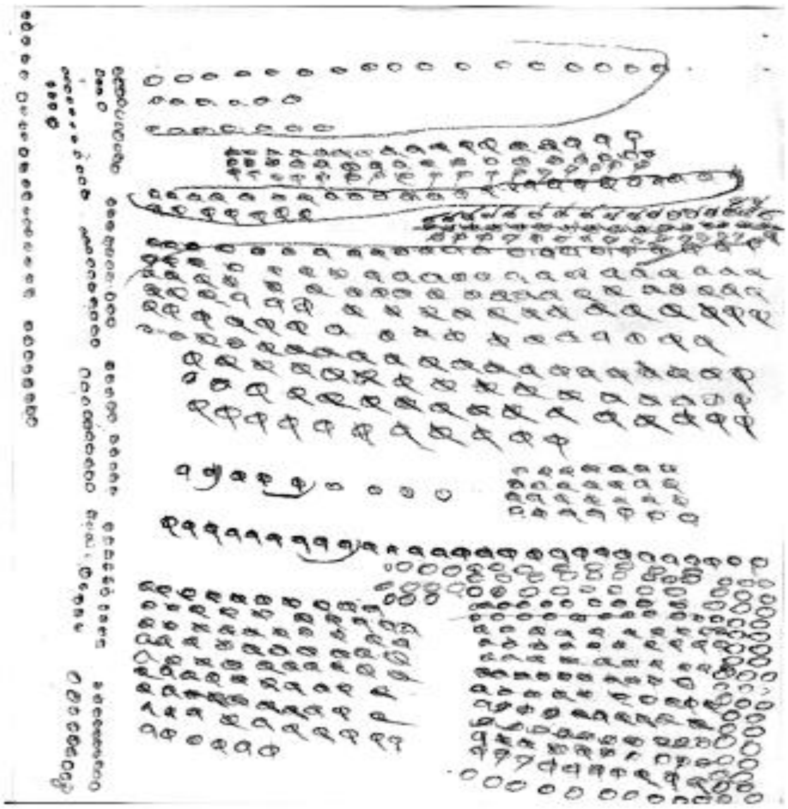
In addition, some research evidence points towards lack of evaluative criteria in some Foundation Phase classes. These are transmissions that they found to be devoid of evaluative criteria relating to instructional discourse. In such tasks what counts as a successful production in terms of instructional knowledge is unclear. The purpose of the task is unclear. Learners are not able to proceed, or they are only given criteria on how they should behave. In some classes the evaluative criteria is difficult to categorize as either weak or strong. For instance, of the nine group work tasks set in a Grade1 class, only four tasks were completed in the classroom and involved some form of plenary feedback (Ensor et al., 2009).

In an analysis of the actual methods used by learners to solve mathematical problems Schollar (2008) found that in general learners at all primary grade levels routinely reduce all addition, subtraction, multiplication and division tasks to counting forwards and backwards, usually in single units. In fact Schollar's analysis distinguished between three methods in solving of these problems.

Firstly, *unit counting*; where all kinds of problems (add, subtract, multiply, divide) are solved by reducing numbers involved to single unit marks and counting them. Schollar (2004) notes that unit counting was common for the Grade 5 learners. 38 % of Grade 5 scripts showed evidence of unit counting. In unit counting, the mathematical problem is solved by reducing the number to simple unit markings and counting up. This is comparable to counting on fingers for numbers larger than 10.

Figure 1 over leaf is an extract from Schollar's findings that shows how a learner solved a problem using unit counting.

Figure 1: Unit counting



Source: Schollar, 2004

In this example above, drawn from a Grade 5 script, separate calculations are performed one by one until the page is filled; thereafter, multiple problems are solved on the same set of marks. Schollar (2008) argues that the method is very confusing when the problem involves larger numbers and especially so when multiplication and division problems are attempted. Further, according to Schollar many mistakes occur when children attempt to tally totals.

Secondly, Schollar (2008) found that learners rely mostly on repeated operations, where multiplication and division problems are solved using whole numbers, but where the problems are reduced to addition and subtraction processes by *repeatedly adding or subtracting* the numbers involved.

Schollar (2008) argues that repeated operations is essentially a more complex version of the above; the skip counting – as against true calculating- takes place through numbers rather than single units.

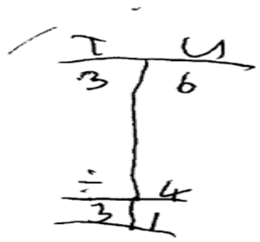
Figure 2: Repeated addition for solving calculation problems

Source: Schollar, 2004

The above scan was drawn from a Grade seven script. In the above scan the division problem 1 420 ÷ 20 has been reduced to the repeated addition of 20 to itself until 1 420 is reached. Each time the addition is performed is ticked and ticks become unit markings which are mechanically counted to yield the answer. Schollar (2008) argues that the method is very confusing if larger numbers are involved. And finally, Schollar (2008) noted that learners used *calculations*- where learners solved all kinds of problems using whole numbers in the conventional way to calculate- as against count- the solutions.

Below, I reproduce an example of how a learner calculated 36 divided by 4.

Figure 3: Inability to calculate



Source: Schollar, 2004

In the above script a Grade Seven learner attempted to use whole number calculation to solve 36 ÷ 4. Schollar (2008) argues that the learner clearly has no idea how to actually use conventional division methods, has no knowledge of times tables and, perhaps most significantly, has no number sense in that 36 divided four times simply cannot be 31.

The scans on figures 1, 2 and 3 typify the methods used by South African learners in problem solving.

Schollar's findings indicated that 79.5 % of Grade 5 and 60.3 % of Grade 7 seven children still rely on unit counting to solve problems to one degree or another. Consequently, Schollar (2008) argues that the majority of South African learners are not developing any kind of understanding of the base-10 number system and the associated critical understanding of place value.

Schollar (2008) has summarized the causes of poor performance in mathematics as a result of failure by teachers to extend the ability of learners from counting to true calculating. Against this background, Schollar (2008) argues that 'all more complex mathematics depends on an understanding of place value within the base-10 number system, the ability to readily perform basic calculations and see numeric relationships' (p. 17). In addition, Schollar (2008), highlights that the problem is caused by the application of ineffective learning practices in classrooms resulting in the virtual disappearance of memorization, consistent drill and regular extensive practice of learned content and consequently learners are not being given the opportunity to develop the 'neural pathways and structures required for the development of higher order cognitive competencies in mathematics' (p.17).

In a study that was aimed at understanding how Grade 1- Grade 3 learn numeracy concepts Cranfield et al. (2005) discovered that most learners experienced difficulties in dealing with 'straight calculations' and the majority of learners used counting all and counting on while none were able to solve straight calculations. Cranfield et al. (2005) claims that none of the learners in the study engaged in “formal” or “innovative methods”. Thus, consideration of the underlying factors in the above study suggests a lack of progression in terms of mathematical development across the Foundation Phase (Cranfield et al., 2005).

More recently,Venkat and Naidoo (2012) analysed a Grade 2 numeracy lesson and revealed a lack of structured sequencing of number concepts. Scott, Mortimer, and Ametller (2011) argue that this lack of structured sequencing inhibits the possibility of learners using known answers to derive unknown answers.

Based primarily on the South African findings outlined above particular attention needs to be paid to the selection, sequencing, pacing and evaluation of knowledge in the teaching of numeracy. Key aspects emerging from the literature on teaching of early numeracy are a focus on selection, sequencing, pacing and the evaluation of knowledge towards more abstract notions of number.

Chapter 3: Conceptual Framework

3.1 Introduction

In this section I explain Bernstein's notion of pedagogic discourse (Bernstein, 1996, 2000). I used the pedagogic discourse to generate concepts for analysing pedagogy using the lens of 'framing' in numeracy lessons. Blackledge and Hunt (1985) comment that one of Bernstein's skills was to classify and label segments of the educational process which allowed others to view clearly his constructs and theories. Bernstein (1977) initially discussed the educational process from three major perspectives: What the academy defines as valid knowledge Bernstein termed "the curriculum". Bernstein defined "pedagogy" as those activities which bring about valid transmission of the knowledge, and he delineated "evaluation" as the realisation of the knowledge transmitted. I began this section by justifying the use of Bernstein's concept of framing in analysing pedagogy.

3. 2 Relevance of Bernstein's principle of Framing

Bernstein's pedagogic discourse provided me with the tools to describe the structuring of knowledge in pedagogic contexts. Singh (1992), in her elaboration of Bernstein's concept of framing says the concept helps to shed light on, and provide a deeper understanding of, the educational processes that unfold inside educational institutions . In a number of studies over 40 years he clarified what the differences were between middle class and working class learners, ranging from their home life and language modalities to differing forms of pedagogy experienced in different schools.

I used the notion of framing because the concept provided me with an internal language for the description of pedagogic discourse. By internal language is meant a conceptual language that directs both observation and analysis (Bertram, 2012).

Further, Bernstein has argued that education specializes consciousness with respect to school ways of organising experience and making meaning, or what has been referred to elsewhere as context independent meanings (Holland, 1981). In the same vein Hoadley (2006) is in agreement with Bernstein when she argues that while everyone has access to the common sense knowledge of everyday life, schooling inducts learners into the 'uncommon sense' knowledge - the school code. Bernstein talks about this process in terms of the specialization of 'voice', which refers to the way in which 'subjectivity is created through the socialization of individuals into categories of agents, knowledge and contexts that are distinguished by the particularity of their voice' (Dooley, 2001). 'Specialization' then 'reveals differences from, rather than commonality (Hoadley, 2006).

This study is concerned with analysing pedagogy across numeracy focused lessons between teacher and learners using framing to determine the nature and extent of control teachers and learners have over the discursive rules of selection, sequencing, pacing and evaluation of knowledge.

3. 3 The Pedagogic Discourse

Bernstein's theory of pedagogy is summarised in his theorizing of pedagogic discourse. Pedagogic discourse describes the 'specialized form of communication whereby differential transmission and acquisition is effected' (Bernstein, 1990, p.182). Pedagogic discourse describes the *relay* of pedagogy. It consists of an instructional discourse embedded in a regulative discourse. Put simply, the instructional discourse is concerned with the transmission of knowledge and skills.

Bernstein (2000) conceptualization of pedagogy thus offers a systematic analysis of classroom interactions between teacher and pupils, pupils and texts, and teacher and texts (at least). Bernstein (1996 p.46) argued that 'pedagogic discourse consists of a discourse of skills of various kinds and their relation to each other'. Bernstein termed the discourse that creates specialized skills instructional discourse while the discourse that defines social conduct he termed the regulative discourse. According to Bernstein Bernstein (2000) a set of internal rules underpin both the instructional and the regulative discourse. The instructional discourse is underpinned by discursive rules or the rules of selection, sequencing, pacing and evaluation of knowledge.

While pedagogy also encompasses classification of knowledge and how boundaries are maintained by the teacher, my study is focused on framing or control over knowledge in numeracy lessons.

3. 4 Framing

Framing is concerned with the 'how' of knowledge and refers to the locus of control over the selection, pacing, sequencing and evaluation of knowledge, and can also be strongly or weakly framed (Bernstein, 2000). With reference to the instructional discourse framing does not refer to the content of knowledge that is framed but to who controls the framing.

As Bernstein puts it:

> Frame refers to the strength of the boundary between what may be transmitted and what may not be transmitted. Where framing is strong there is a sharp boundary, where it is weak a blurred boundary between what may and may not be transmitted (Bernstein, 1971 p.55) .

In other words, framing of the instructional discourse refers to the nature of control over the selection of knowledge (who decides what is valid knowledge and what isn't); the sequencing of knowledge) who decides what is taught first, second etc.); the pacing of knowledge (who decides the rate of transmission or how time is used); and the criteria of assessment (who decides on valid acquisition of knowledge).

Bernstein (2000) further elaborates that framing refers to the nature of control over:

- the selection of the communication;
- its sequencing (what comes first, what comes second);
- its pacing (the rate of expected acquisition);
- the criteria; and
- the control over the social base which makes this transmission possible (p. 12).

Different aspects of pedagogic practice can be strongly or weakly framed, with for example, strong framing over the way knowledge is evaluated (or assessed), and relatively weak framing over the selection, pacing and sequencing of knowledge (Bernstein, 1996, 2000). Strongly framed knowledge is knowledge, in which students have little or no control over the selection of knowledge in the curriculum, and its pacing, sequencing and evaluation, while in weakly framed knowledge, students have much greater control over their own learning process. It would thus seem Bernstein never thought the students really had control, only that the teacher could make the control less explicit and negotiated.

In the pedagogic relationship Bernstein states that:

> …where framing is strong, the transmitter has explicit control over selection, sequencing, pacing, criteria and the social base. Where framing is weak, the acquirer has more apparent control (1996 p.27).

The elements of framing may vary independently, i.e. one could identify strong sequencing and weak pacing in the same numeracy lesson or other combinations. Where framing is strong (F^+), the transmitter of the knowledge [i.e. the teacher] has explicit control over selection, sequence, pacing and evaluation criteria. Where there is strong framing (F^+), the teacher sometimes allows the acquirer to have some control but up to certain limits. If framing is weak (F^-), the acquirer varies the selection, sequence, pacing and evaluation criteria. Weak framing (F^-) means that the transmitter has limited control over what is taking place. Instead, the acquirers have apparent control.

There is a necessity to include F^0, as a framing value for the framing of the evaluative rules. There were cases where I could not observe any overt criteria for task completion. In the case where there is F^0, Hoadley (2005) defines this kind of learning as one where no attempt is made to transmit the concepts and principles in the instructional practice. What counts as a successful production in terms of instructional knowledge is therefore unclear or completely open. Learners are unclear as to how to proceed, or they are only given criteria relating to how they should behave. The teacher gives no evaluative feedback to learners and they are unaware of the correct answers. Consequently, where no evaluative criteria are provided we get F^0 for the evaluative rules. According to Hoadley (2005) F^0 may point to a breakdown in pedagogic discourse, or the absence of (a particular dimension of) pedagogy.

Bernstein (1996) identifies two systems of rules regulated by framing namely:

- the rules of social order, i.e. regulative discourse (RD) and
- the rules of discursive order, i.e. Instructional discourse (ID).

The rules of social order control (RD) the hierarchical relations between the transmitters and acquirers within the classroom situation. The ID is a discourse of competences relative to a given discipline that refers to *what* is transmitted. Bernstein argues that the rules of discursive order (ID) are concerned with the transmission/acquisition of specific competences, and the selection, sequence, pacing and criteria of the knowledge elements commonly associated with the curriculum. It is about choices of tasks, how they are worked with, sequencing, pacing and which knowledge is considered of value in a given context and how it is evaluated. It is the discourse that articulates the kind of skills and knowledge learners should acquire (Bernstein, 2000).

