

# TEACHERS' MEDIATION OF METACOGNITION DURING MATHEMATICAL PROBLEM SOLVING

by

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*Thesis presented in fulfilment of the requirements*

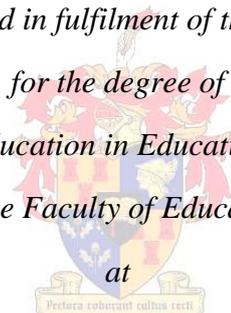
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## **DECLARATION**

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## ABSTRACT

Recent national and international assessments single problem solving out as an important but problematic factor in the current mathematical capacities of South African learners. It is evident that the problem escalates as learners progress to the Intermediate Phase. Research indicates a significant link between metacognition and successful mathematical problem solving. From a Vygotskian sociocultural perspective which formed the theoretical framework of this study, metacognition can be regarded as a higher-order function developing through interaction within social and cultural contexts known as mediation. This qualitative collective case study, informed by an interpretivist paradigm, was designed to explore and compare how Foundation and Intermediate Phase mathematics teachers mediate metacognition during mathematical problem solving. It aimed to offer a deeper understanding of the process of mediation, the complex interplay between cognition and metacognition, and how teachers differentiate the mediation process to accommodate diversity among their learners. To address this, two cases were identified involving a sample of six mathematics teachers each of an urban primary school in the Western Cape Province. The first case was Foundation Phase teachers and the second Intermediate Phase teachers. Semi-structured individual interviews, non-participant classroom observations, and semi-structured focus group interviews were used as methods to gather and triangulate data. Themes that emerged from constantly comparing the data informed the findings. The findings suggest that there are cognitive, non-cognitive and contextual factors which could influence the quality and outcomes of the mediation of metacognition during mathematical problem solving in diverse classrooms. It emphasized the significance of the active role the teacher as a more knowledgeable other plays in the mediation process. Furthermore, it underlined the importance of giving learners challenging mathematical problems requiring metacognition within their zones of proximal development. It was also found that the teacher as mediator should not only have the necessary professional knowledge and strategies, but should also consider the affective factors, perceptions and reactions of learners, during the mediation process.

Keywords: metacognition, mediation, mathematical problem solving, sociocultural theory, differentiated instruction, Foundation Phase teachers, Intermediate Phase teachers

## OPSOMMING

Onlangse nasionale en internasionale assesserings lig probleemoplossing uit as 'n belangrike, maar problematiese faktor in die huidige wiskundige prestasie van Suid-Afrikaanse leerders. Dit is duidelik dat die probleem toeneem dermate leerders na die Intermediêre Fase vorder. Navorsing toon 'n beduidende verband tussen metakognisie en suksesvolle wiskundige probleemoplossing. Vanuit 'n Vygotskiaanse sosiokulturele perspektief, wat die teoretiese raamwerk van hierdie studie gevorm het, word metakognisie as 'n hoër-orde funksie gesien wat ontwikkel deur interaksie binne die sosiale en kulturele konteks bekend as mediasie. Hierdie kwalitatiewe kollektiewe gevallestudie, ingelig deur 'n interpretivistiese paradigma, was ontwerp om te verken en te vergelyk hoe Grondslag- en Intermediêre-Fase onderwysers metakognisie tydens wiskundige probleemoplossing medieer. Dit het ten doel gehad om 'n beter begrip te bied van die proses van mediasie, die komplekse wisselwerking tussen kognisie en metakognisie en hoe onderwysers mediasie differensieer om die diversiteit van hul leerders te akkommodeer. Om dit aan te spreek was twee gevalle geïdentifiseer wat elk uit ses wiskunde-onderwysers van 'n stedelike primêre skool in die Wes-Kaap bestaan het. Een geval was Grondslagfase-deelnemers en die ander Intermediêre-Fase-deelnemers. Semi-gestruktureerde individuele onderhoude, nie-deelnemer klaskamer-waarnemings en semi-gestruktureerde fokusgroep-onderhoude was gebruik as metodes om data in te samel en te trianguleer. Temas wat ontluik het na die konstante vergelyking van data het die bevindinge ingelig. Die bevindinge het getoon dat daar kognitiewe, nie-kognitiewe en kontekstuele faktore is wat die kwaliteit en uitkomst van die mediasie van metakognisie tydens wiskundige probleemoplossing in diverse klaskamers kan beïnvloed. Die bevindinge beklemtoon die noodsaaklikheid van die aktiewe rol wat die onderwyser as die meer kundige ander speel in die mediasieproses. Verder word die belangrikheid benadruk van die daarstelling van uitdagende wiskundige probleme, wat metakognisie vereis, binne leerders se sones van proksimale ontwikkeling. Dit is ook gevind dat die onderwyser as mediator nie net oor die nodige professionele kennis en strategieë moet beskik nie, maar ook die affektiewe faktore, persepsies en reaksies van leerders in ag moet neem tydens die mediasieproses.

Sleutelwoorde: metakognisie, mediasie, wiskundige probleemoplossing, sosiokulturele teorie, gedifferensieerde onderrig, Grondslagfase-onderwysers, Intermediêre Fase-onderwysers

## DEDICATION

This thesis is dedicated to all of my former learners.  
Even though you called me teacher, I was the one who was learning.

Thank you.

*In a completely rational society, the best of us would  
aspire to be teachers and the rest of us would have  
to settle for something less, because passing  
civilization along from one generation to the next  
ought to be the highest honor and highest  
responsibility anyone could have.*

*~ Lee Iacocca*

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- To my sister, Helette who regularly reminded me that there is life after Vygotsky.
- To my parents, for providing a home where critical thinking and values were encouraged and modelled.

*Now glory be to God, who by His mighty power at work within us is able to do far more than we would ever dare to ask or even dream of — infinitely beyond our highest prayers, desires, thoughts, or hopes. ~ Ephesians 3:20-21*

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## LIST OF ABBREVIATIONS

ADHD	Attention Deficit and/or Hyperactivity Disorder
ANA(s)	Annual National Assessment(s)
CAPS	Curriculum and Assessment Policy Statement
DBE	Department of Basic Education
DHET	Department of Higher Education and Training
DoE	Department of Education
FET	Further Education and Training
GET	General Education and Training
HET	Higher Education and Training
MKO	More Knowledgeable Other
NCTM	National Council of Teachers of Mathematics
NQF	National Qualifications Framework
PIRLS	Progress in International Reading Literacy Study
RNCS	Revised National Curriculum Statement
SACMEQ	Southern and East Africa Consortium for Monitoring Educational Quality
SU	Stellenbosch University
TIMSS	Trends in International Mathematics and Science Study
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WCEFA	World Conference on Education for All
ZPD	Zone of Proximal Development

# CHAPTER 1

## ORIENTATION OF THE STUDY

*A teacher of mathematics has a great opportunity. If he challenges the curiosity of his students by setting them problems proportionate to their knowledge, and helps them to solve their problems with stimulating questions, he may give them a taste for, and some means of, independent thinking.*

(Pólya, 1945, p. v)

### 1.1 INTRODUCTION

The above excerpt from Pólya's first edition of *How to Solve It* (1945) emphasizes at least three important aspects of mathematical problem solving that can lead to independent thinking. Firstly, a teacher should consider learners' prior knowledge when challenging them with solving a mathematical problem. Secondly, the teacher should support learners accordingly and, thirdly, should also be a mediator who guides learners into independent thinking. What a great opportunity indeed!

The aim of this qualitative collective case study is to explore and compare how Foundation Phase and Intermediate Phase mathematics teachers mediate metacognition during mathematical problem solving. It sets out to offer a deeper understanding of mediation during problem solving, of the complex interplay between cognition and metacognition, and how teachers differentiate the mediation process to accommodate diversity among their learners. In addition, it aims to add to the limited body of knowledge on the role of the teacher in mathematical problem solving (Ader, 2013; Kennedy, 2009; Lester, 2013).

The study may also be useful in professional development programmes for teachers, empowering them to help diverse learners improve their metacognitive ability during mathematical problem solving. The findings of this inquiry could expand teachers' pedagogical repertoire, helping them create an inclusive classroom in order to work more effectively with disengaged and reluctant learners. Ultimately, it could give

learners the capacity to take control of their own learning, defining their own learning goals and monitoring their progress in achieving them.

This chapter will firstly describe the objectives, background and motivation of this study. Secondly, it will state the research problem and research questions. It will include a description of the research plan, comprising an introductory outline of the theoretical framework, and methods for data collection and analysis. The ethical considerations which underpin the study will be discussed. Lastly, relevant concepts will be clarified, followed by a synopsis of the remaining chapters in the thesis.

## **1.2 MOTIVATION FOR THE STUDY**

The South African schooling system has undergone many changes since the first democratically elected government came to power in South Africa in 1994. One of the first changes to the curriculum came about in 1997, when the new National Department of Education began phasing in the Statement of the National Curriculum for Grades R-9, better known as Curriculum 2005, in the General Education and Training (GET) (Grades R-9) and Further Education and Training (FET) (Grades 10-12) bands (Department of Education [DoE], 2002). Curriculum 2005, an outcomes-based curriculum, received mixed reactions from many different educationalists in South Africa (Christie, 2008).

In 2000, Curriculum 2005 was reviewed, and in 2002 the Revised National Curriculum Statement (RNCS) replaced the Statement of the National Curriculum for Grades R-9 (DoE, 2002). The RNCS was itself reviewed in 2009, resulting in the National Curriculum Statement Grades R-12 (Department of Basic Education [DBE], 2011a). The National Curriculum Statement for Grades R-12 is thus an updated and improved version of Curriculum 2005 and the RNCS.