According to Morais (2002) knowledge, cognitive competences and scientific processes are the contents of instructional discourse. She gives the example that if teachers indicate that an answer is 'right', 'wrong' or ‘incomplete’; they are referring directly to ID. Bernstein (2000) argues that the principle of framing is the means of acquiring the legitimate message, that is, how meanings are put together.

Thus, the pedagogic discourse consists of an instructional discourse embedded in a regulative discourse, and this can be represented as follows:

$$\text{Framing} = \frac{\text{Instructional Discourse}}{\text{Regulative Discourse}} \qquad \frac{ID}{RD}$$

The regulative discourse, i.e. social order rules, is always dominant in relation to discursive rules/instructional discourse (Bernstein, 2000). The fact that the instructional discourse is embedded in the regulative discourse means that the hierarchical relation between the transmitter and the acquirer regulates the selection, sequencing, pacing and evaluative criteria of the instructional knowledge. In a sense, framing regulates relations within a context; it refers to the relationship between transmitter and acquirers (Bernstein, 2000).

3. 5 Operationalization of the concept of framing within number teaching and learning

The analytical framework considered the structure of the pedagogy using Bernstein (1975, 1990, 1996, and 2000) in analysing pedagogy. In relation to analysis of classroom observation data, framing described the relative control teachers had over selection, sequencing, pacing and evaluation of mathematical knowledge. I summarize the conceptual dimensions in Table 2 below.

Table 2: Conceptual categories for characterizing pedagogy

Discursive rules of Framing	Extent to which teacher controls **selection of content**
	Extent to which teacher controls **sequencing of content**
	Extent to which teacher controls **pacing of content**
	Extent to which teacher makes explicit the rules for **evaluation of learners**

In coding data I translated the concept of framing into a coding scheme that I used to analyse the data. I used a four point scale of framing ranging from very strong to very weak control relations. (F^{+}, $F^{+/-}$, F^{-} F^{o},) in designing the data analysis instrument in order to provide for a wide spectrum within which modalities of pedagogic practice could be generated instead of simply using a two point scale instrument which would lead to a simplistic binarization of pedagogic practices. Where framing is shared by both teacher and learner I coded this as $F^{+/-}$. I analysed the instructional discourse in three number lessons according to the following analytical framework:

Table 3: Framing of numeracy lessons

Element	Framing strength		Variation
Selection of knowledge	F^+	During the learning activity the teacher selects knowledge.	Strong framing
	$F^{+/-}$	During the learning activity, both the teacher and the learner select knowledge.	
	F^-	During the learning activity, the learner selects knowledge.	Weak framing
Sequencing of knowledge	F^+	During the learning activity, the teacher sequences knowledge.	Strong framing
	$F^{+/-}$	During the learning activity, both teacher and learner sequence knowledge.	
	F^-	During the learning activity, the learner sequences knowledge	Weak framing
Pacing of knowledge	F^+	During the learning activity, the teacher paces knowledge.	Strong framing
	$F^{+/-}$	During the learning activity, both teacher and learner paces knowledge.	Weak framing
	F^-	During the learning activity, the learner paces knowledge.	
Evaluation of knowledge	F^+	During the learning activity, the teacher evaluates knowledge.	Strong framing
	$F^{+/-}$	During the learning activity, both teacher and learner evaluate knowledge.	
	F^-	During the learning activity, the learner evaluates knowledge.	
	F^0	During the learning activity the teacher makes no comment on the work as it proceeds; the teacher communicates no criteria for task completion. The teacher takes no action to ascertain what the learners are doing and the teacher engages in other work in her space and is not seen to look at what the learners are doing.	Weak framing

3. 6 Conclusion

This study has been informed by Bernstein's theory of the pedagogic discourse and more specifically the principle of framing to analyse numeracy lessons. This provided the conceptual lens through which I analysed the empirical data set from classroom observations.

Chapter 4: Methodology

4. 1 Introduction

The chapter begins with a discussion and clarification of the qualitative research method. A detailed explanation of the data collection methods (lesson observations) is also provided. The data that are described in Chapter 5 come from lesson observations. The chapter further explains the sampling technique used to identify participants. Ethical issues considered in this study are also discussed. Lastly, the chapter details data analysis strategies employed and how reliability and validity of data was ensured in the study.

4. 2 Research Design

Literature suggests that the way researchers develop their research designs is fundamentally affected by a number of factors which included the specific interest of the researcher (Dooley, 2002; Noor, 2008; Rowley, 2002; Yin, 1994; Zainal, 2007).

Bernstein's (2000) theory only provides the language for describing phenomenon. It is an abstract language that is not easily operationalized. That means the language for describing how these are to be seen is not provided in the theory of pedagogic discourse. Bernstein (2000) refers to these, respectively, as internal and external languages of description. By internal language Bernstein is referring to theory as I have described it in Chapter 3 on my conceptual framework. I chunked the classroom transcripts into episodes demarcated by the teachers' change of task in order to understand what was unfolding in terms of locus of control across the lesson in greater detail.

McMillan and Schumacher (2010) describe a research design as the procedures for conducting the study, including when, from whom, and under what conditions the data will be obtained. In other words, the research designs indicate the general plan- how the search is set up, what happens to the subjects, and what methods of data collection are used. The design of a study can be thought of as a blueprint detailing what will be done and how this will be accomplished. Research design involves determining how a chosen method will be applied to answer the chosen research question(s). Key aspects of research design include: research methodology, participant/sample collection and assignment, (if different conditions are being explored), and data collection procedures and instruments.

4. 3 Methodological Approach

In making sense of the world researchers carry with them different beliefs about the nature of reality. The epistemological assumptions that I am making are that knowledge is acquired in social settings through social interactions. People are social human beings and therefore acquire knowledge through social interaction with each other; in this study, framing of valid knowledge by teachers has some bearing on the acquisition of learning numeracy. From Bernstein's theory of the pedagogic discourse, the sociological nature of knowledge and pedagogy has been explained. The approach I used is a 'naturalistic qualitative research' that produced text that represents real life in situ events of teaching (Hatch, 2002).

Bassey (2003) proposes that there exist two particular research paradigms. They are the positivist research paradigm and the interpretive research paradigm. Positivists believe there is reality 'out there' in the world that exists, whether it is observed or not and irrespective of whom observes.

This study utilised qualitative research methods. Rather than reality being 'out there', it is the observers who are 'out there' (Bassey, 2003). Similarly, Cohen, Manon, and Morrison (2002 p.22) agree that, 'the interpretive paradigm, in contrast to its normative counterpart, is characterized by a concern for the individual'.

With this brief explanation of the interpretive research paradigm, I will now discuss it in relation to my study. My research is based on classroom observation and interpretation. The main purpose was to gain an understanding of pedagogy in the teaching of numeracy. What takes place in the classroom is dependent on the teacher and learner control relations across tasks. It is for this reason that a positivist paradigm would be inappropriate for my report. Instead, an in-depth, qualitative paradigm is most suitable.

Classroom observations were conducted as a part of a qualitative study of Foundation Phase teachers' pedagogy in numeracy lessons. Qualitative research is an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem amongst a range of options. A qualitative method was appropriate to analyse pedagogy across numeracy focused lessons.

A similar view is propounded by McMillan and Schumacher (2010) who contend that qualitative research is based on the assumption that reality is a social construction that influences people's actions, thoughts and feelings. It is also mainly concerned with achieving an understanding from the perspective of participants. Qualitative research reports are usually rich with detail and provide meaningful insights into participants' experiences of the world.

Several writers for example, Eisner (1991); (Lincoln & Guba, 1985; Patton, 2002) have identified important characteristics of qualitative research. These are:

- The natural setting or context is used as the source of data. The researcher attempts to conduct research in a manner that will maintain "empathic neutrality" (Patton 1990, p. 55). Observations, descriptions and interpretations used in data collection are contextually situated.
- The researcher becomes the "human instrument" as the data collector.
- Inductive data analysis is used.
- Descriptive, expressive language is used in the research reports, which allows for the "presence of voice in the text" (Eisner, 1991, p. 36).
- Qualitative research is interpretive and attempts to discover the meaning in experiences or events and in turn the researcher interprets the meanings.
- Each study is treated as unique.
- The design of qualitative research tends to be emergent rather than predetermined, and as a result researchers focus on this emerging process as well as the outcomes or product of the research. Because the researcher need to observe and interpret meanings in context, the emergent nature of qualitative research design makes it difficult to finalize research strategies before data collection has begun (Patton, 1990).
- Qualitative research is judged using special criteria for reliability and validity.
- It can yield rich information not obtainable through statistical sampling techniques (Patton, 1990).

By analysing teacher talk contextually, I was able to obtain verbal and non-verbal information regarding the nature and strength of control over mathematical knowledge in number. Through chunking lessons into episodes based on parts of the lesson where teachers' didactic intent remained constant and could be used as units of analysis (Andrews, 2008). I obtained information that would not be available from a statistical sampling technique. In this way I was able to collate the data and used the information to analyse the control relations in numeracy teaching.

This approach was particularly useful in my report as Lincoln and Guba (1985) contend that qualitative data is more easily understood in formats that follow participants' realities: "if you want people to understand better than they otherwise might, provide them information in the form in which they usually experience it" (p.22).

4. 4 Data Sources

I drew data for my report from baseline lesson observations of Grade 2 classes. The data was collected for the Wits Maths Connect- Primary (WMC-P) project. I am a Masters fellow in the project and myself and colleagues were involved in observing and video-taping Grade 2 numeracy lessons in the ten participating schools. I later transcribed all the talk, tasks and representations drawn from three videotaped lessons from one of these schools into lesson transcripts. I selected this school based on their having English as language of learning and teaching (n = 5 of the 10 schools), and because in this school, three of the four lessons that were videotaped were focused on number, offering openings for comparison and contrast across teachers.

4. 5 Data Collection: Video- recording

Conventionally, efforts to measure classroom teaching have used teacher questionnaires because they are economical, simple to administer and generally can be transformed easily into data records ready for statistical analysis. However using questionnaires has its own limitations which researchers believe could be overcome by direct observations of classrooms. Video is generally thought to be a valuable medium for exploring teaching and learning because it captures much of the richness of the class setting (Seago, 2004). There is widespread agreement that researchers and teachers will gain more from watching authentic, realistic classrooms than from watching staged interactions (Sherin, Linsenmeier, & Van Es, 2009).

Because of these anticipated benefits, I chose video recording as the method for collecting data to reflect on my research questions. In the broader project-(WMC-P), the focus was on pedagogy too, so video captured teacher talk, writing and gestures and teacher-learner interactions could usually be heard.

4. 6 Data Analysis

Classroom observations were analysed through the notion of framing as explicated in the conceptual framework. I then applied an analytical tool using the construct of framing to each lesson chunked into episodes. Further, I used the theoretical categories from my conceptual framework, i.e. discursive rules of selection, sequencing, pacing and evaluation of knowledge to help me analyse the nature and extent of control of mathematical knowledge within the three lessons. An analytical tool was developed, based on this analytical framework and it will be discussed in the next chapter as the data is presented.

I transcribed each lesson verbatim after which I chunked the transcripts into episodes. Within each lesson I also noted the time intervals of episodes. This is important in that the time intervals help denote what took place and in what sequence. The episodes were based on the 'didactic intent', Andrews (2009) detailed later in the next chapter. It is within and across these episodes that I then analysed the data using Bernstein's categories of selection, sequencing, pacing and evaluation of knowledge in the tasks.

4. 7 The sample

The research was carried out at a co –educational school where English is the medium of instruction and learning. However, for most learners this is not their mother tongue. The purposeful sampling method was the most appropriate sampling method for my data collection as it enabled me to select three lessons that were all about the teaching of number at grade 2 level. Schumacher (2010) describes purposive sampling as when a researcher selects elements from the population that would be informative about the topic of interest.
McMillan & Schumacher (2010) argues that the sample size is assessed according to the following criteria:

- The purpose of the study
- The research problem
- How the data is to be collected
- Information availability

Research literature shows that there are no hard and fast rules pertaining to sample size. I decided to use a sample size of three teachers because the essence of purposeful sampling is the 'rich amount of information' McMillan and Schumacher (2010) which can be provided even though a small sample is used. I hoped that I would be able to access this rich information from my sample. To that effect in this study three lessons seemed to offer me 'rich –information' on analysing pedagogy in the teaching of number.

4. 8 Ethical Considerations

Clarke (2004) has highlighted the overarching importance of researchers to conduct their work within an "ethic of respect" to those people who participate. Good research practice should therefore involve a partnership and whenever possible should be guided by the needs of the participants who should be an important concern to the researcher. Research ethics therefore imply compliance with acceptable research norms, morals, standards and principles (Clarke, 2004).

To comply and conform to research ethical codes, guidelines, protocols and practices set by the University's Research Ethics Committee the context in which I undertook this research needs to be explained. I am a Masters fellow in the WMC-P project and had clearance for my study within the Project application for ethics clearance from the University and also from the Gauteng Department of Education under Protocol No: 2011ECE012C by the Human Research Ethics Committee of the University of Witwatersrand, Johannesburg.

All data including video and audio is being securely stored (under lock and key) by the research coordinator. Data will be destroyed after five years. All teachers and learners' data used in this study are communicated with anonymity.

A number of ethical issues were also envisaged to emerge from both the collection and use of video-based data in this research. For example the presence of a camera intrudes on the natural environment being studied i.e. their privacy and in a way then research influences the researched. So participants in this research were informed of the nature and purpose of the filming to help them allow their privacy to be shared by the researcher. Participants were assured that the video recordings would only be used for research purposes. It is also imperative to note that according to the clearance obtained for the broader project strict anonymity will be maintained in terms of learners, teachers participating in all writings emanating from the study in the project. Thus all names used in the study are pseudonyms and video recordings are only open to project team members only.

4. 9 Rigor in my research

Sikes in Opie (2004 p. 17) states, "It is on the match between methodology and procedures and research focus/topic/questions that the credibility of any findings, conclusions and claims depend, so the importance of getting it right cannot be overemphasized." McMillan and Schumacher (2010) also assert the notion that claims of validity rest on data collection and analysis techniques and qualitative researchers use a combination of any 10 possible strategies to enhance validity. This means that in order for my research findings to be credible, I had to ensure that the methodology and procedures I chose were best suited to my research topic and questions.

In my study I employed mechanically recorded data in form of video –tapes. McMillan and Schumacher (2010) describe mechanical data as providing accurate and relatively complete records. For data to be usable situational aspects that affected the data record are noted –for instance, failure of equipment, angles of videotaping, and effects of using technical equipment on the context. In most of my lesson videos the angle of videotaping was always focusing on the teacher. This led to some instances of learners' talk not being captured. However, given my focus on pedagogy in classes where the locus of control stayed predominantly with the teacher these gaps did not affect the 'chunking' of the lesson transcripts into episodes in any serious way.

4. 10 Summary

This chapter detailed the essence of the qualitative research method. It also outlined why lesson observations, was the preferred data collection technique. The chapter further detailed ethical issues considered in the report. A discussion of the data analysis strategies employed and how data validity and reliability was ensured rounds off this chapter. A discussion of the data analysis follows in the next chapter.

Chapter 5: Analysis and interpretation of data

5. 1 Introduction

In this chapter I present my analysis of the three lessons separately. Across the three lessons, the analysis began with this format; (i) an overview of the lesson broken down into episodes, (ii) coding and categorizing of data in terms of my operationalization of the concept of framing (described in the previous section). Following Andrews (2009) I divided the three lessons into episodes based on shifts in the 'didactic intent' interpreted via the tasks set by the teacher for the class to work on, and then explored the nature and extent of control over the knowledge in the teaching and learning of numeracy. An episode is defined by the introduction of a 'new' task , although in some instances I broke down an episode into sub-tasks set by the teachers, since they appeared to link to the announced focus of the whole episode. Following Mason and Johnston-Wilder (2004)'s distinction between task and ensuing activity, my episode summary begins with an outline of the task, and I then detail the activity that ensued in classroom work on the task.

5. 2 An overview of lesson A

The focus of the lesson was on the teaching of the number '16'. In order to teach the number 16 the teacher and learners were involved in several tasks. Some of the tasks included whole class counting activities and solving word problems. Learners were also given the opportunity to model the number 16 in various ways. The teacher applied various addition and subtraction activities to teach the number 16 and learners were given individual subtraction and addition problems – detailed in episode form in Table 4. I will now proceed to apply Bernstein's notion of framing across the categories of selection, sequencing, pacing and evaluative criteria.

Table 4: A summary of Lesson A

Time	Episode number	Didactic intent
00.00	1	**Task:** Forward oral count from 1-100, followed by backward oral count 100-1. **Activity:** Learners asked to follow the numbers on their 100 squares.
05.20	2	**Task:** Word problem up on the board: "Sipho has 9 sweets. Nomsa has 4 sweets. Mary has 3 sweets. How many sweets are there altogether?" **Activity:** class asked to use abacuses. Learners told to count out 9, then 4 and 3 on their abacuses. Learners count from 1 and get 16.
07.40	3	**Task:** Teacher asks for a learner to come and write 16 on the chalkboard. **Activity:** One learner writes 16 correctly.
08.20	4	Task: Learner asked to draw 16 objects on the board. Another asked to count 16 counters. **Activity:** A boy draws 15 circles – 14 on one row and 1 below. In count with class, the bottom circle is counted twice to get 16. Boy counts out the bottle tops from a bucket on to the floor: 1, 2, 3 ….12, 13, 16. Boy then counts out another three bottle tops accompanied by the words: 14, 15, and 16. Boy makes an error in counting – skips a counter at 5, 6, and therefore ends up at 16.
11.20	5	**Task:** Representing and identifying 16 in number, words and pictures. **Activity:** A boy writes 16 on board. A learner is called up to count the asterisks- he does this correctly on the second attempt (repeats 14 twice on 1st attempt and gets 15.)
16.30	6	**Task:** Teacher asks for two numbers that add up to 16. **Activity:** Activity: 8 + 8 offered. Teacher writes 8 + 8 = on the board. Learner arranges these in two rows of 8, then counts all and gets 16. 10 +6 offered by learner. 9 + 9 offered by a learner. Teacher asks class to make 9 + 9 and check if it gives 16. 9 + 7 is offered. 15 + 1 offered and checked, written on board. 10 + 1 offered. 9 + 7 offered again. 9 + 8 offered. 17 given as answer by several learners, and rejected. 13 + 3 offered, and 16accepted as answer. 7 + 9 offered. 6 + 10 then offered. 14 + 2 offered. Only the first 4 correct sums (8+8, 10+6, 9+7, and 15+1) have been written on the board; the rest have been acknowledged as correct orally.
27.00	7	**Task:** Teacher announces shift to work with 'minus'-she ask for two numbers that can be taken away to make 16.She reiterates that 'there are many ways to make the number 16'. **Activity:** 17 – 1 is offered. Teacher asks learners to check what this makes on their abacuses. Teacher writes 17 – 1 = 16 on the board alongside the column of addition sums from last task. 18 – 2 is offered. Teacher asks class to verify answers offered by individuals by making on their abacus and counting. 20 – 4 offered. 19 – 3 dealt with similarly.

33.05	8	**Task:** Teacher shifts class to 'Now we look for one number, you add it many times to give 16'.Asks learners to "work it out on your abacus' and tells them to look also for how many times they have to ad this number to give 16. Reiterates that there are many ways to make the number16. **Activity:** A learner is heard to call out 6. Teacher tells class that she wants to see HOW they have added it. Learner offers 16 as an answer. One number, you add it several times. And you tell me how many times you added that number to give you the number 16. That is repeated addition.' Teacher acknowledges and re-explains to whole class that this learner has got "2 eight times" and this has given her 16, referring to the girl's abacus, but does not show whole class the arrangement. Teacher writes on board 2 + 2 + 2 + 2 + 2 + 2+ 2 + 2. She asks class to make this on their abacuses. When 16 has been acknowledged as the answer for eight 2s, another number is asked for that will give 16 when added "many times". 4 offered. Teacher asks "How many 4s". Some say 2; others say 4. Teacher accepts 4; she writes 4 + 4 + 4 + 4 on the board, and asks learners to make this arrangement on their abacuses. One learner is seen to make five 4s, but corrects this with reminder from the teacher that they need only four 4s. Others then make four 4s as well and give 16 as answer. And that "different kinds of methods can be used to make the number 16". She summarises that "The important thing here is for you to know how to write 16 in number, 16 in words – the number name – and how many pictures are we talking about when we talk about the number 16".
45:55- 55:58	9	**Task**: Teacher writes up a set of sums on board for learners to answer individually in their books: 15 + 1 = 16 + 0 = 14 + 2 = 7 + 9 = 18 - 2 = 20 -4 = 19 - 3 = **Activity:** In individual working that follows, some learners appear able to simply write in 16 as answer without use of abacus.

5. 3 Analysis of Lesson A

5. 3. 1 Framing of the selection of mathematical tasks

The excerpt from episode 1 below illustrates what was coded as illustrating strong framing of selection of valid mathematical knowledge:

> T: Ok take out your number charts [referring to 100 square that each child has on desk] and start counting from 1up to 100. We are counting, we are not making noise let's start from 100 - you count from 100 backwards. [Class begins counting rather raggedly.] Let's start together – at the same time – 100, 99, - [Class joins in with her start and count in chorus from 100 up to 1.

In the above excerpt the teacher determined the selection of mathematical knowledge. The teacher selected forward oral counting and backward oral counting activities. Examples from the above excerpt include counting forwards in 1s up to 100 and counting backwards from 100 up to 1. It appears as if the teacher required learners to memorise and recognize number sequences from 1- 100. So this episode was coded as strongly framed or (F^+).

In the next excerpt, drawn from episode 2 there is strong framing of selection of mathematical knowledge by the teacher. The teacher selected a story problem to teach addition of 3 single digit numbers.

> T: Now boys and girls listen to me. [T writes on the chalkboard and reads out:] Sipho has 9 sweets. Listen to me, Nomsa has 4 sweets. And Mary has 3 sweets. Shush! How many sweets are there all together? How many sweets - *are – there*? T: Sipho has 9 sweets.

The teacher determined selection of mathematical knowledge by selecting a word problem to teach addition when she said 'now boys and girls listen to me' and proceeded to write a word problem on the chalkboard. Counting out objects (sweets) was strongly framed as the means of teaching addition.

The following excerpts are interspersed with strong and weak framing of selection of mathematical knowledge between teacher and learners and therefore show variations in the framing relations- from the teacher selecting knowledge to occasions where learners are offered opportunities to select mathematical knowledge. The following excerpt is drawn from episode 6 of the lesson.

> T: Now boys and girls, I want you to give me – *two numbers*, when we add them together, they give us number 16.'
>
> L: 8 + 8.
>
> L: 10 + 6.
>
> L: 9 + 9.
>
> L: 9 + 7.

In the above excerpt the learners selected mathematical content and this was coded as weakly framed.

As the lesson progresses the teacher shifts to working with 'minus' in episode 7 of the lesson.

> T: Now boys and girls I want you to work out with *minus*. Two numbers, you minus, you take away, and then the answer must be 16.
>
> L: 17 -1.

L: 18 -2.

L 20 – 4.

L: 19 – 3.

Again in the above excerpt selection of mathematical knowledge was determined by the learners. This was also coded as weakly framed or F^-.

The following excerpt is drawn from episode 8 of the lesson.

T: Now who can tell me – you look for – *one* – *number*. You look for one number, you add it many times, and it can give us 16. *Only one* number. You add it many times. Repeated addition to give us the number 16.

L: 16.

L: 2.

T: I'm going to give you your books so that we can have an activity inside our books.

T: 17 + 1. Very good but I want one number, that you can add it many times it gives you the number 16 Like what we did with 2.

The teacher appears to be offering learners opportunities to select valid mathematical knowledge by asking them to 'to give me – two numbers' and this is then followed by yet another offering from the teacher 'I want you to work out with *minus*. Two numbers, you minus, you take away, and then the answer must be 16'. In line 247 she says 'you look for one number, you add it many times, and it can give us 16. Only one number. You add it many times'. The teacher restricted the selection to 'two numbers' and 'one number; while decisions about the selection of the actual numbers rested with the learners. The mathematical content was selected by the teacher when she said 'I want you to give me – *two numbers*, when we add them together, they give us number 16'. Selection of mathematical content was strongly framed while the mathematical content itself was weakly framed. Selection of valid mathematical content was shared between teacher and learners and was coded as ($F^{+}/^{-}$).

Another telling case of strong selection of mathematical knowledge is illustrated below from episode 9:

T: I'm going to give you your books so that we can have an activity inside our books.

T: Put the finger on your mouth so that you don't talk … Teacher writes up the following sums thus, with more calls for quiet:].

15+1=

16+0=

14+2=

18-2=

20-4=

19-3=

T: [T distributes L workbooks.] And once you open your books and start writing [more shushing, reprimanding.] Right boys and girls, open your books, and start writing. And use your abacus to count. [Learner workbook seen on camera shows that previous written work involved a set of sums – addition, subtraction, repeated addition sums all making 12. Teacher heard saying: ‘You never copy from others, neh? Take out your ruler and underline your work. You underline your date first. [Teacher circulates, reminds Learners to underline, be quiet, etc. Learners settle to copy questions in near-silence. Learners appear able to simply write 16 as answer to all questions without abacus use. Teacher heard telling Learners that they should draw a picture:] any picture. You don’t have to use stars only. You can make your own. [End of tape.].

The selection of the set of mathematical sums was determined by the teacher only. All the examples within the task had been offered by learners during episode 6 and 7. Selection of the final individual written mathematical tasks was determined by the teacher and thus coded as strongly framed or (F^+) in this task.

5. 3. 2 Framing of the sequencing of mathematical tasks

I present below extracts from lesson A that make reference to instances of sequencing in the lesson. In the following excerpt drawn from episode 1 it appears the terminal objective of the activity was to count from 1 up to 100 orally.

T: Start counting from 1up to 100.

T: Let’s start from 100 - you count from 100 backwards.

In the above excerpts the teacher demonstrated strong framing of sequencing of counting activities by determining the number ranges for the learners, for example the teacher said in line 6 ‘you count from 100’ and in line 14 the teacher said ‘you count from 100 backwards’. The teacher determined counting sequence starting with oral counting forwards and then oral counting backwards. Sequencing of number ranges during the counting activity was thus coded as strongly framed or (F^+) in this task.

In the excerpt that follows sequencing of solving the word problem was strongly framed by teacher. The excerpt was drawn from episode 2 and is presented below:

> T: Sipho has 9 sweets. Listen to me, Nomsa has 4 sweets. And Mary has 3sweets.Shush! How many sweets are there all together? How many sweets - *are* – *there*?
> T: Sipho has 9 sweets.
> [T shows 9 using her fingers to the class].
> T: Nomsa has how many? [Teacher raises four fingers to show the number of sweets].
> L: 4 sweets [in chorus].
> T: 4. And Mary has how many sweets? [As class say 3, Teacher raises three fingers to show the number of sweets.]
> T: Now I want to know, how many sweets are there altogether? Let's count. You can use your abacus.

What emerges from the above excerpt is that teacher determines the way in which the learners solved out the addition problem. This is evidenced by the way in which the teacher repeatedly asked learners the number of sweets. In the word problem the order of the number of sweets begins with Sipho, (9), then Nomsa (4) and finally Mary (3) sweets. This order does not change when the teacher requests the learners to solve the addition problem. This is shown by the way the teacher frames her leading questions to learners. She always began with Nomsa' sweets followed by Sipho and then lastly Mary. Sequencing of solving the word problem was coded as strongly framed or F^+ in this episode.

In episode 6 the teacher involved learners by asking them to offer two numbers that add up to 16. After the teacher had asked learners to identify 16 in number words and then pictures the teacher also determined the next task. The following excerpt shows the task:

> T: I want you to give me – *two numbers*, when we add them together; they give us number 16.

The above excerpt illustrates strong framing of sequencing of mathematical knowledge as the number 16 was determined by the teacher only and this task was coded as F^+.

In episode 7 the teacher announced a shift from working with addition to working with minus. In this episode learners were offered opportunities to provide a sequence of the number sentences that give the difference of 16 when the subtrahend and minuend are subtracted. Learners did not give the whole sequence and the teacher did not check for logical sequencing or completeness.

The following excerpts are offerings from the learners.

> L: 17-1.

L: 18-2.
L: 20-4.
L: 19-3.

Learners provided a sequence of number sentences with a difference of 16. Finding number sentences that make a difference of 16 was coded as weakly framed and coded as F^{-}.

In episode 8 the teacher appears to be shifting the focus to repeated addition. In this task the teacher also offers learners opportunities to provide one number that can be added to make 16. Learners offered the following numbers:

T: 16.
T: Eight 2s.
T: You have it already? Let me see. It's 3s. I said make four 4s. Like here, four 4s. [Camera on a child who appears to have made six 4s.] Four 4s Donald, you must have four 4s. Count your 4s. How many are there here?

In the above excerpts learners were in control of the sequencing of the number sentences that add up to 16. This task was weakly framed in terms of sequencing because learners were offered opportunities to sequence the numbers. Sequencing of repeated addition was coded as F^{-}.