The current policy statement for teaching and learning in South African schools lays down clearer specifications on the content to be covered each term in each grade and subject (DBE, 2011a). The National Curriculum Statement Grades R-12 comprises (a) Curriculum and Assessment Policy Statements (CAPS) for all approved subjects, (b) National policy on the programme and promotion requirements of the National Curriculum Statement Grades R-12, and (c) National Protocol for Assessment Grades R-12 (DBE, 2011a). The National Curriculum Statement Grades R-12 was gradually implemented per phase between 2012 and 2014 (DBE, 2013). Some of the aims of the

National Curriculum Statement Grades R-12 (DBE, 2011a, p. 5) are to develop learners that are:

- Able to identify and solve problems and make decisions using critical and creative thinking.
- Work effectively as individuals and with others as members of a team.
- Organise and manage themselves and their activities responsibly and effectively.
- Collect, analyse, organise and critically evaluate information.
- Demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation.

Mathematical problem solving in the micro-community of the classroom can offer an ideal context in which to work towards these goals. Most of the goals proposed above relate to higher-order thinking. To achieve them, learners will need to engage in metacognitive behaviour. Martinez (2006) describes metacognition as our ability to control and monitor our thoughts. From a sociocultural perspective, however, it could be claimed that learners do not spontaneously develop higher-order thinking skills (Vygotsky, 1978). The role of the teacher is thus of central importance in mediating these processes and creating opportunities where all learners have an equal opportunity to reach the goals of the National Curriculum Statement Grades R-12 (DBE, 2011a). This inquiry will explore how the mathematics teachers involved in the study mediate metacognition in order to develop learners who would ultimately meet the requirements stipulated by the DBE (2011a, p. 5).

The decision to focus my explorative lens on mathematics was motivated by the current predicament facing mathematics education in South Africa. The 2011 Trends in International Mathematics and Science Study (TIMSS) compared international results in mathematics. It confirmed once again that the performance of South African mathematics learners is considerably poorer than that of almost all the other participating countries (Mullis, Martin, Foy & Arora, 2012). The DBE's (2013) Annual National Assessment (ANA) indicated a drastic discrepancy between the number of learners in Grade 3 who achieved fifty percent or more for mathematics and the number of those who did so in Grade 6. While 59% of learners in Grade 3 achieved fifty

percent or more, only 27% of Grade 6 learners were able to achieve comparable results. The DBE (2013) recognized this phenomenon as an area of concern, noting that:

The performance in mathematics is observed to be at an average performance mark of 50% and above in Grades 1, 2 and 3. However, the decline in performance commences at the Grade 4 level and therefore a more detailed intervention that targets the teaching and learning of mathematics at the intermediate and senior phases is warranted. (p. 4)

In 2007, only 43% of learners in Grade 3 reached a basic level of competency in numeracy. The question was then asked: Why do learners in the Foundation Phase perform so poorly in South Africa (DBE, 2011c)? One of the findings, as recorded in *Action Plan to 2014: Towards the Realisation of Schooling 2025* (DBE, 2011c), was that “learners were generally given too few opportunities to solve problems” (p. 59). While it was encouraging that Grade 3 learners met the 2013 target of 58%, set for mathematics performance in the Action Plan to 2014 (DBE, 2011c), the target of 55% set for Grade 6 learners was unfortunately not reached.

Still more perturbing is South African learners’ mathematical performance compared to that of other countries in Africa. The report of the Third Southern and East Africa Consortium for Monitoring Educational Quality (SACMEQ III) showed that even South Africa’s top performing Grade 6 learners could not match the level of competence in mathematics of their peers in other African countries (Moloi & Chetty, 2010). The number of Grade 6 learners applying higher-order thinking skills to solve concrete or abstract problems was significantly lower than the number of Grade 6 learners who had basic numeracy skills. It is clear that the South African school system does not adequately equip learners to be competitive in an ever-changing, globalized world. The DBE highlight this argument in their *Action Plan to 2014: Towards the Realisation of Schooling 2025* (DBE, 2011c) when they state that:

Our children and the youth need to be better prepared by their schools to read, write, think critically and solve numerical problems. These skills constitute the foundation on which further studies, job satisfaction, productivity and meaningful citizenship are based. (p. 25)

It is not surprising therefore that one of the policy suggestions in the SACMEQ III report (Moloi & Chetty, 2010) is that teachers need to expose learners to more

extensive applications and high-order questions involving both concrete and abstract problem solving skills.

The results from the school in this study showed evidence of a better performance than in most other South African schools. I felt that exploring how teachers in this school mediated metacognition during mathematical problem solving could offer valuable insights, and that these could contribute to improving results for a much wider spectrum of schools. Despite this school's better performance, however, there was evidence of a discrepancy between the mathematics results in the Foundation Phase and Intermediate Phase, which this study will explore further.

### **1.3 PROBLEM STATEMENT**

Both from the arguments and the recent international and national assessments mentioned in section 1.2, it is clear that problem solving is an important, but also a problematic factor in the current state of mathematics education in South Africa (DBE, 2013; Moloi & Chetty, 2010; Mullis et al., 2012). From the recent Annual National Assessments it is also evident that the problem escalates as learners progress to the Intermediate Phase of their schooling (DBE, 2013).

As a learning support teacher, working with both Foundation and Intermediate Phase learners who experience difficulties in mathematics, I noticed that these learners frequently have trouble structuring their thoughts or are unable to explain their thought-processes during mathematical problem solving. While most can solve a simple algorithm (such as  $12+15-8$ ) on their own, they find it much harder when it is embedded in a mathematical problem. A possible explanation could be that problem solving involves different skills, one of which is metacognition.

This concern was already expressed some decades ago by the founding father of metacognition research, John Flavell (1976). He asked, "Is there anything that could be taught that would improve [learners'] ability to assemble effective problem solving procedures?" (p. 233). Metacognition has since been recognized by many researchers as a significant element in the problem solving process (Desoete, 2007; Efklides & Vlachopoulos, 2012; Jacobse & Harskamp, 2012; Mevarech, Terkieltaub, Vinberger & Nevet, 2010; Özsoy, 2011; Schoenfeld, 1985). Anderson and Krathwohl (2001), however, argue that, because of its abstract nature, metacognition is more difficult to teach or assess than factual, conceptual or procedural categories of knowledge.

Nonetheless, metacognition can be made more accessible with appropriate teaching, especially for learners who experience specific barriers to learning (Lai, 2011). A classroom environment which allows them opportunities to articulate their thinking and where they can view modelled thinking can provoke and support metacognitive behaviours. This can have positive long-term effects on their performance in problem solving.

However, despite the recognition of the role of metacognition in successful mathematical problem solving, only limited research has been done to explore teachers' mediation of metacognition and ways in which they could differentiate the mediation process, empowering all learners to become more metacognitive when solving problems. Furthermore, it is strange that, even though the significant decline in performance from the beginning of the Foundation Phase to the end of the Intermediate Phase is a great concern for schools and the DBE (2013), no studies could be found that address this matter.

#### **1.4 RESEARCH QUESTIONS**

The goal of this study is to gain insights into the issues discussed in section 1.3. In order to do so, the following research questions will be addressed:

1. How do Foundation and Intermediate Phase teachers mediate metacognition during mathematical problem solving?
2. How do Foundation and Intermediate Phase teachers differentiate the mediation process during mathematical problem solving in such a way as to support all the learners, given their diverse abilities and needs?
3. How do teachers in the Foundation and Intermediate Phases differ in the way they mediate metacognition during mathematical problem solving?

#### **1.5 RESEARCH PLAN**

A research plan guides the investigator from the research questions to the conclusions at the end of the study (Rowley, 2002). It ensures that there is a clear understanding of how the research process unfolds. Figure 1.1 on the next page provides a visual synopsis of the research plan for this inquiry.