In episode 9 the teacher provided the sequencing of the addition and subtraction sentences that learners had to answer individually. The following excerpts show that the teacher strongly framed the sequencing of the addition and subtraction sums:

15 + 1=

16 + 0=

14 + 2=

18 - 2=

20 - 4=

19 - 3=

Sequencing of addition and subtraction sentences was provided by the teacher and coded as strongly framed or F^{+}.

5. 3. 3 Framing of the pacing of mathematical tasks

Pacing was analysed in relation to discussion and answering of questions that ensued during the lesson.

In episode 1 the pacing of the counting activity was strongly framed. For example, in the following excerpt the teacher assisted a learner in keeping track of the number count.

> T: We are here [Teacher helps a learner to keep track of the number count on the 100 squares.].

Pacing of valid mathematical knowledge was strongly framed because when the teacher said 'we are here' she was stopping the lesson so that all learners could be on the same page. Pacing was coded as strongly framed or F^+.

The following excerpts from episode 2 shows strong framing of pacing of mathematical content by the teacher. The teacher made sure that all learners had got the correct answer by constantly questioning learners. For example, when the teacher said 'somebody said 'no' in line 113. In line 30 the teacher encouraged learners to 'work it out first', so pacing of the task was determined by making sure all learners were ready before moving on. This was evidence of strong framing of the pacing of the mathematical content. Pacing of mathematical content was coded as strongly framed in this activity.

> T: Let's all work it out first.
> T: Ok. Is he correct?
> L: [Yes in chorus].
> T: Very good clap hands for him.
> T: Is this correct? Is this 16?
> Class: Yes.
> T: Is this 16?
> Class: Yes.
> T: Yes? Somebody said 'No'! [Class responds yes more loudly.

The teacher stopped the lesson to make sure that all learners got the correct answer before moving to the next task. For example, in the following excerpt from episode 6 the teacher made sure she clarified the sum before moving on:

> T: Ok, *shush shush,* let's count. I heard someone saying 17. Let's hear if it is 17. [After hearing some learner:] It is 16. Very good. [8+8, 10+6, 9+7 are written up on board as equal to 16.] Another 2 numbers, another 2 numbers –again that when we add them together -. They are many.

> T: Here, use this one [shows learner two more beads on adjacent column. Learner pulls these down, and then continues appropriately to next columns, but does not stop at eight 2s, pulls down ten 2s.

> T: EIGHT! There must be eight. Again, count them, the 2s must be eight. [Learner pushes all beads back.] Start counting them again. [Learner starts pulling beads down in groups of 2 again. This time Teacher keeps count of number of groups of 2 to begin:] one, two. [Learner now stops at eight groups.] Good. Then you start counting

> them and tell me how many how many are there. [To another learner:] Where is yours? [Camera focuses on a learner who pulls five groups of 2 beads down on one column, then three on next column, then counts them all in ones.

Overall the dialogue above shows that the pacing of mathematical knowledge was strongly framed as the teacher made sure that she delayed proceeding with the tasks until all learners who had problems in understanding repeated addition understood. Pacing of valid mathematical knowledge was thus coded as strongly framed.

Strong pacing of pacing mathematical knowledge is further evidenced when in episode 8 the teacher paid attention to individual learners. Pacing of mathematical knowledge was also coded as strongly framed.

5. 3. 4 Framing of the evaluation of mathematical tasks

The lesson was further analysed in terms of the evaluative criteria. In episode 1 the principle that governed the evaluation criteria was unit counting as the following excerpt shows:

> T: Point at your number. Point at the number, when you call a number makes sure point it.

By constantly asking learners to 'point at the number' the teacher was evaluating learners' competency of mathematical knowledge through the use of a concrete strategy- unit counting. Further evidence in the emphasis on unit counting by the teacher was shown as the lesson progressed in the following excerpts:

> T: Okay, let's count them altogether and see how many are there? [Learners count their bead arrangements in 1s from 1 on their abacus up to 16.]
> T: 4s? How many 4s? [One L seems to answer two 4s, another four 4s.] Four 4s. Ok, let's see. [Boy has made an arrangement with four 4s. Counts them in ones and gets 16.] They are 16. Four 4s.

In the above excerpt the teacher evaluates the competence of learners to check the correctness of the number 4 in repeated addition by encouraging the learners to point at the a concrete strategy of working with numbers. Evaluation of criteria was coded as strongly framed F^+ for this activity.

However, there are instances when the teacher did not provide any evaluative criteria to the learners. For example, in the following excerpt in episode 4 transmission of evaluation criterion was not observable.

> T: Very good. Now you start counting them from here [T indicates one end of the line; warns other learners not to 'disturb' the count. Boy makes an error in counting – skips a counter at 5, 6, and therefore ends up at 16].

The learner made an error in counting but the teacher took no action to correct the learner. This was task was coded as F^- because the teacher made no attempt to correct or comment on the learner's error.

The teacher appears to be encouraging the use of count all strategies- a concrete strategy of working with number. For example in the following excerpt drawn from episode 4:

> T: Teacher puts a small bucket full of bottle tops on the floor in front of the class. Learner counts out bottle tops. T asks him to 'count aloud'. Boy is heard to continue his count as '9, 10, 11, 12, 13, 16' – so there are 14 bottle tops out. Other learners show disapproval by saying 'ah ah'. Boy then counts out another three bottle tops accompanied by the words: 14, 15, and 16. There are now 17 bottle tops in the line.].

The teacher made no attempt to correct the learners even when some learners voiced their disapproval of the wrong execution of the counting of the bottle tops by making some interjections saying 'ah! ah'. This was coded as F^0.

Further when learners seemed to be getting facts correctly without calculation the teacher did not make any comments. Instead it appears as if the teacher encouraged learners to use unit counting as she said 'let's all start counting, let's all work it out first.

In the lesson there are also some instances when the teacher encouraged the use of concrete strategies such as 'counting all'. The following excerpts from the lesson highlight the encouragement of concrete strategies for counting.

> T: Who can come and count 16 things for me here? [Learner selected. Teacher puts a small bucket full of bottle tops on the floor in front of the class. Learner counts out bottle tops. Teacher asks him to 'count aloud'. Boy is heard to continue his count as '9, 10, 11, 12, 13, and 16.

In the above excerpt the evaluation criteria was coded as strongly framed as the rules or principles governing counting methods were explicitly specified in terms of counting out concrete objects by teacher.

There are instances when the instructional content was made explicit by the teacher. The teacher made the evaluation criterion explicit by making comments on learners' work as the following excerpts from episode 6 will show:

T: He says 10+1. Let's add 10+1 and tell me the number.

T: The answer is - ?

Class: 17.

T: 17. Which means it's not correct.

In the above excerpts the teacher commented and corrected on learners who had problems getting numbers that add up to 16. This is evidenced when the teacher says 'which means it's not correct' this task was coded as F^+. However, within this notion of correct and incorrect responses the only method for producing the answer that was promoted was based on unit counting. There was no attempt to promote a derived strategy based on using prior answers.

In some cases when learners made some correct productions of numbers that add up to 16 the teachers commented positively like in the following excerpt:

T: Very good. Which means 13 + 3 is equals to 16 [class chorus 16 with her].

This task was coded as F^+ because the concept of addition of numbers that add up to 16 was reinforced by making positive comments to learners such as 'very good'.

The teacher also monitored individual learners as they carried out group work in finding numbers that make a difference of 16 as highlighted in the following excerpt drawn from episode 7:

T: Let's see yours. Where is your 20? Where is your number 20? Count 20. [Another learner has 24 beads pulled down – (has maybe done 20+4?). Petunia counts out 20 beads in 1s.] Then take away 4, minus 4. [learner pushes 4 beads back – two on each of her two bead columns.] Then what is your answer? [Learner counts all in ones and says 16.] Very good my girl. So – another two numbers? Another two numbers, you take away?

In the excerpt above the teacher made some comments on the individual performance of learners as they were finding numbers that have a difference of 16. The principle governing the instructional concept of subtraction was also reinforced by the teacher. This task was coded as $F^{+.}$

In episode 9 the teacher made some explicit and clear comments on how the various ways of representing the number 16.

T: We can use different kinds of methods to make the number 16. The important thing here is for you to know how we write 16 in number, 16 in words – the number name, and how many pictures are we talking about when we talk about the number 16.

In the above excerpt the teacher made some specific comments by summarizing various ways of writing the number 16. The teacher showed learners various ways of writing the number 16 - words, pictorial and numerals. This was coded as F^+ as the teacher made multiple ways of representing 16 explicit to the learners. The table below shows a brief summary of the framing relations across the categories.

Table 5: Summary of framing across categories in Lesson A

Category	Framing
Selection	F^+
Sequencing	F^+ and F^-
Pacing	F^+
Evaluation of knowledge	F^+ and F^0

The above table shows that selection of mathematical tasks was strongly framed in the lesson and sequencing of mathematical knowledge was both strongly and weakly framed. Pacing of mathematical knowledge was strongly framed while provision for mathematical knowledge was sometimes strongly framed, but on other occasions no criteria were discernible for how to produce solutions.

5. 4 An overview of lesson B

The focus of the lesson was to teach addition of two single digit numbers. Learners were engaged in forward oral counting, skip counting and counting in multiples of 5s. Learners were requested to identify and recognize 2 digit- numbers and later on given individual written tasks detailed in table 4 below.

Table 6: A summary of Lesson B

Time	Episode	Didactic intent
00:00	1	**Task:** Teacher asks learners to count from 1 up to 50, then skip counting from 2- 50, followed by counting in multiples 5s up to 100. **Activity:** Learners instructed to start counting orally. Learners start counting orally using their fingers; some learners appear not to be using their fingers for counting. The teacher rubs the chalkboard. Teacher asks learners to count in 2s up to 50 ‘now can we go on to count in 2s up to 50’. All learners start counting orally in 2s up to 50, (some learners count up to 54 using their fingers while some leaners do not use their fingers) and some learners makes murmurs to indicate that they should stop at 50

		and some learners use their fingers to count). Teacher interjects and says to the learners ‘We are counting up to 50, can you take out your counters?’ learners take out their counters and start counting orally from 5 in unison. Learners are seen on camera not to be pulling beads in groups of fives but in ones. [Teacher distributes counters to learners without counters] .
04:12	2	**Task:** Teacher tells leaners that ‘Now we want to talk about addition’. **Activity**: Teacher asks a question. ‘Now can anyone just add for me any two numbers? Any two numbers that you know? You add them and someone can give us the answer. Any numbers, yes (teacher points to a learner). 100+100 offered and rejected by teacher ‘Ah isn’t that too much for us’. 10+10+10 offered. Teacher says to class ‘ Yes, she says 10+10+10, can we work out the answers and if you have the answers you can raise up your hands 10+10+10’ Some learners use counters to add 10+10+10 , while others raise up their hands to give the answers immediately without using the counters). 1+1+1offered.T: Yes he is saying 1+1+1its fine but we want to get the answer for 10+10+10Learner says ‘30’.T: 30, now let’s go to 10+10+10, can we all count 10.Learners count 10 counters using their counters individually aloud. Teacher asks leaners to join them together ‘Now let’s join them altogether; we want to help those who have not got the answer lets count the 10, 10, 10’. Learners start counting from 1 up to 30 using counters). T: ‘Now I want you to add 7 and 3.7 and 3 and I want to see the 7 and the 3. Learners start counting 7 counters and then 3 counters individually. 7 and 3, I want to see your counters, I want to see the 7 and the 3’. 5 + 5 + 5 offered by learner. T: Let’s do that. Can you tell them the answer?’ One learner says 15.
14:16	3	**Task:** Teacher writes numbers on the chalkboard and asks leaners to identify the numbers orally: I will write any number I want you tell me what number it will be, I will write any number you tell me what number it will be are we altogether on that one?’ **Activity:** Teacher writes 0, 15 and 15 on the chalkboard and leaners correctly identify the numbers orally. Teacher asks learners to write any number on the chalkboard and several learners write 100, 21, 20, 31 and 11. Teacher asks several learners to go to the chalkboard and write numbers on the chalkboard: You will all come, you will all come. You can use this side (teacher points to the other side of the chalkboard).
20:56 50: 04	4	**Task:** Teacher calls out five addition sums- 5+3=,2+5, 6+1, 8+0, 0+ 2 **Activity:** Learners write down the answers individually on pieces of paper. Learners use tallies to work out the addition number sentences and some learners could be seen working out answers using fingers. Teacher asks learners to exchange their pieces of papers and asks one learner to come to the chalkboard and work out 5 + 3 = and asks the learner to show

		the class how they got the answer. Learner just writes 8 and teacher reiterates that she wants someone to indicate how to get the answer. Teacher selects one learner who makes 5 tallies and 3 tallies on the chalkboard and teacher assists in by writing 1;2;3;4;5;6; and 7.Teacher asks learners to count all the counters together by unit counting. Several learners are asked to do 2 + 5 and 6 + 1, and then 8+0; Teacher asks learner to count 8 tallies and then 0 tallies. Learners seem to be having problems counting 0 tallies and teacher explains that 0 means nothing so the answer remains 8. Teacher asks learners to exchange their answer sheets: ‘the first one was 5+3(teacher writes 5+3 on chalkboard) Now who can come and show us how we are going to do it? 5+3’. We have got 5, yes how do we get to the answer, I want you to show us how we get to the answer, let’s give her time, let’s give her time. Learner writes 8 on the chalkboard. I want someone who is going to show us how we get the answer. Learner goes to the chalkboard and draws 5 tallies and 3 tallies. Yes, do you see this (teacher points to what the learner has written) it’s not clear I will show it she put 1,2,3,4,5(teacher makes five tallies) and then L:(learners count along with the teacher up to 5 tallies) that’s her counters and then 5 and then we said addition we are joining (teacher writes addition sign in front of the tallies) with 3(teacher points to 3) and then there is (teacher makes 3 tallies as learners count along), then we count them all together what do we get? L: 8 (in chorus). Let’s count (learners count the tallies starting from 1 up to 8 now you can mark your paper if the answer is 8 you mark it correct’. The next its 2+5. Learner writes 7. T: Show us how we get the answer’ He gave us the answer, but we want someone to show us how we get to that answer, let’s do it fast please. learner makes 2 tallies and then another 5 tallies and adds them up to get 7. T: Yes do we see this? How many do we have here? (Pointing to 2 tallies) Lr:(in chorus, 1, 2) T: and this side? L: 1, 2, 3, 4, 5(all learners in chorus) T: If we join them together how many do we get? Let’s count together: lr: 1,2,3,4,5,6,7, (in chorus.) the next one is 6+1(teacher writes 6+1 on the chalkboard), then 8+0, then 0+2.Now you show us how you are going to get the answer . One learner goes to the chalkboard and writes 7.T: ‘Now the first one was 6+1.’ learners count 6 tallies aloud. T: ‘Plus…’ lr: ‘1’. T: How many altogether?’ All learners count the tallies from 1 up to 7. T: Now if your answer is 7 on your paper please mark it correct, if its 7 mark it correct. T: ‘We go on to 8+ 0.Let’s go on to 8+0’.here we have got how many? (Teacher points to the 8 tallies). Learners count the tallies in chorus up to 8. T: We have got 8 plus (pause). So what do we put here? Lr: 8 (in chorus). T: ‘No not the answer, we have got 8 + 0 and what do we put the other side? ‘.Learner: 0(chorus) .T: T: Zero it means it’s nothing, so our answer remains lets count’. Learners count in chorus: 1; 2; 3; 4; 5; 6; 7; 8. T: Our answer is (pause) . Learners: 8 in chorus. T: ‘Because we have got 8 and the other side we have got nothing, so the 8 this side remains our (pause) it remains our (pause)’. Teacher asks learner to come solve 2 + 0 =. Learner appears to be struggling getting the correct answer and writes 11. T: It’s not 11 it’s his counters .They are 2 counters , but what we do is the 0 part of it we don’t write anything, because we all know that 0 its nothing, so this side there is nothing then there we add out 2 counters 0+ 2.What do we get?

		Learner: 2 (Chorus) T: 'We get 2 we remain with these 2, this side there is nothing and this side there is 2.You can finish marking and give the owners papers.

5. 4. 1 Analysis of lesson B

Again, data was examined in relation to the selection of tasks and completion of tasks in the whole lesson. An analysis of the framing relations in terms of sequencing of knowledge within episodes and across episodes was done for the whole lesson.

5. 4. 2 Framing of the selection of mathematical knowledge

The following excerpts from episode 1 of lesson B illustrate strong framing of mathematical knowledge. The teacher selected oral counting and skips counting tasks as valid mathematical content.

> T: Now I want us to count by counting from 1 up to 100, together all of us. Teacher begins counting at 1.
> T: Now can we go on to count in 2s up to 5.
> T: While I do that can we count in 5s up to 100.

The above excerpts show that the teacher made the selection of oral counting as mathematical content. This is shown when the teacher said 'I want us to count by counting from 1 up to 100' and was followed by yet another selection of skip counting in sequences in 2s up to 50 when the teacher said 'now can we go on to count in 2s up to 50', followed by counting in multiples of 5s orally. All the selected counting activities were valid mathematical content. Selection of counting and skip counting activities in episode 1 was strongly framed and I coded selection as F^{+}.

In episode 2 highlighted in excerpts below selection of counting tasks appears to have been strongly framed. The framing of selection of tasks was strongly framed in that the teacher determined the she wanted only two numbers.

> T: Now we want to talk about addition.
>
> T: We are going to do addition.
>
> T: Now can anyone just add for me any two numbers? Any two numbers that you know? You add them and someone can give us the answer. Any numbers, yes (teacher points to a learner).
>
> L: 100+100.
>
> T: Its fine but let not go over to hundred, we want to get our numbers up to 30. We don't go over 30; let's limit our numbers to 30.
>
> L: 10+10+10.

L: 1+1+1.

In the above excerpt the teacher selected addition number sentences as mathematical content to be transmitted to the learners and this is illustrated when the teacher said ‘we want to talk about addition’ and ‘now we are going to do addition’. Selection of addition as a valid mathematical content Also the teacher indicated strongly framing of selection of mathematical content by setting the parameters for the number ranges when she said ‘It’s fine but let’s not go over to hundred, we want to get our numbers up to 30’. This was coded as strongly framed or F^+.

However, as the conversation proceeds learners were offered opportunities to select addition number sentences. This is illustrated when the teacher said ‘… can anyone just add any two numbers that you know’. Learners went on to offer various addends such as ‘100 + 100’, 10 + 10 + 10 and 1+1 +1’. The above selections illustrate weak framing in terms of selecting addition number sentences. Learners were involved in offering the addends. Selection of addition number sentences was done by the learners. This was coded as weakly framed or F^- .

In episode 3 the teacher required learners to identify numbers orally from the chalkboard. The decision on what numbers to identify was made by the teacher. This is shown in the excerpt below:

> T: I will write any number I want you tell me what number it will be, I will write any number you tell me what number it will be are we altogether on that one?

When the teacher says to the learners ‘I will write any number’ it shows that she is selecting what she considers valid mathematical knowledge for the learners. This task was therefore strongly framed. I coded identifying and recognizing numbers as strongly framed or F^+ because only the teacher provided the numbers.

There is also variation in terms of selecting numbers in this lesson. While the focus of the task is still the same the teacher offers learners opportunities to make the selection of numbers so that learners could identify them orally. The following excerpt is illustrative of this shift in control relations in terms of selecting numbers:

> T: Now who wants to come and write a number for us so that others can tell us what number it is?

When the teacher said to the learners ‘who wants to come and write a number’ she was offering learners opportunities to make decisions about what numbers to select. The selection of numbers was thus coded as weakly framed.

In the last episode selection of addition number sentences was also strongly framed as the following excerpts will show:

> T: I will just give you numbers I want to see those who are going to write all the answers correct. I will give you pieces of papers then I will call out numbers, you add those numbers then you write down your answer’.

What is evident from the above excerpt is that the decision around which addition number sentences to select lied with the teacher. This is evident when the teacher said ‘I will just give you numbers’. Selection of addends was strongly framed or F^+ in this task.

5. 4. 3 Framing of the sequencing of mathematical knowledge

Data was also analysed in terms of the extent to which teacher and learners had control over the sequencing of framing of mathematical knowledge.

In the excerpt below I show the sequencing relations during the counting tasks in episode 1:

> T: Now I want us to count by counting from 1 up to 100, together all of us [Teacher begins counting at 1].
>
> T: Now can we go on to count in 2s up to 50).
>
> T: While I do that can we count in 5s up to 100.

Sequencing of counting was strongly framed in this task. This is evident when the teacher said to learners ‘Now I want us to count by counting from 1 up to 100, together all of us [Teacher begins counting at 1.’

In episode 2 sequencing of addition number sentences were strongly framed as indicated in the excerpts below:

> L: 100 + 100.
>
> T: Ah isn’t that too much for us?
>
> T: Its fine but let not go over to100, we want to get our numbers up to 30. We don’t go over 30; let’s limit our numbers to 30.
>
> L: 1+1+1.
>
> T: Yes its fine 1+1+1 but we want to get the answer for 10+10+10.
>
> T: Now let’s go to 10+ 10+ 10.

The above excerpt illustrates that sequencing of addition number sentences was strongly framed. For example, when the teacher said ‘it’s fine but let’s not go over to 100’ she was controlling the number range which leaners could count up to. Sequencing of addition number sentences was therefore strongly framed.

In episode 3 the following excerpts also show that sequencing of identifying numbers was strongly framed. The following excerpts highlight this:

> T: I have got this number, you raise up your hand [teacher writes the zero on the chalkboard] [line 107],
>
> T: Now what about this one? [Teacher writes 15 on the chalkboard) which number is this one? (Teacher points to the number 15 on chalkboard).
>
> T: ‘…here now what about this one? [Teacher writes 21 on the chalkboard] T: We don’t shout please.

The teacher said ‘I have got this number’, now what about this one’ and here now what about this one?’ This shows that the sequencing of numbers was strongly framed by the teacher beginning with the 0, 15 then followed by 21. The order in which learners had to identify those numbers remained the same. Also in terms of sequencing the teacher did not accept any interjections that had the potential to disturb the regulative order in which the numbers were being offered by the teacher. This is shown when the teacher said ‘we don’t shout please’. The sequencing of identifying numbers was strongly framed or F^+.

In episode 3 there was strong framing of sequencing of addition number sentences. This is shown in excerpts below:

> T: 5+3= 5+3, just write down your answer.
>
> T: Next one [some learners are still counting the counters from their abaci] 2+5; 2+5.
>
> T: Next one 6+1.
>
> T: Yes 6+1.
>
> T: The next one [pause] 8+0; 8+ 0.
>
> T: Now we go on to the last one, 0+ 2.

The excerpts above show that sequencing of mathematical knowledge was strongly framed. By constantly saying ‘next one’ the teacher maintained strong control over the ordering of the addition number sentences that she considered valid mathematical knowledge. Sequencing of addition number sentences was coded as strongly framed or (F^+) on this task.

5. 4. 4 Framing of the pacing of mathematical tasks

I further analysed framing in relation to the extent to which teacher and learners had control over the pacing of mathematical knowledge in the lesson. In the extract below drawn from episode 1 pacing of counting was determined by teacher and therefore coded as strongly framed.

T: Can you take out your counters?

T: Is there anyone who doesn't have?

T: Ok thank you I will do something; just wait who does not have counters?

T: I will look for them.

T: I will look for them for you.

T: [teacher distributes counters to learners without counters].

When the teacher said 'ok I will do something, just wait those who does not have counters' she made sure that all learners were ready and had the necessary manipulatives for use in the counting tasks. Again when the teacher said 'I will look for them for you' she was weakening the framing of the pacing of the lesson. Thus pacing was weakly framed as the pace of the lesson was dictated by the availability of manipulatives for all learners. Pacing was thus coded as F^- .

In episode 2 there is evidence of weakening framing of pacing on the offerings of the number sentences as exemplified in the following excerpts:

T: Who didn't get the answer 30?

T: Who else did not get 30? Who else did not get the answer?

T: We are still waiting for others, let's all find the answer first.

T: Lets us wait for her.

T: Now let's try and look at the chalkboard.

What is striking in the above excerpt is that the teacher waits for every learner to complete the task for example, when the teacher said 'let us wait for her'. The production of a correct answer was not only accepted if it was offered by some learners but if all learners had grasped addition number sentences that were being transmitted. Pacing of number sentences that add up to 30 was weakly framed as the teacher prolonged the discussion of the number sentence in relation to learners' understandings. The teacher proceeded to the next task after making sure that all learners were ready to move on. This is shown when the teacher said 'now let's try and look at the chalkboard'. Pacing was weakly framed and coded as F^-.

Weak framing of pacing in the identification of numbers is further evidenced when the teacher wanted learners to identify and write numbers on the chalkboard. I present the following excerpts below to highlight this weakened pacing in writing and identifying numbers.

> T: Now who wants to come and write a number for us so that others can tell us what number it is?
>
> L: [Learner rubs out the number 100 and writes 21].
>
> T: Just let him write.
>
> T: [Teacher gives several learners pieces of chalk to go and write numbers on the chalkboard] Now, You will all come, you will all come, you can also use this side (points to the other side of the chalkboard].

The above excerpt illustrates firstly, that the teacher opens up the space for learners to work on their own pace, this is shown when the teacher said 'just let him write'. Secondly, when the teacher gave several learners pieces of chalk to write numbers on the chalkboard she was weakening framing of pacing in writing and identifying numbers. Pacing was weakly framed or coded as F^- on this task.

An analysis of episode reveals 4 that there are weak and strong variations in pacing relations within tasks. I provide excerpts drawn from episode 4 below to show this variation in framing of pacing relations.

> T: Just write down your answer.
>
> T: Just write down the answer; just write down the answer please 5+3.

It appears in the above task that the teacher is concerned with putting pressure on the learners to complete the task. This is evidenced when the teacher continually reiterates to learners that 'just write down the answer the answer' and what they write does not seem to matter. Pacing was coded as strong F^+ within this task, but weak overall in the lesson only episodes and a small number of tasks within each lesson.

5. 4. 5 Framing of the evaluation of mathematical tasks

I present below an episodic analysis of lesson B. Transcript data on the counting task revealed that the principles for producing answers advocated for in the lesson were mainly in the form of unit counting. This can be seen in the following conversations where the teacher encourages learners to use counters only in producing answers. The following excerpts drawn from episode 1 shows that the principle governing the evaluation of criteria was strongly framed for the task on oral counting. This is illustrated in the following excerpts below:

> T: Now I want us to start by counting from 1 up to 100, together all of us [teacher begins count at 1 and learners count after the teacher].
>
> T: Can we go on to count in 2s up to 50.
>
> T: All learners count in 2s up to 50, some learners count up to 54 and some learners makes murmurs to indicate that they should stop at 50, some using fingers to count.
>
> L: [Learners take out their counters and start counting orally from 5 in unison. Learners are seen on camera not to be pulling beads in groups of fives but in ones.

The required performance of learners is to count forwards orally firstly, counting from 1-100, secondly skip counting in 2s up to 50 and thirdly skip counting again in 5s up to 100 but no concept of skip counting is transmitted. For example on camera learners are seen counting using beads but pulling beads in ones instead of fives. This episode was coded as F^{+} because the teacher provided criteria for counting to the learners when she said 'Now I want us to start by counting from 1 up to 100' and continued to request learners to engage in skip counting.

In episode 2 the teacher required learners to add any two numbers and the excerpts below highlight the conversation:

> T: We all know what we do when we are doing addition.
>
> T: Now can anyone just add for me any two numbers? Any two numbers? You add them and someone can give us the answer.
>
> T: 100+ 100' [some learners give the answer as 200 in a chorus fashion] while some learners suggest that 100 + 100 is too big].
>
> T: Ah isn't that too much for us.
>
> T: its 200. It's fine but let's not go over to hundred, we want to get our numbers up to 30. We don't go over 30; let's limit our numbers to 30.
>
> L: 10 + 10 + 10.

L: [some learners use counters to add 10+10+10, while others raise up their hands to give the answers immediately without using the counters].

L: 1+1 +1.

The coding of this task reveals the absence of transmission of the evaluative criteria. Further the teacher wanted learners to add 'any two numbers' but it appears she is accepting repeated addition of two-digit numbers. The teacher does not make clear whether she wants learners to add two-digit and one –digit numbers or one –digit and one-digit numbers or repeated addition. Learners offered '100+ 100' followed by '10+10+10'. I coded this episode as F^0.

In episode 3 the teacher provided the evaluation criteria for learners to identify numbers. This is illustrated in the following excerpt:

T: I will write any number I want you to tell me what number it will be.

Evaluation criteria was coded as strongly framed or F^+ because the teacher explained the requirements of the task. Identifying numbers was strongly framed as the means of teaching recognising and saying out numbers.

Further the teacher's evaluating criteria appears to be accepting of unit counting. The following excerpts illustrate this:

T: Now I want you to add 7 and 3.7 and 3 and I want to see the 7 and the 3.
[Learners start counting 7 counters and then 3 counters individually].

T: Now you don't shout your answer, you don't shout your answer let's wait for others, 7 and 3, I want to see your counters, I want to see the 7 and the 3.