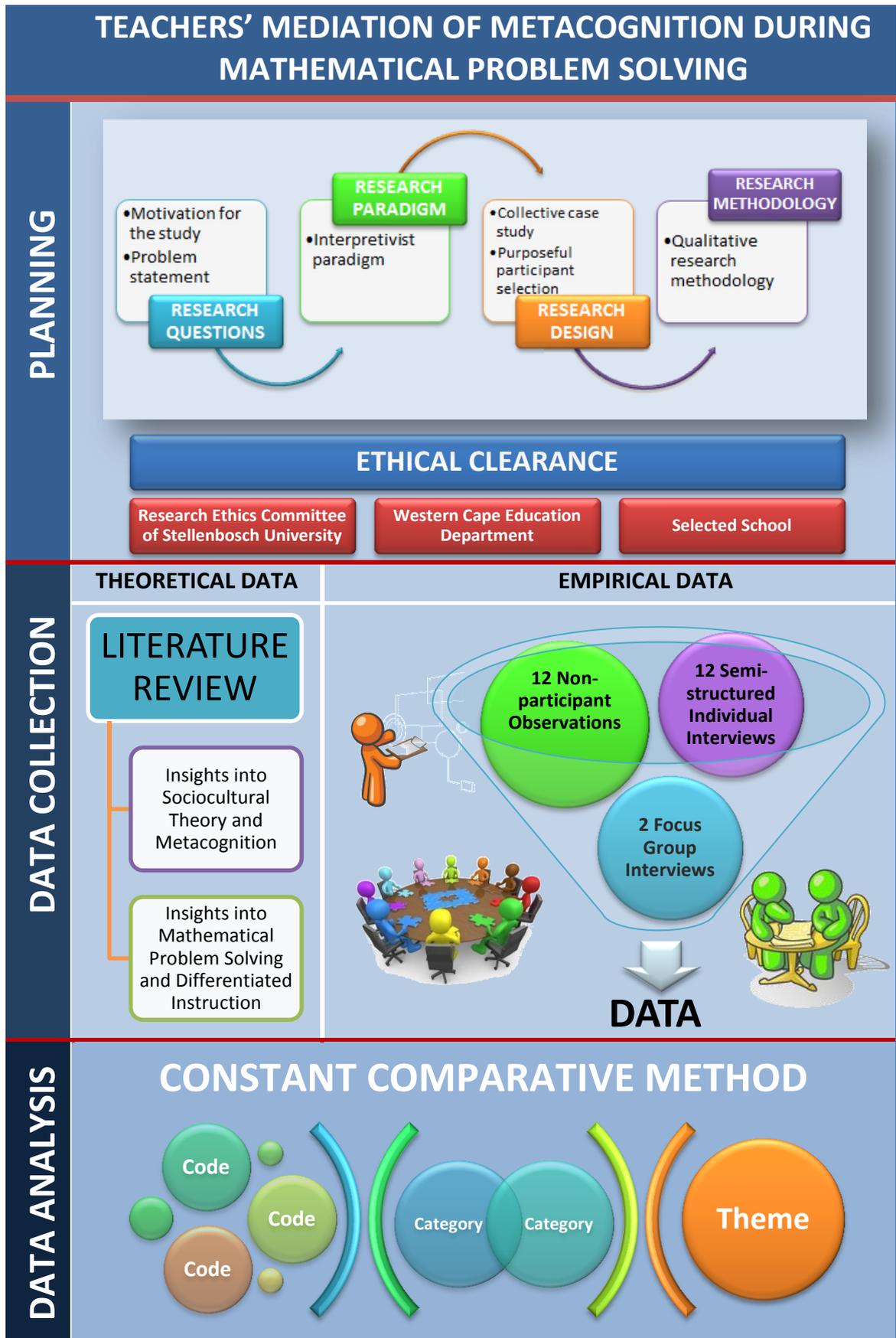


Figure 1.1. The research plan

The research plan, among other aims, involves defining the research paradigm, selecting the appropriate research design and methodology, as well as choosing methods to gather and analyse the data; it also includes the ethical considerations which contribute to the validity of the study. An abbreviated version of the theoretical framework will be presented in the next section. This will be followed by a brief description of the components of the research plan.

### **1.5.1 Theoretical framework**

The theoretical framework that forms the foundation of this study is based on Lev Vygotsky's sociocultural theory. A detailed account of this theory and its constructs which are relevant to this inquiry can be found in sections 2.2 and 2.3. According to Vygotsky (1978), knowledge is socially constructed. A sociocultural, mediational approach treats learning as a social process. This resonates with the familiar South African philosophy of *Ubuntu* that expresses the central notion of social interconnectedness. The philosophy of Ubuntu is significant for education in South Africa, as it reflects the reciprocal relationship between parents, peers, teachers and the larger community in the cognitive socialization of the child and his or her subsequent social construction of knowledge (Human-Vogel & Bouwer, 2005). There is a general acceptance that Ubuntu is characterized by cooperation, group work or *shosholozza*, rather than the individual competitiveness that is familiar to most people in the western world. These features of Ubuntu can promote a classroom climate and culture in which metacognition can be mediated through mathematical problem solving.

This is in line with Vygotsky's (1986) statement that any higher mental function necessarily goes through an external social stage in its development, before becoming an internal, truly mental function. For the purpose of this study, the focus will be on mathematical problem solving, as it offers an ideal context in which to explore how teachers mediate metacognition. Clarification on what mathematical problem solving is and how it is positioned within the South African school curriculum, as well as its relation to metacognition, can be found in section 3.2.

A further important and relevant aspect which needs to be explored in conjunction with the mediation process is the way in which teachers differentiate the mediation process to meet the needs of the diverse learners in their classrooms. In July 2001, the Ministry of Education published *Education White Paper 6 on Special Needs*

*Education: Building an Inclusive Education and Training System* (DoE, 2001). It brought about many changes, such as including learners with barriers to learning in ordinary schools. This has far-reaching consequences, since in order to adhere to the expectations set out in Education White Paper 6 (DoE, 2001) teachers now have to adapt their teaching strategies and manage their classrooms to accommodate the full range of learning abilities and needs.

George (2005) points out that this reworking of strategies in the classroom should ensure that the learners' different interests and needs are addressed, to ensure that *all* learners experience challenge, accomplishment and gratification. An effectively differentiated classroom should offer regular opportunities to all learners at diverse levels of development to extend their knowledge, thoughts and skills. Lawrence-Brown (2004) emphasizes the importance of balancing the challenge of teaching with the opportunity to achieve success when differentiating teaching in the classroom. Sections 3.3 and 3.4 give a comprehensive overview of the philosophy of differentiated instruction as a possible solution to addressing the growing diversity in our classrooms.

It is generally assumed that, from the moment learners start school, their success in mathematics will depend heavily on the quality of the teaching they receive. The teacher's role, which is central in the analysis of this research, is to create a learning environment which offers abundant opportunities for active participation. This involves imparting appropriate information and teaching explicit knowledge, skills and strategies, including metacognition, which will be beneficial to the diverse needs of learners in the classroom.

### **1.5.2 The research paradigm**

The paradigm, or worldview, guides the researcher's philosophical assumptions about the research question and the selection of tools, instruments, participants and methods used in the study (Ponterotto, 2005). Paradigms are central to research design, since they impact on both the nature of the research question and on the way in which the question is to be studied. In designing a study, coherence can be preserved by ensuring that the research question and methods used fit logically within the paradigm (Durrheim, 2006).

This study will be guided by an interpretivist paradigm. For the interpretive researcher, causes and effects are mutually interdependent; any event or action can be

explained in terms of multiple interacting factors, events and processes (Henning, Van Rensburg & Smit, 2004). According to Mack (2010), the interpretivist holds that research can never be objectively perceived from the outside: rather it must be perceived from inside through the direct experience of the people involved. The clear causal links that can be found in laboratory research cannot be made in the world of the classroom, where teachers and learners construct meaning together (Mack, 2010). The role of the researcher in the interpretivist paradigm is to “understand, explain, and demystify social reality through the eyes of different participants” (Cohen, Manion & Morrison, 2007, p. 19). The aim in this paradigm is thus to understand, rather than to explain.

The interpretivist paradigm which will inform this study assumes a relativist ontology (there are multiple realities), a subjectivist epistemology (researcher and participant create understandings together), a naturalistic (in the natural world) set of methodological procedures which are interactive and qualitative, and a formative axiology (values are inseparable from the inquiry and outcomes) (Denzin & Lincoln, 2011). A comprehensive description of the research paradigm and its underlying philosophical assumptions can be found in section 4.2.

### **1.5.3 The research design**

“The research design is the logic that links the data to be collected and the conclusions to be drawn to the initial questions of a study; it ensures coherence” (Rowley, 2002, p. 16). For this research, I will adopt a qualitative case study approach. Baxter and Jack (2008) contend that this approach enables one to answer “how” type questions, as asked in this study. A case study is used to understand real-life phenomena in depth, taking into account the significant contextual circumstances of the phenomena and providing the researcher with an insider view of the holistic and meaningful characteristics of real-life events (Yin, 2009).

Stake (2005) identifies three types of case study: intrinsic, instrumental and collective. A case study can be classified as instrumental when the focus of the research is to gain insight or understanding into a particular phenomenon, in this instance *mediation of metacognition during mathematical problem solving*. In the light of Stake’s (2005) configuration, this investigation can be described as a collective case study, that is, an instrumental case which involves more than one case.

Merriam (2009) describes a case study as a bounded system. In this research, Foundation Phase mathematics teachers are treated as being one bounded system, while the second bounded system are applied to Intermediate Phase mathematics teachers. Participants will be purposefully, rather than randomly, selected in order to ensure that the information collected is directly relevant to the problem addressed. See section 4.3.2 for a detailed description of the selection process. For Stake (2005) the case is regarded as subordinate to the phenomenon under investigation; nevertheless, it is still “looked at in depth, its contexts scrutinized, its ordinary activities detailed” (p. 445). During analysis of the data, the *thick*, detailed description of the cases will guide me in making meaning of what is of primary interest. A more comprehensive account of the research design of this inquiry is presented in section 4.3.

#### **1.5.4 Methodology**

This study employs a qualitative methodology. This depends on personal interaction over time between the researcher and the participants, leading to deeper insights, adding richness and depth to the data (Tuli, 2011). Qualitative methodologies are inductive in nature, as they are in favour of discovery and process, are less interested in generalizability, and are more interested in a deeper understanding of the research problem in its unique context (Ulin, Robinson & Tolley, 2004). The specific need for qualitative classroom research in South Africa, in order to improve our understanding of what really happens in schools, is strongly urged by Henning (2012) when she states:

In the absence of classroom research, much of what we say about the three consecutive curriculum policy changes (in just over a decade) is based on assumptions we have about classrooms, upon educational ‘legends’, and on the newly introduced national assessments (ANAs) and international tests, such as the TIMSS and the PIRLS. But what these tests do not give us is a picture of classrooms. They give us only conclusions about what may not be happening in classrooms. That is not enough to direct a country’s education practice. It is not enough to serve the social justice mandate of a new democracy. (p. 185)

In the light of the above statement, the relevance of following a qualitative methodology is that it will take the researcher (and the readers of this study) into

classrooms to explore the phenomena under study. See section 4.4 for a broader description of the research methodology as it is understood in this inquiry.

### **1.5.5 Methods for generating data**

According to Willis (2007), the interpretivist prefers qualitative methods, such as interviews, observation and focus groups. These methods claim to offer better ways of coming to understand how people interpret the world around them and are therefore considered suitable for this study. Qualitative methods of data generation have the capacity to provide rich, detailed or thick data, since the qualitative researcher's goal is to obtain an insider's view (Tuli, 2011).