I coded this task as F^+ because the teacher asked learners to add the two numbers although the criteria for producing answers are specified in terms of counting all in unit counting. I extracted the following excerpts from an addition task to show yet again evidence of providing criteria that promotes unit counting in working with numbers.

T: Now let's go on the next its 2 + 5, now someone to come and show us. This time we want a boy.

L: [Learner writes 7 on the chalkboard].

T: Show us how you got the answer.

[Learner writes 7 again].

T: Thank you but we want someone to show us how we get the answer.

L: [Learner makes two tallies and then another 5 tallies and counts them all up starting from 1].

T: Yes do we see this? How many do we have here? [Pointing at 2 tallies]. [Learners count in chorus- 1, 2].

T: And this side? [Teacher points at the number 5].

L: [Learners count in chorus-1, 2, 3, 4, and 5.].

T: If we join them together how many do we get? Let's count together?

L: [Learners count in chorus starting from 1 up to 7].

T: Now mark your answer if its 7 you mark it correct, if it's not 7 it means it's not wrong.

The above excerpts show that the principles governing producing the correct answers were promoting unit counting. The teacher encouraged learners to use tallies when she said 'yes do we see this? How many do we have here [pointing at 2 tallies]. Also, what emerged from the teacher' evaluation is the way she also encouraged the use of counting all strategies. This is shown when the teacher said, ''yes do we see this? How many do we have here? [Pointing at 2 tallies],' and this side? [Teacher points at the number 5], and If we join them together how many do we get? Let's count together? The concept of addition of number bonds was made explicit to the learners by the teacher and this was coded as F^+.

Table 7: Summary of framing across categories in Lesson B

Category	**Framing**
Selection	F^+ and F^-
Sequencing	F^+ and F^-
Pacing	F^-
Evaluation of criteria	F^+ and F^0

Overall the selection and sequencing of mathematical content was strongly framed and pacing of mathematical knowledge was weakly framed in the lesson above. Evaluation of criteria was strongly framed with notable absences of evaluation criteria in some cases.

5. 5 An Overview of lesson C

The lesson focus was on ordinal numbers – with this seen in the sequencing of multiple episodes involving this idea. Learners recited a poem after the teacher as a whole class. Learners were then asked to do a forward oral count activity from 1 up to 50, followed by counting in 2s up to 50. The teacher had a discussion with the class on the names of games that the children play at home and at school. The teacher put up a number chart whence learners where asked to identify ordinal numbers from 1st up 15th. This activity was then followed by an activity in which ten learners went into a queue and other students were asked to identify the positions of the learners in the queue, this was then followed by teacher asking learners to identify places where people stand in queues. This was followed by an activity in which learners identified the months of the year orally from a chart. This was preceded with the teacher giving the learners an activity in groups about positions. Learners were asked to read the story and answer questions about positions of the athletes in the race. A group activity was then given to the learners to answer the questions about the race. I provide an analysis of the lesson below.

Table 8: A summary of Lesson summary C

Time	Episode	Didactic intent
00:00	1	**Task:** Reciting a poem: Ten green paw-paws **Activity:** Learners instructed to recite the poem after the teacher with finger actions alongside reciting. Learners recite the poem in a chorus after the teacher from 10 and each time a paw-paw falls use fingers to show subtraction or counting backwards. This is continued up to 1.
00:05	2	**Task:** Forward oral count from 1 up to 50, followed by skip counting in 2s up to 34. **Activity:** Learners instructed to point at the number on their 100 square files. Learners are asked to 'point at the number' each time they count a number. Learners asked to count from 1 up to 50 as a class. Some learners count up to 51 and 52. Teacher asks learners 'we were going to count up to which number?' Learners in chorus reply that up to 50.
00:16	3	**Task:** Oral discussion about positions using 1st, 2nd and words 'first' 'second' and so on. **Activity**: Teacher asks learners how they make decisions around who start when playing games. Before learners answer teacher asks another question 'before we go to when you are playing games, tell some of the games that you play with your friends'. Some learners mention soccer, skip rope and Mukhusha. Teacher asks the earlier question about how they make decisions on who start playing a game. One girl says'face'. Teacher repeats this and says 'I hear you every time you say 'face, face' we don't say face from today onwards I am going to teach you the correct way to say I am number one because face it's not face its 'first' let's say first'. All learners repeat the word 'first' in chorus. Teacher writes the word 'first' on the chalkboard.
00:19	4	**Task:** Identifying ordinal numbers from 1 – 15 on a chart.

		Activity: Teacher writes numbers 1 and 2 on the chalkboard and asks learners how to write the numbers as ordinal numbers. Learner correctly says 2^{nd} and teacher demonstrates how to write 2^{nd} on the chalkboard. Learners asked to identify and say out ordinal numbers from pre-pared chart. The numbers are from 1 to 15. Learners identify the numbers orally as a class. Teacher asks 10 learners to stand in a queue. We want to do a small game about numbers you will go with the numbers number 3, number we call it (learners in unison say third) (points to third on chart) third we take the---- the, and when we write the name it's like this (teacher writes the word third on chalkboard), so we will just take this (underlines the letters rd on the word third) and put on the top right corner of 2 and it will be-----' All learners say 3^{rd} in chorus. This pattern continues up to number 15. Can I have the rest of the people on this(*points to a group of learners*) on this table, can you please come and stand here everyone(learners stand up and go to the front of the classroom) and when we are on a line we stand like this we don't stand like this (arranges learners in a queue) or ok let's stand like this so that we can see the faces of the people lets count them I don't know how many they are lets count them let's start(teacher points to learners as the learners count). Teacher points to learners in the queue beginning with the first one as learners count in chorus. Teacher asks questions about positions of learners in the queue 'Yes what position is Ruvimbo? Please you put up your hand when you know the answer those ones we are not counting'. One learner says Ruvimbo is 9^{th}. This is acknowledged and followed by 'let's clap hands for her (*all learners clap hands'.* Teacher ask leaners another question 'Good, that's a very good answer lets clap hands for her, good, eh! Boys and girls now you know how to answer. Is it? About positions of people can stand in a line where, where can we stand in a line? Like where we are given positions like where we are given positions' Teacher puts a pre-pared chart on the chalkboard and asks a question 'now we are going to count something else using those numbers also, is it?' Teacher asks another question about the chart 'this chart is talking about…' One girl answers and says 'The months of the year'. Teacher asks another question, 'how many months do we have in a year?' Learners count 12 in chorus. Teacher tells learners that 'let's give them positions we are going to count them first, second , third lets go' Learners start counting from 1^{st} , 2^{nd}, 3^{rd}, 4^{th}, 5^{th} , 6^{th}, 7^{th}, 8^{th}, 9^{th}, 10^{th}, 11^{th}, and 12^{th}. 'I have a question there on my paper can someone read the question for us please' referring to question the pre-paid chart. One learner reads the question and another shouts January. The first month is February (as teacher points to the words) hu hu did you hear that someone said the first month is shouting the wrong answer the first, we say first means what, firsts means January. Teacher continues asking positions of months up to the month of December.
00:46 - 00:52	5	**Task:** Reading a short story about 'running a race' – which involves ordinal numbers. **Activity**: Teacher asks learners 'who can read the heading for us? Eh

		yes (teacher points to a learner) the heading the heading, what is it'. One learner answers 'Running a race'. Teacher asks leaners to read the story 'Please lets read that together pointing the "running a race" lets read running a race, I said running a race'. Teacher asks learners 'we just want to read here, let's read the story who is going to read the story first for us?' Several learners take turns to read one sentence each. Teacher asks learners to read again 'Now with your friend I want you to read again and answer questions and put up your hand, I just want to come and check you just put the answer next to this space in front of the question, lets read and find out, lets read the story first then we will answer (some learners are reading and some are not reading). Some learners appear not to do understand that activity and the teacher explains 'Ok Listen some people I don't understand what is exactly happening it's a race is it? eh can I have eh so that I explain, can you come this group please come, can you please I am explaining here please I am coming neh (teacher takes a group of learners to the front of the class and starts explaining - they are running its race now they are standing like this Olicah is a girl Olicah is in front, it's a race they are running after each other neh, now the first one is …. Learner answers correctly. Teacher explains further 'Number 2, number 3 and we go and we go (bell rings) and our question is saying who is in front of Pet let's count them'. This one is now listen, listen, who is in front of Pet? This is Pet, this is Lee so when we say front, front means someone who is (uses hands to point to the front of the line) so here who can we say is in front of Pet? Who is in front of Pet? ITS (inaudible) others are understanding good let's sit down and complete our homework our group work please sorry. let's go back (to the learners in the line) we said the answer we write here please don't talk please eh you write here, excellent who is behind Monica, where is Monika(inaudible) (Learner shows teacher some completed work) . T.Wow this is excellent, ok let's continue with our work.

5. 6 Analysis of lesson C

5. 6. 1 Framing of the selection of mathematical tasks

The excerpts draw from episode 1 below illustrate that the teacher selected the mathematical knowledge to be transmitted. The teacher selected a poem:

T: We want to do a poem.

T: We are going to use our fingers as we do our poem.

It appears the mathematical content of the activity hinged on transmitting the concept of backward oral counting from 10 – 1. Selection of backward oral counting was strongly framed.

In episode 2 the teacher decided the mathematical knowledge to be transmitted. The following excerpt illustrates the selection of counting activities by the teacher.

> T: Ok now we just want to count to count, count, count very quickly and we will be done. Can we please take out our show files and open the page with the 100 chart counter is it?

The mathematical concept in focus was oral counting from 1 -100 and skip counting tasks. Because all the forward oral counting and skip counting task was offered by the teacher only I coded this activity as strongly framed or F^+.

Further selection of knowledge to be transmitted by the teacher was evident as the lesson progressed. The following excerpts drawn from episode 3 highlight strong framing of selection of ordinal numbers by the teacher:

> T: We want to do a small game about numbers you will go with the numbers number 3, number we call it [learners in unison say third] [points to third on chart] third we take the---- the, and when we write the name it's like this [teacher writes the word third on chalkboard], so we will just take this and put [underlines rd o the word third] and put on the top right corner of 2 and it will be-----.
>
> L: Third in chorus.

The teacher decided to use a game in order to teach the concept of ordinal numbers. Selection of mathematical knowledge to be transmitted was strongly framed and coded as F^+.

In episode 4 the teacher selected the manipulatives to transmit the concept of ordinal numbers. This is illustrated in the following excerpts:

> T: Now I was telling you that we can use numbers to count different things, eh! Good, now we are going to count something else using those numbers also, is it?
>
> T: Wait for me please [*teacher sticks a chart written months of the year on the chalkboard*] this chart is talking about.
>
> L: The months of the year in chorus.

The mathematical concept in focus was that of ordinal numbers transmitted via a chart with a list of months of the year. Selection of mathematical tasks was strongly framed of F^+.

Similarly in episode 5 selection of mathematical knowledge was strongly framed. The following excerpts highlight strong selection of mathematical knowledge.

> T: Good thank you boys and girls now I want to give you a small task which you are going to work in pairs you are going to work in pairs is it?

T: Who can read the heading for us?

L. Running a race.

T: Can we see it is written running a race?
L: [all learners say yes in chorus].

T: Please let's read that together pointing the "running a race" let's read running a race, I said running a race.

T: Now with your friends we want to answer the questions how many questions do we have?

The teacher selected a short story and required learners to read and answer questions about ordinal numbers. Selection of the story and questions as a mode of transmitting the mathematical concept of ordinal numbers was strongly framed and coded as F^+.

5. 6. 2 Framing of the sequencing of mathematical tasks

The lesson was further analysed in terms of sequencing of tasks and clear progression of ideas as well. Lesson was analysed in relation to the following indicators- when the teacher always or almost determined the sequence of transmission of knowledge in the lesson and or when interjections potentially disturbing the order of learning are dismissed or ignored by the teacher. This I coded as F^+ whereas when learners were offered the opportunities to vary the sequencing of the transmission of knowledge I coded it as F^-.

In episode 1 strong framing or F^+ of mathematical knowledge the over the sequencing of mathematical tasks coupled with strong framing over progression of mathematical ideas within the lesson was exhibited. The following excerpts from episode 1 show evidence of strong framing of sequencing of mathematical knowledge:

T: We want to do a poem.

T: Ten green paw-paws on the tree top.

T: Along came the wind and one went flop.

T: So we were having ten green paw-paws, wind came and one went flop, how many do we have now?

Class: 9 in chorus.

T: Along came the wind and one went flop.

T: So how many do we have now?

Class: 8 in chorus.

The teacher continued in the same way to 0.

In the above excerpts the teacher appears to be transmitting the concept of backward oral counting using a poem. Sequencing of the concept of backward counting was clearly demonstrated through the use of a context. Every time the wind blew it subtracted away one paw-paw from the tree. There is a link between backward oral counting in the activity and the mathematical concept of subtraction. Because of this link the task was coded as strongly framed or $F^{+.}$

Sequencing of the concept of counting was also shared between the teacher and the learners. Learners made decisions around the sequencing of the numbers as they answered to the teacher's questions whenever a paw-paw fell. For example, whenever a paw-paw fell from the tree the teacher asked learners to show the number of remaining paw-paws in the tree on their finger. Because learners were asked to answer questions around the ordinal numbers being transmitted sequencing was strongly framed.

Sequencing of the mathematical concept of ordinal numbers in episode 3 illustrates that learners were offered opportunities to determine the order of the ordinal numbers. This is because the teacher asked learners questions related to order of numbers from 1 up to 15. For example the excerpts below highlight a clear progression of the ordinal numbers from 1 up to 15.

> T: I am going to put the numbers here (pointing to the chart which she has stuck on the chalkboard) so that you know
>
> First when we say first.
>
> T: When we go to number 2 you are number 2 in your game.
>
> T: We want to do a small game about numbers you will go with the numbers number.
> 3, number we call it third [points to third on chart].
> T: Good let's go to the next number [points at 4th on chart].
> T: From 4 we go to.
> T: The next number what is the next number.
> L: Sixth.
> T: Its sixth and we say sixth.
> T: The next one.
> L: 7.

The teacher continued up to 15.

Again sequencing of ordinal numbers was strongly framed in the above task. This is because the teacher decided questions and their order. Coding sequencing of ordinal numbers was coded as strongly framed or F^+.

In episode 4 sequencing of ordinal numbers was strongly framed. The following excerpts illustrate this:

> T: We are going to count something else using those numbers also, is it?
>
> T: Wait for me please [teacher sticks a chart written months of the year on the chalkboard] this chart is talking about years?
>
> L: The months of the year.
>
> T: Excellent it's talking about [pause] its talking about months of the year [points to the heading of the chart] months of the year so we can also count using our [pause] how many months do we have in a year?
>
> T: Ok let's count them or ah! let's Say them first putting up our fingers we say January, February, March , April May, June , July, August September, October, November, December.
>
> T: Now: let's give them positions we are going to count them first, second , third let's go [teacher takes a pointing stick to put at the months on the chart] lets count them first , second and see where we end let's go.
> T: 1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th.

Sequencing would be coded as F^+. The reason for this is that the teacher decided on what order the transmission of ordinal numbers would took place. For example when the teacher said, 'we are going to count them first, second, third let's go' she was deciding on the order in which she wanted the learners to start counting the ordinal numbers. Framing of sequencing was strongly framed or F^+.

5. 6. 3 Framing of the pacing of mathematical tasks

Control over the pacing of reciting the poem in episode 1 was strongly framed by the teacher. It is the teacher who asserted the pacing or expected rate of transmission. She decided that the poem would continue until there were no remaining paw-paws in the tree. Learners did not have control over the stipulated pacing of the backward oral counting concept that was being transmitted. Learner interventions were not accepted even when they had mastered reciting the poem and wanted to take a lead in reciting the poem. For example in the following excerpt in episode 1 pacing was strongly framed by the teacher.

> T: Please don't disturb the lesson, how many do we have?

Pacing of the concept of backward oral counting was coded as strongly framed or F^+ on this task because the teacher did not seem to allow any interjections from the learners.

Pacing of the counting tasks in episode 2 was also strongly framed. The teacher asserted the expected rate of transmission of the counting tasks. The following excerpt illustrates the teacher's control over the forward oral counting task:

> T: Some people don't listen I said we were going to count up to which number? L: [50 in chorus].
>
> T: Up to 50 others but they were counting up to fifty what anywhere they were not listening when I say let's count to a certain number [some learners make some noise] eh please , please, please, please, please listen to me, when I say let's count to a certain number we must count to that certain number.

She decided that learners had to stop counting at 50. Pacing was coded as strongly framed because learners did not have control over the stipulated number ranges.

Pacing in episode 3 was also strongly framed. The teacher controlled the rate of transmission by making injunctions to learners such as:

> T: Can you please put down your hands everyone we all play games is it but for us to start a game they we must do something be must do something because we can't start both of us at once what do we do to find who must start.
>
> T: Can we please sit on our bums and put down our hands you are all right its only unfortunate that you say the words the wrong way, so those words mean something [teacher goes to the chalkboard].
>
> T: Eh if you are done putting your thing put it in the chair bag; put your pencils away please.
>
> T: Good let's go to the next number.

The teacher made injunctions to learners to:

> T: Put down your hands everyone.
> T: Put down your hands put your pencils away.

She decided when to stop the learners doing the task by making sure that learners strictly adhere to time frames she sets. Again pacing is controlled by the teacher when she said 'good let's go to the next number' 'let's say together the next one' 'the next one' 'it's eighth the next one'. Pacing was therefore coded as strongly framed or F^+ on this activity.

An interesting phenomenon about episode 4 is the amount of pedagogic time allotted to it. The activity is allocated about 20 minutes of total pedagogic time. This task was thus coded as strongly paced or F^+ because the amount of time spent on identifying ordinal numbers was determined by the teacher. Overall, it appears that the teacher was a key determinant in determining the rate of acquisition of the concept of ordinal numbers. She made decisions about the completion of tasks on identifying ordinal numbers. Pacing of the mathematical activities was thus coded as strongly framed or F^+.

5. 6. 4 Framing of the evaluation of mathematical knowledge

It appears the required performance of learners in episode 1 is to orally count backwards from 10 - 1. This is however, not explicitly explained to learners but emanates from the context. The concept of backward oral counting is left opaque to the learners. This is illustrated in the following excerpts:

> T: As we were doing our poem did you see how the numbers were going? When we started how many paw-paws did we have?
>
> T: When we started how many paw-paws did we have?
> L: 10 in chorus.
> T: And something was happening what was happening?
> L: The wind takes one.
> T: [Teacher writes date on the chalkboard] the date is twenty--- [pause].
> Class: 24.
> T: So when the wind was coming what was it doing?
> T: Taking away paw-paws so the number where they going bigger or smaller [teacher raises up right hand to show bigger and hand down to show smaller].
> **[**Three learners enter into the classroom; the other one is late; other one from the office to get prestick] Good morning Edward what happened today? transport yes ok please put on your glasses [Edward sits down] and may you please try to face here is it because right now we are not yet writing or you can come and put your table here this will be much better so that when its group work [inaudible talk as some learners assist to move the table] all of you where are you going? [Sorry, teacher gestures to the person operating the video].

The teacher made very little attempt to explain the mathematical concept of backward counting of numbers to the learners although the learners appear to have realized that 'the wind take one'. The mathematical concept itself was not overtly explained or represented. Also the teacher shifted from a counting backward activity to writing the date and asking learners the date without reinforcing the concept of backward counting. In fact she left learners unclear as to the relevance of reciting the poem in relation to number learning and the date. This task was coded as F^0 because no criterion was provided.

In episode 2 the required performance for learners was counting orally from 1 up to 50 and skip counting in 2s up to 34. In this counting task the principle advocated for in evaluating the criteria was unit counting. This is illustrated in the following excerpt:

> T: I want us to count at the numbers because we are going to deal with numbers.

Similarly, advocating for the use of unit counting unfolds as a principle for producing answers as the task continues:

> T: Now I when we count I want us to point at the numbers.
>
> L: [All learners count in 2s pointing at the numbers with their fingers on the show file.

The framing of the evaluative criteria was strongly framed or F^+ because the teacher offered learners clear instructions on how to count efficiently by asking them to 'point at the number.'

In the following task drawn from episode 3 the evaluation criteria was strongly framed. This is illustrated in the following excerpts:

> T: We don't say face from today onwards I am going to teach you the correct way to say I am number one because face it's not face its 'first' let's say first.
> Class: First
> T: We write first this way [teacher writes the word first on the chalkboard.
> T:Not this way[teacher cancels the word face on the chalkboard] this way when you say face it means you are talking about, about your face [points to her face making circular motions with her hands] but the number we call it first [points to the word face].
> T: Let's all say first.
> T: I am going to put the numbers here so that you know 1^{st} when we say first
> [Teacher writes the word first on the chalkboard] Now first [teacher pointing to the word first on chalkboard] now first when we write first [points to the word 1^{st} on chart] we write our 1 but on the top right we write eh some letters there who can tell us the letters that we write , who can tell us that the letter that we write to show that this.
> T: We write [shows learners one finger pointing upwards] and where do get that st we can't the whole word we write, so we just take this [underlines st on the word first] it

will show us that 1 is first good when we go to number 2 you are number 2 in your game, you are playing a game aha.

L: Second.

L: You say some times sekond , sekond it's not sekond, its second with emphasis , isn't it I am going to write the name here I am going to write the name here(teacher writes the word second on chalkboard) lets read second , second.

T: Good second is number---(points to 2nd on chalkboard) but sometimes when we write in our Maths books, sometime it's too long to write second so we write a 2 nicely but after that 2 what do we get from second, yes Chantel.

L: [inaudible].

T: We take *ndi* *ndi* and we put where we put here [pointing to the 2nd on chart] so whenever you see a number with nd here it means its position number and we call it second neh.

The evaluation criterion was strongly framed in identifying and saying correctly the ordinal numbers. This is well illustrated in the dialogue cited above when the teacher repeatedly emphasizes the appropriate way of writing and saying ordinal numbers. This is illustrated when the teacher said 'when we write first we write our 1…, but on the top right we write eh some letters' and continued to explain to learners the correct way of writing ordinal numbers both as words and as numbers. Framing of the evaluation criterion was strongly framed because the required performance was made clear and explicit by the teacher to the learners.

The evaluation criterion in the last episode was also strongly framed. This is because the teacher made some comments both to individuals and the whole class, monitored how learners were answering the questions. She made some points to clarify what was expected of them in the task. The following excerpts are illustrative of the strong framing of the evaluation criterion:

T: I want you to read again and answer question number and put up your hand I just want to come and check.

T: Ok Listen, listen some people I don't understand what is exactly happening it's a race is it? eh can I have eh so that I explain, can you come this group please come, can you please I am explaining here please I am coming neh [teacher takes a group of learners to the front t of the class and starts explaining] they are running its race now they are standing like this Olicah is a girl Olicah is in front, it's a race they are running after each other neh, now the first one is.

L: Olicah.

T: Number 2, number 3 and we go and we go [bell rings] and our question is saying who is in front of Pet lets count them [teacher touches each learner in queue as the learners count].

T: Others are understanding good let's sit down and complete our homework our group work please sorry ,let's go back [to the learners in the line] we said the answer we write here [pointing for the learner] please don't talk please eh you write here ,excellent who is behind Monica, where is Monica[inaudible]
[Learner shows teacher some completed work]
352. T.Wow this is excellent, ok let's continue with our work. [End of tape].

When the teacher said 'so that I explain' she was making some explanations to the whole class on how to answer the story questions using ordinal numbers using learners as examples.

For example in in the following excerpt:

T: 8 let's put up 8 fingers [teacher raises both hand to show learners 8 fingers].

T: And put 7 in the air.

T: 6 good [teacher shows 6 fingers to the learners].

In some instances the teacher explicated the evaluative rule by requiring learners to explain their answers for example:

T: When we started how many paw-paws did we have?

L: Ten [in unison].

T: And something was happening what was happening?

In the following excerpt, the teacher made the explanations of ordinal number very detailed by modelling the correct way for the learners:

T:We don't say face from today onwards I am going to teach you the correct way to say I am number one because face it's not face its 'first' let's say first.

T: We write 1^{st} this way [teacher writes the word first on the chalkboard. and the teacher explicated the criteria further.

T:Not this way[teacher cancels the word face on the chalkboard] this way when you say face it means you are talking about your face [points to her face making circular motions] but the number we call it first[points to the word first]' 'It's 6 and we say sixth' 'It's 7 so we say 7^{th} [pointing to the number 7th on chart] because at the end we have the sound *th,* the next one,' 'Its 8^{th} let's say together.

And in some instances the teacher made comments to the whole class therefore making the evaluation criteria very explicit:

T: Twelfth its twelfth let's say together let's say together twelfth' listen to this girl, listen carefully and look at her lips the way she says it'

T: Fifteenth let's say, let's clap hands for her, now let's say the number together'

T: Normally it's good to give a full sentence we say Tendai [not her real name] or who is fifth is it don't just stand up and say 5th you must give us a sentence.

In some cases the teacher required learners to give reasons for their answers thus making the requirements of the expected performance explicit to learners:

T: Ah don't just say now let's cross check the answer, let's count the months and see if its September, from 1st, 2nd until we finish let's go.

And in some cases the teacher moved around monitoring what the learners were doing for example:

T: Ok Listen, listen some people I don't understand what is exactly happening it's a race is it? eh can I have eh so that I explain, can you come this group please come, can you please I am explaining here please I am coming neh [teacher takes a group of learners to the front of the class and starts explaining] they are running its race now they are standing like this Nyasha [Not her real name] is a girl Nyasha is in front, it's a race they are running after each other neh, now the first one is.

Framing of the mathematical knowledge in terms of the evaluative criteria was coded as F^{+}.

Table 9: Summary of framing across categories in Lesson C

Category	**Framing**
Selection	F^{+}
Sequencing	F^{+}
Pacing	F+
Evaluation of criteria	F^{+} and F^{0}

The table above on teacher C' pedagogic practices show strong framing in selection, sequencing, pacing and evaluation of mathematical knowledge. A notable exception is the absence of the evaluation criterion in some parts of the instruction practice.

In the following section I discuss the findings of the report.

5. 7 Discussion/Interpretation of Data

This report set out to analyse framing relations of the pedagogic practices of Grade 2 teachers across number focused lessons.

Given the above analysis of data of the three lessons, the key question to ask then is- what do the discursive rules of framing in relation to selection, sequencing, pacing and the evaluative criteria offer in relation to analysing the teaching of number? I draw from the work of Neves, Morais, and Afonso (2004) that focuses on the micro processes in the classrooms related to pedagogy that is also a focus of my study. Hoadley (2006) has shown that framing offers possibilities for analysing the inner logic of pedagogy.

Hoadley's research was located in the South African context and focused on working class children. Her findings appear to be germane in my study also, since the school where my study was located predominantly serves learners from a mixed range of settings.

The most interesting finding was that all three teachers encouraged the use of unit counting- a concrete strategy of working with numbers. This finding is in agreement with Schollar (2008) who found that the fundamental cause of poor performance across our education system was a failure to extend the ability of learners from counting to true calculation in their primary schooling.

There are similarities emerging out of the three lessons observed across the whole range of framing, such as: teacher-dominated selection, sequencing, pacing and evaluation of knowledge as predominant modes in all the three lessons. The most striking feature inherent in all the three lessons in terms of selection, sequencing, and pacing and of mathematical knowledge [task] is the strong framing of tasks by all the three teachers observed in the lessons. Some tasks selected by all teachers show evidence of lack of provision of any criteria producing answers and a push for unit counting.

This finding has also been noted by Hoadley (2006) who in her study noted that 'tasks set up by the teacher were emptied of mathematical content and evaluative criteria appeared to be weak or absent' (p. 703).

A careful analysis of the three lessons reveals the over usage and application of concrete methods in counting based methods for working with number. This in itself is in contrast to what research literature advocates for. Literature both national and international validates the shift from concrete to the more abstract calculation-based methods that are required for efficient working with number as the range increases (Ensor et al., 2009; Gray et al., 2000; Schollar, 2008).

The lessons observed notably lesson A and B, show evidence of disconnections in terms of tasks selected by the teachers. In fact this disconnection in sequencing of mathematical tasks is prevalent in the two lessons. Teachers seem not to emphasize the use of known facts so that learners can use known facts to derive unknown facts. Emphasizing known facts to derive unknown facts has already been discussed in the international literature review section, Maclellan (2012), and locally Venkat and Naidoo (2012) have also noted the downplaying of this important thread of mathematics learning within the schools that are in the WMC-P project.

It also appears that teachers A and B emphasized rote counting in the counting tasks that they selected. Literature has shown that children begin schooling with some knowledge of numbers and that knowledge is mostly based on reciting conventional number symbols. What the teachers need to do is then to move the learners from simply engaging in reciting the numbers to more abstract ways of understanding the meanings of the number symbols (Aubrey, 1997). I would suggests that to move learners from merely reciting numbers teachers need to shift the gear up and engage learners in understanding the cardinality of number. This has been reflected in the literature (Bryant, 1997; Gelman & Gallistel, 1978).

What seems to be emerging from most counting activities in the lessons alluded to above is an emphasis of reciting numbers for the sake of reciting. There appear to be no further action from teachers after the learners have dutifully recited the numbers. I would argue that while rote counting is not bad per se over reliance on it as obtained in the lessons draws back learners in acquiring the sophisticated strategies of working with number.