The gathering of data begins with a comprehensive review of the literature related to the phenomena to be explored. Empirical data will be collected from both Foundation and Intermediate Phase mathematics teachers at the same urban, public primary school in the Western Cape Province. I have a professional connection with this school, where I am a private learning support teacher. I selected this site not only because recruiting participants from among the teaching staff would be convenient but also because the school's mathematics results in the ANA's showed evidence of a better performance than is the case in most other South African schools. This could offer valuable insights in answering the research questions.

Empirical data will be collected through semi-structured individual interviews, observations and focus group interviews. All the interviews and observations will be audio-recorded with the participants' consent. Semi-structured interviews allow participants to express their ideas and views freely within the broad dimension of the topic. According to Robson, Shannon, Goldenhar and Hale (2001), this approach represents a compromise between the standardization of structured interviews and the flexibility of unstructured interviews. I will use an interview schedule (see Appendix A), consisting of open-ended questions, as a guideline to ensure that all the important and relevant data are collected.

The next step in the data gathering process will involve non-participant observations. These will take place in each participant's classroom during a lesson in which the focus is on solving mathematical problems. This method of data collection brings the researcher into the real-life context, observing actions taking place in real time (Henning et al., 2004). I will use an observation schedule (see Appendix B) listing

specific indicators identified from the literature and interviews and guided by the research questions of the study.

The last step of the data gathering process will include two focus group discussions, using semi-structured open-ended questions. One group discussion will involve the Foundation Phase participants, while the other will include the Intermediate Phase participants. I will use a focus group interview schedule that will ensure all topics are covered before ending the interview (see Appendix C). Robson et al. (2001) maintain that the social nature of focus group interviews makes them a highly efficient method of collecting data, since the views of several people can be obtained simultaneously. Furthermore, the focus group offers a measure of validation for the information, creating a space in which data gathered from the interviews and observations can be developed and elucidated. This type of validation is generally referred to as triangulation (see section 4.6.5). A description of the methods selected to generate the data for this study can be found in section 4.5.

### **1.5.6 Data analysis**

Bogdan and Biklen (2007) describe data analysis as a process of sifting and organizing all the information gained from transcripts and other material to make meaning of the data and present what has been discovered. The process includes reducing the data to manageable units and coding the information (Kolb, 2012).

An inductive approach will be used in this inquiry. This means that the themes and categories according to which the data will be organized and coded will not be developed before collecting the data (McMillan & Schumacher, 2006). Glaser (1969, as cited in Flick, 2006) advocates constant comparison as a method for interpreting qualitative data. This method will be used to analyse the data collected in this inquiry. Schwandt (2007) explains that the data analyst works with the authentic language of the participants to generate codes and categories. After the material has been coded and classified, it is constantly integrated into the further process of comparison. The analysed data will be presented according to the themes which emerge from constantly comparing, reducing and refining the data. In section 4.7, a deeper explanation is given of this method and the way in which data will be analysed and interpreted.

### **1.5.7 Ethical considerations**

At any time people are involved as research participants, their well-being should be the top priority. The research question is always of lesser importance (Mack, Woodsong, MacQueen, Guest & Namey, 2005). Ethical considerations relate to principles of ethical clearance, informed consent, confidentiality and the dissemination of data. All the participants need to give informed consent prior to taking part. Each participant will be assured of the confidentiality of the interviews and observations. Pseudonyms will be used instead of their real names to ensure confidentiality. Before any data obtained from the participants are used in the study, it will be disseminated to them for their approval. The name of the school will not be revealed. The study will only commence once ethical clearance has been issued by the Research Ethics Committee of Stellenbosch University (see Appendix D) and permission has been granted by both the Western Cape Education Department (see Appendix E) and the school (see Appendix F) where the research will take place. A more comprehensive discussion of the ethical considerations is included in section 4.8.

## **1.6 CLARIFICATION OF CONCEPTS**

### **1.6.1 South African education system**

South Africa's National Qualifications Framework (NQF) recognizes three bands of education: General Education and Training (GET), Further Education and Training (FET), and Higher Education and Training (HET). School life spans 13 years or grades, from Grade R, through to Grade 12. GET includes Grade R to Grade 9 and is divided into three phases, Foundation Phase, Intermediate Phase and Senior Phase. GET is compulsory for all learners in South Africa. FET includes Grade 10-12 and is non-compulsory.

### **1.6.2 Foundation Phase**

The Foundation Phase is the first phase of the GET band and includes Grades R, 1, 2 and 3 (DoE, 2002). In this study, the focus will only be on Grades 1 to 3 of the Foundation Phase.

### 1.6.3 Intermediate Phase

The Intermediate Phase is the second phase of the GET band and includes Grades 4, 5 and 6 (DoE, 2002).

### 1.6.4 Teacher as mediator

In the context of this study, the role of the teacher as mediator follows Vygotsky's (1978) well-known observation that the formation of all higher mental functions involves a child and a *more knowledgeable other* (MKO). The teacher is considered as the MKO who provides the learners with the psychological tools (see section 2.3.1.1) which enable them to solve certain problems. The mediator not only assists learners to solve problems but also identifies the minimum level of support they will need to successfully complete a task and thereafter to function independently (Lantolf & Poehner, 2013). Therefore, the mediator intercedes to support learners to bridge the gap between what they are unable to do independently at that time and what they can do with assistance (Grosser & De Waal, 2008). In the *Policy on the Minimum Requirements for Teacher Education* (Department of Higher Education and Training [DHET], 2011), mediation is identified as one of the seven collective roles of teachers in South African schools. See section 2.3.1.3 for detailed discussion on the role of the teacher as mediator.

### 1.6.5 Metacognition

A review of the literature reveals a lack of consensus among researchers on the concept of metacognition (Veenman, Van Hout-Wolters & Afflerbach, 2006). It is generally agreed that it refers to metacognitive knowledge and the regulation of cognitive skills. Metacognitive knowledge usually involves declarative, procedural and conditional knowledge. The regulation component refers to the planning, monitoring and evaluation of one's cognition needed to achieve personal goals (Kramarski, 2009). The concept of metacognition is explained in more detail in section 2.4.

### 1.6.6 Mathematical problem solving

Schoenfeld (1992) holds that what distinguishes a *mathematical problem* from a *mathematical exercise* is that a problem is perplexing, non-routine and without a standard algorithmic solution that a learner could instantly employ. Therefore, some of

the so-called problems on a mathematics worksheet which only require the learner to implement the same process repeatedly would not be considered as mathematical problem solving. Because of its repetitive nature, it would rather be seen as a mathematical exercise. This is often referred to as *routine mathematical problem solving*. However, when solving a novel or *non-routine problem*, a learner could experience *cognitive disequilibrium* at the outset (Graesser, Lu, Olde, Cooper-Pye & Whitten, 2005). A mathematical problem creates an obvious space between the learner's immediate knowledge to instantly solve the problem and the process he or she actually needs to undertake to solve the problem.

### 1.6.7 Differentiated instruction

Differentiated instruction is a philosophy that enables *all* learners to learn in a way that each of them will best understand. It offers teachers the flexibility to differentiate the content, process or product in response to a learner's ability, interest or learning style (Tomlinson, Brighton, Hertberg, Callahan, Moon, Brimijoin & Reynolds, 2003). Section 3.4 gives a detailed description of differentiated instruction.

It should be noted that I regard *teaching*, *instruction* and *training* as three distinct concepts, even though they are often used interchangeably in the research literature. Instruction implies the provision of *instructions* that need to be followed to complete something successfully (Schwab, 2013). The instructor is thus regarded as the dispenser of knowledge and skills through instructions. Similarly training includes the passing of skills from an experienced trainer to an inexperienced trainee implying drilling and repetitive activities (Inglis & Aers, 2008). Instruction and training can therefore be associated with a more teacher-centred approach and even though both can be considered as facets of teaching, the latter involves much more (Inglis & Aers, 2008; Schwab, 2013). Teaching is what a teacher does. It includes the teaching of academic work, but also considers the emotional and sociocultural aspects of the learner's development (Inglis & Aers, 2008; Schwab, 2013). It is thus a more learner-centred approach.

Throughout this thesis the words *mediation*, *teaching* and *learning* are preferred and used over the words *instruction* and *training* except where empirical research studies that are reviewed in this thesis specifically use the words instruction or training.

The term *differentiated instruction* is thus used as it follows the convention of most research done in this field.

## **1.7 CHAPTER DIVISION FOR REMAINDER OF THESIS**

*Chapter 2* provides the first part of the literature review. It presents a comprehensive review of the literature on sociocultural theory and its constructs which form the theoretical framework for this study. This is followed by a discussion of the concept of metacognition, as well as a review of other empirical studies related to the topic of this thesis.

*Chapter 3* is the second part of the literature review. It is structured around the notions of mathematical problem solving and differentiated instruction. The literature as well as research studies related to these notions will be reviewed to provide a better insight into these concepts.

*Chapter 4* will describe the research methodology, including the methods of data collection, data analysis, and strategies used to increase the validity of the study, as well as the relevant ethical issues.

*Chapter 5* will present and highlight the results of the analysis. Each case will be described in detail, along with the themes that emerged from the data. Themes will be presented and supported by direct quotes, using the participants' own words, to enhance the validity of the study and to provide thick and rich descriptions representing the participants' perspectives.

*Chapter 6* will report on the significant findings of the study as they relate to each research question. This will be followed by the recommendations and implications for practice and future research, as well as the strengths and limitations of the study and a conclusion. Finally, a list of references used in this thesis will be provided as well as an appendix section that will include copies of relevant documents used during the study.

## **1.8 SUMMARY**

In this chapter, I have provided an introduction and a background orientation to the study. This included aspects such as the motivation for the study, the problem statement, and the research questions I aim to address. This was followed by a

description of the research plan that includes the theoretical framework, paradigm, design and methodology that will underpin the study. Thereafter an indication was given of the methods that will be used to generate and analyse the data. A brief description of the ethical considerations was outlined and some major concepts relating to this inquiry were clarified, followed by a synopsis of how the remainder of the thesis will unfold.

In the next chapter, I will present a comprehensive review of the relevant literature on sociocultural theory and its constructs as well as on metacognition, to establish a solid, theoretically accountable framework for the study.

# CHAPTER 2

## LITERATURE REVIEW: INSIGHTS INTO SOCIOCULTURAL THEORY AND METACOGNITION

### 2.1 INTRODUCTION

One of the responsibilities of an educational researcher is to be well acquainted with the literature in one's field of study (Boote & Beile, 2005). Hart (1999) remarks that "the review is therefore a part of your academic development – of becoming an expert in the field" (p. 1). Bell (2005) further asserts that the literature review is intended not only to inform the researcher but also to inform the reader of the knowledge relating to the study. Boote and Beile (2005) emphasize that a prerequisite for performing high-quality, in-depth research is a high-quality, in-depth literature review, especially in educational research, where problems are more intricate and messy than in most other disciplines.

Henning et al. (2004) identify three reasons for undertaking a literature review in a thesis: (1) to contextualize the study, (2) to synthesize and critically review the literature on the research topic, and (3) to relate the findings of the study to the existing literature. Thus the literature review supports our understanding of the meaning of the data gathered from the research study.

The literature for this study is reviewed in this chapter and in Chapter 3. This chapter includes a detailed discussion of Lev Vygotsky's sociocultural theory, which provides the theoretical framework. Attention is given to the basic tenets of sociocultural theory, as well as various constructs associated with it, including *mediation*, *internalization* and the *zone of proximal development* (ZPD). This is followed by a discussion of the concept of *metacognition* and how it can be mediated by teachers in the classroom, which is significant in pursuing the research questions as indicated in section 1.4.

## 2.2 SOCIOCULTURAL THEORY

In recent years, sociocultural theory has emerged as one of the major influences on classroom research in the fields of teaching, learning and cognitive development (Cross, 2010; Eun, 2010; Lantolf & Thorne, 2007; Lerman, 2001; Mercer & Howe, 2012; Rezaee, 2011; Reveles, Kelly & Durán, 2007; Steele, 2001; Turuk, 2008; Wang, Bruce & Hughes, 2011; Yetkin Özdemir, 2011). Sociocultural theorists believe that young children learn mainly through interactions with other people in their immediate social world. What children learn is influenced by the beliefs and customs of the specific social and cultural contexts in which they are positioned (Vygotsky, 1978). Sociocultural theorists recognize the importance of human neurobiology in the development of higher-order thinking, but maintain that the most significant forms of cognitive activity develop through interaction within social and cultural contexts (Lantolf & Thorne, 2007).

Sociocultural theory promotes pedagogical methods which honour human diversity (Mahn & John-Steiner, 2013). This provided the motivation for selecting sociocultural theory as framework for investigating how teachers in increasingly diverse classrooms mediate metacognition during mathematical problem solving to meet the varied needs of all learners. Smagorinsky (2009) observes that learners who learn and develop differently are still exposed to adversity in society. This can create *secondary* handicaps (Vygotsky, 1993), which may even be more detrimental than the primary difference itself. However, when perceptions can be changed to encourage alternative methods of thinking about and acting towards diversity (such as inclusive education), a more supportive and respectful context can be created, one in which all learners can flourish (Smagorinsky, 2009). Smagorinsky (2009) regards Vygotsky as one of the pioneers of inclusive education. However, he also claims that Vygotsky's contributions to an understanding of inclusive education are mostly overlooked and therefore illustrate "the achievement and the depths of reading that await anyone who wishes to claim an informed perspective on his [Vygotsky's] research" (Smagorinsky, 2009, p. 91).

### 2.2.1 Historical background of sociocultural theory

Sociocultural theory is mainly rooted in the works of Lev Semyonovich Vygotsky (Lantolf & Thorne, 2007). A Russian Jew, Vygotsky was born in 1896 in

Orsha, Belarus and raised in Gomel. In 1913 he was selected in a lottery as one of a small percentage of Jews to enrol at Moscow University where he studied law and graduated in 1917; the year of the October Revolution. While at Moscow University he also joined a free university from which he graduated in 1917 with majors in philosophy and history (McGlenn-Nelson, 2005).

After Vygotsky graduated he went back to Gomel. There he taught at a teachers' college and worked with children with physical and mental disabilities. It was during this time that he began to show a keen interest in psychology, as he sought to find new ways in which one could support and understand these children's development (Mahn & John-Steiner, 2013).

In 1924, when the Soviet Union was established, Vygotsky moved to Moscow. He was invited by the director of the Moscow Institute of Psychology to join the institute and started to work on psychological research. In an era when psychologists tried to develop a simple account of human behaviour, Vygotsky studied a variety of issues. These included the psychology of art, language and thought, as well as learning and development, leading ultimately to the creation of a rich, complex theory (John-Steiner & Mahn, 1996). He wrote about 200 works during his time in Moscow; unfortunately, a number of these are now lost (Ivic, 1994). Vygotsky died of tuberculosis in Moscow in 1934, at the early age of 37, putting an untimely end to his remarkable research in psychology. Yasnitsky (2011) describes him as one of the most popular, respected and admired pioneers of psychology. In 1936, two years after Vygotsky's death, the political climate in Russia became increasingly oppressive under the Stalinist regime, resulting in a ban on Vygotsky's work which only became accessible again after about twenty years (Kozulin, 2011; Mahn & John-Steiner, 2013).

Today, the English translation of Vygotsky's published work of several thousand pages is collected in six volumes and several books which challenge the reader with some complex thinking and often difficult reading (Smagorinsky, 2007). Smagorinsky (2013) acknowledges that it can be a challenge for teachers to interpret and apply Vygotsky's work in their classrooms. This is exacerbated by the fact that some of Vygotsky's original Russian words and ideas have been lost or distorted in translation. Van der Veer and Yasnitsky (2011) acknowledge that many errors can be made in translating the work of a historical author, emphasizing the additional

ideological and political reasons which could negatively have influenced the translation of Vygotsky's work.

### **2.2.2 Influences on Vygotsky's sociocultural theory**

Vygotsky's work is guided by the Marxian tradition, influenced primarily by the views of Karl Marx and Friedrich Engels (Lerman, 2001; Veresov, 2005; Wertsch, 2008). They understood phenomena as continuously changing and saw human behaviour as influenced by the social and cultural environment which the individual internalizes (McInerney, Walker & Liem, 2011). Veresov (2005) asserts that Vygotsky was influenced not only by Marxism, but was also a "child of the Silver Age of Russian culture and philosophy" (p. 31), and that one cannot underestimate this influence on his work. Kozulin (1986) mentions the strong influence of the French psychological school of Pierre Janet on Vygotsky's work, especially the role of *others* in the creation of individual consciousness. Gredler and Shields (2008) identify Benedict Spinoza and G.W.F. Hegel as two of the philosophers whose work Vygotsky read as an adolescent and who influenced his beliefs about cognition and cognitive change. His work was also inspired by several of his contemporaries and predecessors, but given the political and ideological situation during the Soviet years, he had to refrain from identifying some of those influences in his work (Veresov, 2005).

Even though Vygotsky was critical of some of the dogmatic assumptions of Marxist doctrine, he found the notion of social justice inspiring (Thorne, 2005). He pursued the development of a psychology that could influence the large scale intervention of public education, enabling a society that would be cognitively and socially enlightened. Wertsch, a sociocultural theorist who made a significant contribution in translating Vygotsky's work into English (Mahn & John-Steiner, 2013), identifies three Marxist principles which Vygotsky incorporates into his research on development and which frame his sociocultural theory (Thorne, 2005). Firstly, Vygotsky applies Marx's holistic view of the unit of analysis in his genetic method. Secondly, he endorses Marx's formulation of the social origin of human consciousness, and, thirdly, and probably the most significant influence on Vygotsky's work, was Engels's concept of tool and sign mediation by which humans change nature and in the process transform themselves (Thorne, 2005; Vygotsky, 1978; Wertsch, 2007).

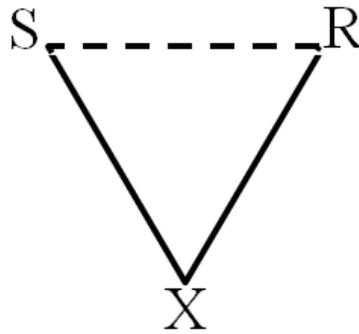
## **2.3 THEORETICAL PRINCIPLES AND CONSTRUCTS OF SOCIOCULTURAL THEORY**

Kozulin (2004) is puzzled by the continuing popularity of Vygotsky's ideas in recent years, especially bearing in mind that they were developed shortly after the Russian Revolution. This mystery might be explained by the fact that we are only now prepared to ask questions to which Vygotsky's theory can provide answers (Kozulin, 2004). Levykh (2008) concurs with Kozulin's (2004) explanation, arguing that, even in translation, Vygotsky's work addresses the most vital concerns of the current educational discourse. From the perspective of 21st-century schooling, Smagorinsky (2009) finds Vygotsky's work, specifically his notion of secondary handicaps (see section 2.2) still remarkably fresh and relevant.

In this section, the major theoretical principles and constructs associated with sociocultural theory will be clarified. The central construct of the theory, mediation, will be described, followed by a discussion of the concepts of internalization and the zone of proximal development and their relation to classroom education.