Teacher A, while asking learners to work on a word problem does not comment or offer a specific directed comment to a learner who gets the answer quickly and correctly without calculation. This point to a lack of emphasis by the teacher on the principles governing the evaluative criteria of working with addition problems. There is need for a deliberate move by teachers to emphasize in their teaching the importance of learners using recalled facts and more sophisticated strategies. What is also striking with reference to solving word problems is the lack of emphasis by teacher A to shift learners from the direct modelling approach of solving word problems to the problem modelling advocated for in mathematics literature research (Gray et al., 2000).

In terms of teaching mathematical symbolisms teacher C seems to emphasize among learners the overarching importance of orally saying the numbers correctly. Throughout the activity when she was teaching ordinal numbers the lesson shows a deliberate emphasis on correctly saying the number sequences. This has been highlighted in the literature base as important by Fuson (1988). Teacher C thus offered learners the opportunities to practice and say the ordinal numbers.

There are indications of the use of count all strategies in teacher A and B's lessons. Research evidence has highlighted the need for teachers to assist learners to shift from using concrete based strategies to more sophisticated strategies. This appears not to be the prevailing scenario in these two lessons. Instead, there is a proliferation of counting all strategies that are constantly emphasized by the teachers. The over reliance on counting all as a counting strategy has been noted in some findings by Ensor et al. (2009) in South African schools. These 'primitive methods' of working with number find their way into high school and as already suggested militate against sophisticated notions of working with number.

The current report found that all teachers selected tasks and offered learners opportunities to work on the tasks and then offered evaluation criteria. These results do not differ from Hoadley (2006) who found low rate of learner selection of tasks in Grade three literacy classrooms.

What then are the implications of such a pedagogy that does not offer learners opportunities to select mathematical tasks? I would argue that an optimal pedagogic would allow teachers to select mathematical tasks for learners as learners might not have the proficiency to select challenging tasks or may not know what is worthwhile learning. This finding is in agreement with Ridgway (1976) findings which showed that the teacher's responsibility is to provide for the mathematical activity in breadth and depth.

The present findings seem to be consistent with other research which found that learners were being exposed to knowledge that is familiar and particularistic and meanings that are concrete and context dependent (Hoadley, 2008). In lesson A, all answers offered for addition, subtraction and repeated addition, were produced and checked through concrete unit counting, with no linking back to previous example – so highly localized (Venkat & Naidoo, 2012).

Sequencing of mathematical tasks in lesson B were also emphasizing unit counting. However, this seems not be the case in lesson C. Part of this difference could be partly attributed to the fact the teacher C's evaluative criteria was in most cases clear and explicit.

Learners were then systematically led by the teacher in saying and identifying ordinal numbers through a variety of activities which included games, the use of manipulatives [chart of the months of the year], the use of questioning, and reading a short story and answering questions. In fact the selection of tasks in lesson C remained focused and tasks were clearly linked to the concept of ordinal numbers. A possible explanation for this might be the explication of the evaluation criterion by the teacher.

On the one hand, the extent to which teachers controlled the ordering of tasks is suggestive of strong teacher control of the order in which transmission would take place. In the same way, as the selection of task was teacher dominated the sequencing of tasks was also teacher subjugated. The ordering of task completion was also highly teacher controlled with very little input from learners and in case of lesson C there was a wholesome control of the ordering of tasks and their completion.

In the current study pacing across the three lessons was also strongly framed by teacher A and teacher C. In lesson A, framing of pacing was highly determined by the teacher. This also accords with Hoadley's (2003) observations, which showed that learners had to wait for everyone to complete a task and thereby holding back fast learners.

It is interesting to note that in all three lessons of this study a very important question then arises about the nature of strong framing of pacing of tasks. An example of this are the findings by Ensor et al. (2009) that learners spent very low amounts of time on calculating and very little time counting- by- calculating which are sophisticated strategies of working with number. Low levels of individual task completion have also been corroborated in a study carried by Hoadley (2006) she observed that of the ten individual work tasks set, none were completed in the lesson "so as to allow for some kind of plenary feedback" (p.27).

Another interesting dimension emerging from lesson C is the time spent by the teacher reading and explaining the story before learners could attempt to answer the questions. This has been observed in both teacher A and teacher C. This finding is in agreement with Hoadley's (2006) findings which showed that in working class children learners worked to the pace of the slowest learner.

Pacing of valid mathematical knowledge in lesson A and C was strongly framed. According to Morais (2002) allows learners to learn by discussing with their peers, and stronger framing of pacing did not allow learners to discuss and construct mathematical knowledge with their peers in smaller groups. When pacing is determined by both teachers and learners (F+/-), possibilities for learners to question, make conjectures, try new methods of understanding numbers, experiment with different number combinations are privileged and come to the fore and hence aid meaningful learning of number.

In lesson C there is evidence of stronger framing of pacing than in lesson A. The present finding seems to be consistent with other research. Hoadley (2003) found that in classes where good teaching did take place learning activities were strongly framed. This was a result of the differentiation of activities to meet learners' needs. In contrast, teacher B paced the classroom teaching at the level of the slowest learner in her class. The teacher waited for one learner who appeared to be having problems to complete the task, e.g. the whole class waited for a learner to complete the number sentence; 10+10+10. A considerable amount of time was spent waiting for one learner. This finding has important implications- differentiating tasks for slow, average and fast learners. It is encouraging to compare this with Rose (2004) in his research into literacy pedagogy who specifies a weakening of the framing of pacing and sequencing rules.

In terms of evaluation of criteria there are some interesting scenarios emerging out of all the three lessons observed. The evaluative criteria for all teachers seems to be ranging from being very detailed in some instances, slightly detailed to instances where the explanations are not detailed nor illustrated. The evaluation criterion for teacher C was strongly framed. The scenario that emerges out of lesson B shows some instances where the evaluative criteria have not been explicated to learners by the teacher. Morais (2002) stresses the importance of explicating the evaluative criteria as the most crucial aspect of a pedagogic practice to promote higher levels of learning.

The evaluation criteria for teacher A was intertwined with strong framing and in some cases an absence of the evaluation criteria completely. These results are consistent with those of other studies (Hoadley, 2006). It is encouraging to compare this finding with that found by Morais (2002) who found "explicating the evaluative criteria as the most crucial aspect of a pedagogic practice to promote higher levels of learning of all students" (p.568).

This study has been unable to demonstrate that the explication of the evaluative rules, and weak framing over pacing, creating the opportunity for students to intervene in the expected rate of their acquisition, are those aspects identified as being most crucial in facilitating access to school learning (Hoadley, 2006).

One of the findings by Reeves, (2006) was that there is a positive relationship between mathematics achievement if the teacher exercises control over an appropriate sequencing, selection and pacing of learning. However, the findings of the current study on selection, sequencing and pacing do not support the previous research by Reeves (2006), in that evaluation of criteria were relatively frequently either absent, or promoting of very basic level counting strategies.

5. 9 Conclusion

This section has brought to the fore the findings from this study. What has emerged centrally is that tasks that leaners were being exposed to especially in lessons A and B were mainly unit counting tasks-which are a concrete strategy. Also the evaluation criteria were more explicated in lesson C than in lessons A and B. The following chapter (Chapter 6) rounds off the report by capturing the main points of the study and explains the limitations, recommendations and areas that require future and further investigation.

Chapter Six: Conclusion

6.1 Introduction

This study, located within Bernstein's sociology of pedagogy applying the construct of framing was concerned with analysing pedagogy across number focused lessons to determine the nature and strength of control over mathematical knowledge by teachers and learners over the discursive rules of selection, sequencing, pacing and evaluation of knowledge number lessons.

Analysing pedagogy using framing relations was chosen since teaching numeracy is problematic for teachers. Despite the substantial amount of research done on this topic, difficulties associated with the nature and strength of control still persists in the teaching of number. The conceptual tools that informed this study were drawn from framing and provided me with understanding knowledge control relations in teaching of numeracy.

6. 2 Implications for the teaching of numeracy at the grade 2 level

It is fair to say that the actual pedagogy of Foundation Phase teachers in this study does not digress radically from that of other teachers in other such schools. The use of concrete strategies is consistent with those highlighted in Hoadley, (2007) and Schollar (2008) referred to in the previous section which has shown that the practice is rampant in many South African primary schools.

However, there are differences with the other teachers in the way in which numeracy knowledge is selected, sequenced, paced and evaluated in spite of the fact that the curriculum has been substantially changed in the development of the Foundations for Learning documents, and now Curriculum Assessment Policy Statement (CAPS). The CAPS document has stronger specification of pacing, selection, sequencing and evaluation of criteria.

What the literature also reveals is that the explication of the evaluation criteria is a key aspect of pedagogic variation, in particular in relation to the transmission and acquisition of the school code in mathematics pedagogies. What emerges from my analysis is the playing out of a scenario in which teachers frequently do not explicate the evaluative criteria for the learners or promote counting focused strategies.

6. 3 Limitations of the study

One of the limitations that I perceive in this study pertains to empirical data from lesson observations. However, with a small sample size, caution must be applied, as the findings might not be transferable to all schools. However, the findings lay a foundation for what could be considered in future research especially when one considers that studies done elsewhere also pointed to teachers focusing more on rote learning of both concepts and procedures and less on procedural and conceptual understanding.

A second limitation in this study was its focus on only Grade 2 classes, which in turn would limit the generalizability of the findings. Another limitation was that the lessons observed were base-line observations made early in the year when teachers were still trying to get used to the new learners. This may have affected teachers' selections of tasks and decisions around sequencing and pacing. The base-line lesson observations were a once off activity which however, could have been complemented with the use of interviews and document analysis for both teachers and learners. Follow-up lesson observations over a prolonged time could have enhanced the generalizability of the study.

Thirdly, the study was conducted in one school at one defined point, resulting in a data set particular to this particular school in Johannesburg, South Africa. However, the issues raised are of national importance in the teaching of numeracy in infant classes.

6. 4 Reflections

The journey through this study was never without second thoughts on how better I would have navigated through it. These thoughts always struck me whenever I felt frustrated, confused, and on the verge of resignation during the gruelling moments of data analysis when I found myself feeling depressed and stressed. Having come to the end of the journey, I wish to keep record of these thoughts to serve as permanent reminders of those moments, as well as to offer encouragement and direction to others who may come across this research while in similar circumstances. If I were to do this research all over again, I would undertake several steps differently; however, I am not going to enumerate them all here, but rather outline some of the most critical ones, in order to provide a reflexive account of the study.

As I reflect back on the process involved in completing this study, I realize how much I have learnt. While this has been a long and challenging road to travel it has been worthwhile. As a developing researcher, I look back and question the framework, tools and orientation I have adopted for this study. They have shaped what I have come to see, and while they explain many aspects that this study aimed to investigate, it must be noted that the framework is still in its developmental stages and not yet stable. Of note is that although Bernstein (2000) provides a language of description of pedagogic discourse through classification and framing, there are difficulties working with the concept of framing empirically. This is because in my study I 'saw' them separately and this posed challenges for me. For example, instances of the classification relation are evident only through the framing relations, the interactional. The interactional and organizational are dialectically linked, and empirical instance of one always imply the other.

Atkinson (1985) has argued that, in practice, 'this latter aspect of boundary seems equally a matter of classification and frame, since it is often related directly to the relative purity and strength of the membrane of curriculum contents' (p. 136).

6. 5 Recommendations

It is not the intention of this study to prescribe particular options for adoption, but rather provide suggestions for possible consideration with due reference to and as informed by the findings of this study. Based on the limited scope of this study, a number of tentative recommendations are made.

The content, skills, and concepts to be acquired need greater specification in the curriculum, and learning outcomes and assessment standards as they are currently used inhibit this specification. Thus, the curriculum needs to specify exactly what teachers need to teach and offer guidance in terms of task selection for both fast and slow learners. The practice of teaching to the slowest learners 'holds' back most learners and result in slow coverage of number tasks both within grades and across grades.

Studies carried out by the ESA Group have shown that specific pedagogic practices are favourable to learning of all students. Morais et al. (2004) argue that a mixed pedagogic practice – practice with strong or weak framing according to specific aspects of the teaching-learning in instructional context in dimensions is more ideal for learning.

Selection of the mathematical tasks should be characterized by strong framing (F^+) that is the teacher should have control over the micro-selection of tasks. If the teacher is also able to tell what should be done to meet that characteristic and to explicate the foundation principles underlying the selection of that characteristic, s/he also demonstrates passive realization for the same characteristics. If, when acting in the classroom the teacher implements a pedagogic practice where this characteristic is present, s/he can also demonstrate active realization for that characteristic.

Morais (2002) articulated values of framing which are optimal for the achievement of learners. These values of framing stress the explication of the evaluative criteria as a key pedagogic practice that promotes higher levels of learning of all students.

My findings suggest that teachers need to be provided with overviews that depict progression within and between grades and phases. Greater content specification as well as assessment specifications would also enhance progression stipulations.

While teachers need to adjust pacing to learners' abilities they should not 'hold' back fast learners by offering them tasks that are not differentiated. Teachers need to offer learners differentiated tasks in order to accommodate every learner if meaningful learning is to take place for all learners in numeracy teaching.

Teachers need to select tasks that are rich in depth and breadth as this allows learners to acquire proficient number learning in the early stages of their schooling. Literature has shown that the teaching of early number is dependent on systematic and deliberate methods that seek to enhance learners' mathematical abilities to work with number later in life.

Explicit evaluation criteria (very strong framing) require that some characteristics of pedagogic practice require student control over pacing (very weak framing), so that there is time to explicate the criteria.

6. 6 Further Research

This research has exposed many more questions for me than answers. Specifically to extend the findings of the present study, it would be instructive to contact this study on a larger longitudinal study cohort again at the end of 2013 (the transition period from foundation phase to intermediate phase) or even further into the participants' careers to determine shifts in framing relations in the teaching of numeracy.

The current study focused on analysing pedagogy. It would be interesting to conduct a study from the view point of Heads of Departments involved in the supervision of foundation phase teachers as well as various phases of the school.

There is room in this conversation to develop a study which could explore analysing pedagogy amongst Heads of Departments and subject advisors in the teaching of mathematics.

It would be interesting to analyse pedagogy across number focused lessons with a focus on the pedagogical content knowledge of the teachers and their beliefs about the teaching of number.

On a more practical level, the development of a more varied pedagogy would provide an opportunity for comparing teachers' teaching approaches and degrees of success of the different methodologies in analysing pedagogy. In tandem with this, a critical reappraisal of the evaluation and pacing of numeracy lessons could provide the basis for a study to explore future teachers' pedagogy in number teaching.

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