### **2.3.1 Mediation**

Within a sociocultural framework, mediation can be understood as the way in which people regulate and alter their own and other's social and cognitive behaviour through culturally derived concepts, artefacts and activities (Lantolf & Thorne, 2007). Vygotsky (1978) distinguishes between elementary and higher mental functions. Our elementary mental functions are genetically inherited, and therefore reside in biology. They include reflexes such as involuntary attention, mechanical memory, flight and perception. In elementary functions, there is a direct link between a stimulus in the environment and a response from the person, referred to as the classic Stimulus-Response (S-R) model (Mahn & John-Steiner, 2013). For the development of higher mental functions, however, Vygotsky (1978) found that an intermediate link (X) between the stimulus (S) and the response (R) was needed, as illustrated in Figure 2.1. This intermediate link enables humans to deliberately regulate their behaviour, first intermentally and then intramentally. Referred to by Veresov (2007, p. 1) as the "magic triangle", it stands in sharp contrast to the classic behaviouristic S-R model.



**Figure 2.1. Vygotsky's visual representation of mediation (1978, p. 40)**

It could be argued that mediation is based on Vygotsky's (1978) assertion that "[a]ll the higher functions originate as actual relations between human individuals" (p. 57). A core principal of mediation, according to Hardman (2010), is that learners can achieve more with mediational assistance than on their own. This view of learning as mediated by a culturally *more knowledgeable other* (MKO) suggests a pedagogy that clearly aims to support learners (Hardman, 2008).

The main idea of mediation, according to Lantolf and Poehner (2013), is not just to assist learners to solve a problem, but to identify the minimum level of support a learner requires to successfully complete a task. The mediator should therefore continuously gauge the learner's readiness to take more control, modifying the mediation accordingly until the learner can function independently. This echoes Vygotsky's (1987) argument that, given the minimum level of support required to solve a certain problem, mediation will enable learners to perform beyond their actual level of development, thereby giving an indication of emerging potential. Mediation can thus be expected to evolve over a period of time, which may vary from a couple of minutes to several weeks, to the point where the mediator's assistance can be reduced. Eventually, a learner might only require an implicit statement such as, *Are you sure?* or gestures, like raising an eyebrow, to indicate that something is not right (Lantolf & Poehner, 2013). The importance of the quality of mediation is thus emphasized, as it directly creates possibilities for development (Poehner & Lantolf, 2013).

Lantolf (2006) contends that Vygotsky "proposed a new ontological understanding of humans as mediated beings" (p. 69). Engeström (2009) and Lantolf (2006) argue that Vygotsky's recognition of humans as mediated beings was groundbreaking, as it blurred the longstanding dualism between the Cartesian individual and

the restricted social structure. Vygotsky acknowledges the crucial influence of nature (biological factors) as well as nurture (cultural and social factors) in human development. Lantolf (2006) captures the essence of this interplay when he explains that cultural and biological factors create “a dialectically organised mental system in which biology provides the necessary functions and culture empowers humans to intentionally regulate these functions from the outside” (p. 70). Engeström (2009) neatly argues that one cannot try to understand the individual without the societal influence of his or her cultural artefacts, nor can one understand society without taking account of the agency of individuals who create and use these artefacts. Within the framework of a sociocultural theory, it is agreed that the emergence and the definition of humans’ higher mental processes, including metacognition, are grounded in mediation (Wertsch, 2007), which develops as an individual acquires and masters signs and tools (Damianova, Lucas & Sullivan, 2012; Vygotsky, 1978).

### ***2.3.1.1 Tools and signs as mediational means***

Tools and signs are artefacts produced over time by human culture and are made available to future generations, which in turn alter these artefacts before passing them on to succeeding generations (Lantolf, 2000). Children are born in an already developed society that uses cultural tools and signs (Mahn & John-Steiner, 2013). For Vygotsky (1978) the function of a tool is:

[T]o serve as the conductor of human influence on the object of activity; it is *externally* [original emphasis] oriented; it must lead to changes in objects. It is a means by which human external activity is aimed at mastering, and triumphing, over nature. (p. 55)

This intermediate link or tool is merged into the cognitive operation, constructing a transformed relation between stimulus and response (Lindblom & Ziemke, 2003). Vygotsky (1978) explains that “[t]he sign, on the other hand, changes nothing in the object of a psychological operation. It is a means of internal activity aimed at mastering oneself; the sign is *internally* [original emphasis] oriented” (p. 55). Often the term *psychological tool* is used when referring to a sign, while the terms *technical tool* or *physical tool* are used when referring to a tool (Lantolf, 2000; Vygotsky, 1981; Wertsch, 1985). Even though Vygotsky identifies both physical tools

and psychological tools (signs) as mediational means, he is primarily interested in psychological tools, and in particular language (John-Steiner & Mahn, 1996).

Petrová (2013) believes that these tools offer valuable means for engaging in culturally more appropriate strategies when dealing with everyday problems. They go beyond the value and efficacy of the existing strategies which individuals would otherwise employ. Levykh (2008) explains that the child will initially use the sign as a way to behave, connect, and in a way control the social environment. In the end, however, the same sign will become the way for the child to control his or her own behaviour. Thus it could be reasoned that the higher mental functions dynamically emerge through radical transformations of the elementary mental functions by the use of tools and signs situated in social interaction (Lindblom & Ziemke, 2003; Mahn & John-Steiner, 2013). Vygotsky (1981) identifies the following as examples of psychological tools and their complex systems, “language; various systems for counting; mnemonic techniques; algebraic symbol systems; works of art; writing; schemes, diagrams, maps, and mechanical drawings; all sorts of conventional signs” (p. 137).

Sociocultural theory, therefore, considers mathematical concepts as already culturally constructed. It does not expect learners to rediscover mathematical concepts which are already part of their culture (Schmittau, 2004). It is the role of the teacher or culturally *more knowledgeable other* (MKO) to mediate these already culturally constructed mathematical concepts to learners (Schmittau, 2004). During the process of mediation in a classroom, intermediaries are placed between the learners and what is to be learned, enabling them to acquire higher mental functions and to achieve what might otherwise have remained out of reach (Kozulin, 2002). The mediator can be in close proximity, as are parents or teachers, or separated in space and time, for example, when texts are read that have been produced by others (Lantolf, 2007). Wertsch (2010), however, while agreeing with Vygotsky’s insight that cultural tools and mediated action help to shape the formation of higher mental actions, raises some cultural and political questions, specifically whether it is equally accessible in today’s world.

### ***2.3.1.2 Types of mediation***

Wertsch (2007) identifies two modes of mediation: *explicit* and *implicit* mediation. Explicit mediation tends to be intentional and the object of consciousness

and includes external objects, people or signs. Implicit mediation is more internal, semiotic and is rarely reflected upon. This distinction should not be oversimplified or viewed as representing opposite poles, since it forms part of a much wider conceptual framework which makes it inevitable that many common properties will be shared (Wertsch, 2007). Lantolf and Poehner (2013) observe that the quality of mediation may change from explicit to more implicit, as the learner gains more control on the way to self-regulation.

Karpov (2005) derives two further types of mediation from Vygotsky's work: *cognitive mediation* and *metacognitive mediation*. Cognitive mediation refers to higher mental processes, such as perception, memory, and thinking, that become the tools a learner needs to solve subject-domain problems, for example, learning to calculate or to read (Karpov, 2005).

On the other hand, metacognitive mediation refers to the development of the psychological tools of self-regulation that are responsible for the control and regulation of the learner's cognitive processes (Karpov, 2005). Karpov and Haywood (1998) argue that metacognitive mediation is rooted in interpersonal communication. During this joint activity between a child and more knowledgeable other, psychological tools are used to regulate the child's behaviour. Luria (1961, as cited in Karpov & Haywood, 1998) gives the example of a mother saying no to prevent a child from doing something dangerous or inappropriate. Simultaneously the mother is regulating behaviour and providing the child with a tool of self-regulation. The child, through egocentric or private speech, will begin to tell him- or herself not to yield to temptation or do something wrong, sometimes even imitating the mother's voice.

The use of egocentric speech for self-regulation can be seen as a transitional step leading to inner (non-vocal) speech, which later becomes the child's internalized tool for self-regulation (Vygotsky, 1978). Wertsch (2010) believes that this notion of egocentric speech influenced Vygotsky's view that children's problem solving and concept development originate in their participation in interpersonal communication, not simply in interaction with the physical environment. Wertsch (2010) argues that through "social interaction children appropriate certain linguistically mediated problem solving, thinking, and regulatory techniques first for external, social activity, then for individual cognitive activity as well" (p. 234). Vygotsky (1978) himself clearly singles

out the important role of interpersonal and intrapersonal communication during metacognitive mediation when he states:

The specifically human capacity for language enables children to provide for auxiliary tools in the solution of difficult tasks, to overcome impulsive action, to plan a solution to a problem prior to its execution, and to master their own behaviour. (p. 28)

### ***2.3.1.3 The teacher as mediator***

The educational encounter of mediation is a complex reciprocal process which is not just unequivocal support provided by an expert to a novice during a task (Doehler, 2002). The process of mediation involves distinct human features, such as emotions and different thinking habits, which affect the way the teacher as mediator and the learner engage in the process and in the specific learning environment (Abdul Rahim, Hood & Coyle, 2009). The nature of mediation and its success in the classroom are the product of the joint actions of teachers and learners. Even though the teacher as mediator has the power at the start of the mediation process, it is the prerogative of the learner to respond or not to respond and how to respond. This might not necessarily be the way the response was anticipated, so the teacher might need to make significant adjustments to the mediation process (Hasan, 2002). The learners' actual responses to mediation will reveal their different developmental levels and indicate the pedagogical support that each learner will need to move the learning process forward. Therefore, there is always an element of uncertainty in this reciprocal dimension of mediation. The learners' actions and/or reactions guide the teacher to adapt the intervention in such a way as to assist them in taking control of their own learning (Doehler, 2002).

Scrimsher and Tudge (2003) assert that, if we take Vygotsky's view of mediation seriously, we as teachers should try to learn from our learners. Mediation implies that, while learning, the learners also teach the teachers, and that teachers should accordingly guide learners to higher levels of difficulty using "explanation, interpretation, modelling, the indication of significance and relative importance, careful questioning to lead learners towards the development of the concept, giving feedback, and the like" (Mason, 2000, p. 347). This view of the teacher's role as mediator is also reflected in the *Policy on the Minimum Requirements for Teacher Education* (DHET, 2011), where it is explicitly stated that:

The educator will mediate learning in a manner which is sensitive to the diverse needs of learners, including those with barriers to learning; construct learning environments that are appropriately contextualised and inspirational; communicate effectively showing recognition of and respect for the differences of others. In addition an educator will demonstrate sound knowledge of subject content and various principles, strategies and resources appropriate to teaching in a South African context. (p. 49)

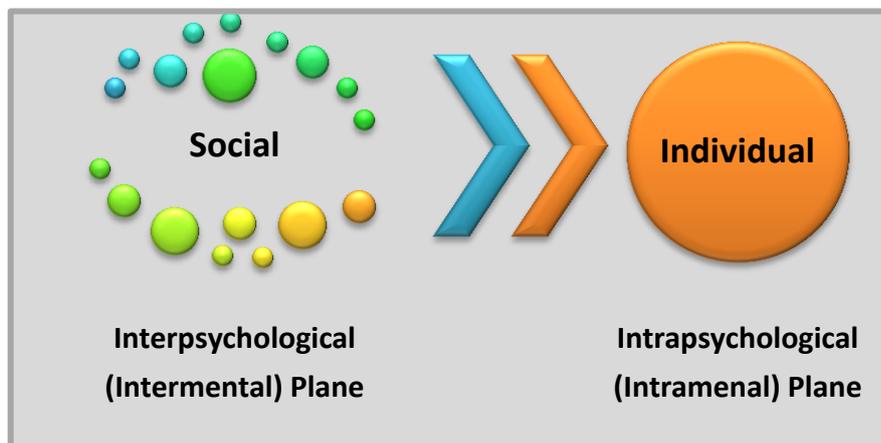
Today's educators face the challenge of meaningfully engaging learners of diverse backgrounds and abilities in activities that lead to "joyful discoveries" (Scrimsher & Tudge, 2003, p. 294). This makes classroom design a complex task, both physically and conceptually. Winsler (2003) argues that Vygotsky's theory forces us to think of learners in their contexts. This takes into account their previous experiences, cultural backgrounds, their available tools and artefacts, and the way their experiences are mediated in the classroom by more knowledgeable others, specifically in terms of social interaction and language. Vygotsky developed the concept of *perezhivanie* to describe an important component of a learner's emotional experiences (Mahn & John-Steiner, 2013). While there is no satisfactory translation in English of the Russian term *perezhivanie*, it can be seen as "the process through which humans perceive, emotionally experience, appropriate, internalise, and understand interactions in their environment" (Mahn, 2003 as cited in Mahn & John-Steiner, 2013). The concept of *perezhivanie* therefore urges the mediator to also be sensitive to affective factors, perceptions and reactions of learners during mediation. To consider and harmonize these dynamic, complex levels is by no means an easy task for the teacher as mediator, but despite the time and effort taken to accomplish it, is certainly of great value (Winsler, 2003).

### **2.3.2 Internalization**

The socioculturalists' view of mediation opposes the direct learning of stimulus and response. Rather, it proposes a theory that higher-order thinking develops in the social context of a collaborative, mediated activity through tools and signs. Vygotsky (1978) pioneered this sociocultural approach to understanding cognitive processes in childhood development, arguing that cognitive development is a social activity. Mahn and John-Steiner (2013) maintain that a sociocultural approach emphasizes the

interdependence of the social and individual processes in the co-construction of knowledge.

This leads us to the concept of internalization. Vygotsky (1978) describes this as the process whereby the interpersonal activity, in the form of social relations between individuals and interaction with socially constructed artefacts, is turned inwards and transformed into an intrapersonal activity. He explains this interdependence in his general genetic law of cultural development (see Figure 2.2), “Every function in the child’s cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological)” (1978, p. 57).



**Figure 2.2. Higher mental functioning: Vygotsky’s general genetic law of cultural development.**

Vygotsky (1998) believed that internalization directs the child’s development and that “through others, we become ourselves” (p. 170). This strongly relates to the philosophy of *Ubuntu* (see section 1.5.1), which places a high value on social interconnectedness. By bringing about the birth of higher mental functions, internalization holds a fundamental position in the sociocultural construal of human development (Damianova & Sullivan, 2011).

While sociocultural theory claims that every higher mental function is founded on a social relation between at least two people, this does not mean that every social relation can become a higher mental function (Veresov, 2007). For Vygotsky (1987), the process that finally leads to internalization consists of a long chain of

developmental events. John-Steiner and Mahn (1996) see internalization as transformative, rather than transmissive. This is also echoed in Ghassemzadeh, Posner and Rothbart's (2013) statement that Vygotsky viewed mediation as a process by which information from the external and internal world is filtered and, when internalized, transforms the "mind" of the child in a qualitative way (p. 10).

The concept of internalization helps us to understand that the source of all higher mental activities is initially outside of the mind and is anchored in social activity before it is internalized (Lantolf, 2000). However, this does not mean that mental activity that was once an external form of mediational support has no means of mediational support after internalization; the support is now internally available to the individual (Lantolf, 2000). Only after internalization does psychological functioning come under the voluntary control of the person. The internalization of psychological tools during the process of mediation helps individuals to develop the metacognitive abilities which contribute to their higher-order cognitive functioning (Kozulin, 2003). Papaleontiou-Louca (2008) argues that it is through internalization that children are able to provide the supportive other role for themselves, not only by completing a specific task on their own but also enabling them to solve new problems in the future.

### ***2.3.2.1 Language in the internalization process***

Internalization thus leads to the development of the child. Fox and Riconscente (2008) emphasize the importance of language during this process. This is mirrored in Lindblom and Ziemke's (2003) argument that psychological tools bridge the gap between elementary and higher mental functions, and that the most significant psychological tool that mediates our thoughts, feelings and behaviour is language. Damianova and Sullivan (2011) see speech as the supreme instrument during mediation, making internalization possible. Vygotsky (1978) himself maintained that initially "the child begins to master his surroundings with the help of speech" (p. 25). Later, this social speech is internalized by the child and is transformed into egocentric or private speech which is vocalized and audible, but which now takes on a cognitive function. With cognitive development "private speech becomes sub-vocal and evolves into inner speech, or language that at the deepest level loses its formal properties as it condenses into pure meaning" (Lantolf, 2000, p. 15). As can be seen in Figure 2.3,

Vygotsky (1987) hypothesized that children's egocentric speech is an interim stage between external and internal speech.



**Figure 2.3. Egocentric speech as the interim stage (Vygotsky, 1978)**

Kozulin (1986) noticed the irregular grammar and syntax, distinctive of inner speech, which indicates the submergence of social communication into one's own reasoning. Ghassemzadeh et al. (2013) argue that, since speech is a tool that operates in a social context agreeing to certain social rules, the whole process of higher mental activities is social in nature. When children participate in social interaction, they internalize certain linguistically mediated problem solving, thinking and regulatory techniques, initially for external or social activity but later for individual cognitive activity (Wertsch, 2010).

### ***2.3.2.2 Imitation in the internalization process***

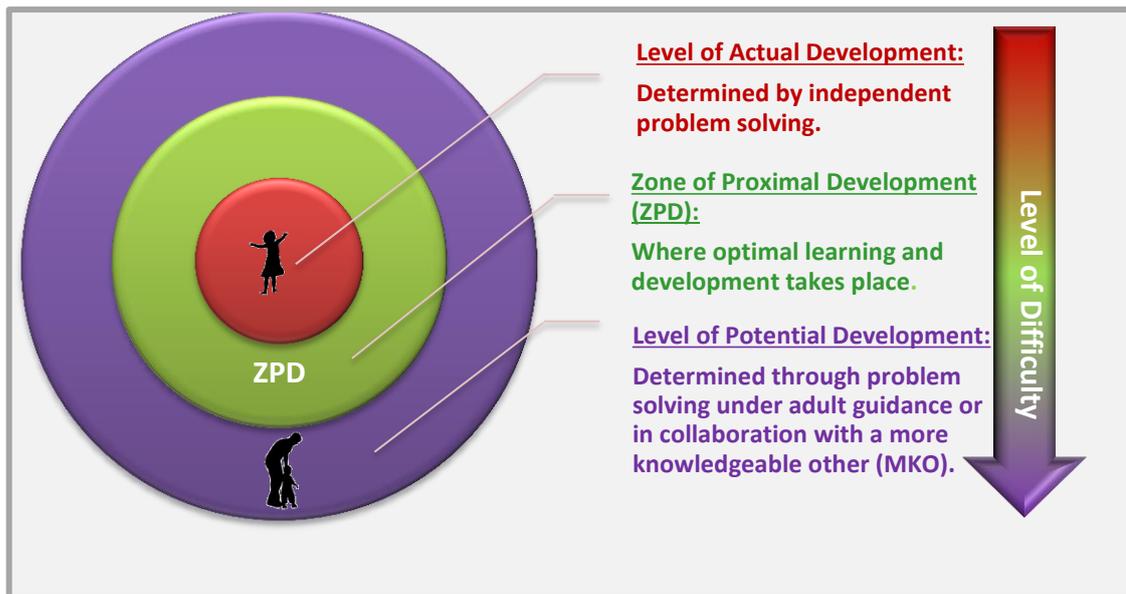
Sociocultural theory maintains that the key to internalization lies in the uniquely human ability to imitate the deliberate activity of other people (Lantolf & Thorne, 2007). Vygotsky (1978) argued that children can only imitate what is within their developmental range. If an adult or more competent peer offers a too advanced solution to a problem, the child will be unable either to understand or imitate the solution, even if it is repeatedly presented. Lantolf (2000) makes a clear distinction between imitation and copying. He refers to the latter as the exact mimicking of what an adult or more competent peer seems to do, while describing imitation as a multifaceted activity in which the child is regarded not as a copier, but as an understanding, communicative person. This view is echoed by Vygotsky (1997) when he argues that “imitation is possible only to the extent and in those forms in which it is accompanied by understanding” (p. 96). Children's ability to imitate in the cognitive domain is not limitless, but is determined by their cognitive level and developmental potential

(Vygotsky, 1998). However, children are able to imitate cognitive activities in the social domain, which can be far beyond the level of their independent cognitive abilities. Vygotsky (1998) defines the concept of imitation as:

Everything that the child *cannot do independently* [original emphasis], but which he can be taught or which he *can do* [original emphasis] with direction or cooperation or with the help of leading questions, we will include in the sphere of imitation. (p.137)

### 2.3.3 The zone of proximal development

In the light of the fundamental principles of the sociocultural theory of learning, it can be assumed that the cognitive development of a child is not a clear-cut linear process. At the same time, there can be different levels of development in the different mental functions of the child. During the internalization process, some functions can be at the interpsychological level, while others are already at the intrapsychological level. At a particular stage in a child's life there will be functions which are already matured and can be seen as "fruits" of development, while other functions are in the process of maturation and can be thought of as "buds" or "flowers" of development (Vygotsky, 1978, p. 86). Thus one can distinguish at least two levels of development of mental functions in the child. The first level is the *actual level of development*. This can be determined by the learning tasks the child can solve independently (fruits) as a result of already completed developmental cycles. The second level is the *potential level of development*, which is measured by the tasks the child can solve in cooperation with an adult or more knowledgeable other (Vygotsky, 1978). The latter can be described as "functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state" (Vygotsky, 1978, p. 86). Figure 2.4 illustrates the distance between the actual developmental level and the level of potential development which Vygotsky terms the *zone of proximal development* (ZPD). "The actual developmental level characterises mental development retrospectively, while the zone of proximal development characterises mental development prospectively" (Vygotsky, 1978, p. 86).



**Figure 2.4. The zone of proximal development**

The zone of proximal development is the arena in which social forms of mediation develop (Ableeva & Lantolf, 2011; Lantolf, 2000). It could be argued that it is that dynamic area of sensitivity in which the shift takes place from interpsychological to intrapsychological functioning of higher mental functions (Vygotsky, 1978). It is thus a creative and complex cooperation between all the role-players occurring in a specific environment (Levykh, 2008). As Vygotsky (1986) explained, “Development and maturation of the child’s higher mental functions are products of this cooperation” (p. 148). Gredler (2012) points out that there is a common misconception that the zone of proximal development was a major part of the Vygotsky’s theory about learning and development, when in fact it is mentioned in less than fifteen pages out of the six volumes of his collected works. In reality, it was only one aspect of the role of collaboration between the child and the more knowledgeable other (Gredler, 2012).

For the purpose of this study, it is important to note that I agree with Lantolf and Thorne (2007) that the concept of the zone of proximal development is often used interchangeably, but incorrectly, for the terms *scaffolding* or *assisted performance*. Jerome Bruner and his colleagues (Wood, Bruner & Ross, 1976) created the metaphor of scaffolding to refer to any type of assistance given by an expert to a novice. It is usually done through other-regulation to help a novice to complete a task, while the power is retained by the expert (Lantolf & Thorne, 2007). In the zone of proximal

development, on the other hand, the adult or more knowledgeable other constantly seeks opportunities to hand over the power to self-regulate to the novice (Lantolf & Thorne, 2007). Another aspect not taken into account in the idea of scaffolding is that the teacher or more knowledgeable other can also be drawn into his or her own zone of proximal development, as he or she learns from the interactions taking place in the joint activity (Lerman, 2001). Verenikina (2008) warns that a literal interpretation of the metaphor of scaffolding can lead to a constricted understanding of the collaboration between the learner and teacher, with the learner viewed as a passive recipient of the teacher's direct instruction. The concept of scaffolding only partially reveals the richness of Vygotsky's concept of the zone of proximal development (Daniels, 2001).

### ***2.3.3.1 The zone of proximal development in education***

Haywood and Lidz (2007, p. 74) state that “nowhere in the field of human endeavours is Vygotsky’s concept of the zone of proximal development more relevant than in education”. What is important for the teacher is not what the learners have already learned, but what they are capable of learning. Thus, the zone of proximal development defines the optimal conditions of learning. Vygotsky (1978) states, “what is in the zone of proximal development today will be the actual developmental level tomorrow, that is, what a learner can do with assistance today, she or he will be able to do it alone tomorrow” (p. 87). The teacher should fashion learning activities in such a way that they begin with what the learners can do independently (actual development) then link with what they can perform with assistance (potential development) (Siyepu, 2013). The teacher or more knowledgeable other guides the child’s learning using clues, suggestions, clarification, joint participation, motivation, regulating and controlling the child’s focus of attention (Lindblom & Ziemke, 2003). During such an activity, learners will gain the knowledge and skills to independently solve problems that were previously just beyond their reach. Teaching should be aimed at moving learners seamlessly from their current zone of development into the next (Westwood, 2004). Thus the zone of proximal development is not constant, but will change to reflect new, higher-order learning.

The role of the teacher during this process not only includes mediation and careful discernment of what to teach within a learner’s zone of proximal development, but also involves learning from the learner (Scrimsher & Tudge, 2003). To ensure that

the learners are appropriately challenged in their zones of proximal development Vygotsky (1998) recommends that after giving a learner a problem to solve:

We show the child how such a problem must be solved and watch to see if he can do the problem by imitating the demonstration. Or we begin to solve the problem and ask the child to finish it. Or we propose that the child solve the problem that is beyond his mental age by cooperating with another, more developed child or, finally, we explain to the child the principle of solving the problem, ask leading questions, analyse the problem for him, etc. (p. 202)

Veresov (2004) recommends that the level of teaching should correspond to the level of the child's cognitive development, but adds that for teaching to be efficient, productive and progressive, it should be aimed at the level of potential development. Vygotsky's emphasis on supporting the child in solving challenging tasks is a central feature of the concept of the zone of proximal development. From a Vygotskian perspective, the main goal of education is to engage learners in their own zones of proximal development as frequently as possible (Ketterer, 2008). This can be accomplished by giving them stimulating and culturally significant learning and problem solving tasks which are slightly more difficult than what they can do independently, encouraging them to seek collaboration from a more knowledgeable other to solve the task (Ketterer, 2008). By completing a task in this way, learners are more likely to solve the same task independently in the future on an intrapsychological level. By employing higher mental functions, such as metacognitive knowledge and metacognitive regulation, they can thus mediate their own problem solving. Research indicates that for metacognition to be optimally utilized, tasks should be located inside the zone of proximal development (Iiskala, Vauras, Lehtinen & Salonen, 2011). In the next section a comprehensive description of metacognition as a construct, its components and its implications for classroom teaching will be reviewed.

## **2.4 METACOGNITION**

Nowadays the term metacognition is often heard in conversations about educational reform (Wilson & Clarke, 2004). In the literature, however, it emerges as quite a complex, vague and even confusing construct which has fascinated cognitive psychologists and educational researchers for many years (Tarricone, 2011). The

popularity of a term is by no means an indication of how well it is understood, or even of the level of agreement on the meaning and definition of the term (Wilson & Clarke (2004). However, in his book, *The Society of Mind* (1986), Marvin Minsky states:

It often does more harm than good to force definitions on things we don't understand. Besides, only in logic and mathematics do definitions ever capture concepts perfectly. The things we deal with in practical life are usually too complicated to be represented by neat, compact expressions. Especially when it comes to understanding minds, we still know so little that we can't be sure our ideas about psychology are even aimed in the right directions. In any case, one must not mistake defining things for knowing what they are. (p. 39)

This is particularly true when one attempts to define metacognition. However, it should not prevent one from making an honest effort to understand the construct, especially as research suggests a substantial correlation between metacognition and successful mathematical problem solving, one which is of great relevance and interest to this study (Desoete, Roeyers & De Clercq, 2003; Efklides & Vlachopoulos, 2012; Erbas & Okur, 2012; Holton & Clarke, 2006; Iiskala et al., 2011; Jacobse & Harskamp, 2012; Kennedy, 2009; Kim, Park, Moore & Varma, 2013; Kuzle, 2013; Mevarech & Amrany, 2008; Mokos & Kafoussi, 2013; Wilson & Clarke, 2004).

Starting with a pure linguistic analysis of what is meant by *meta* and *cognition* may offer a better understanding of this complex concept. *Meta* is a Greek word meaning after, behind, above, about or beyond a higher logical level; to step away or look at a situation as if one were a fly on the wall (Cheal, 2011). *Cognition* refers to the numerous mental skills gained during the acquisition and utilization of knowledge (Reed, 2013). It can be explained as one's thinking and reasoning (Wong, 2002). Combining the meanings of *meta* and *cognition*, one could define metacognition as "cognition about cognitive phenomena," or more simply "thinking about thinking", as John Flavell did in the late 1970's when he first introduced the term (Flavell, 1979, p. 906). Since then, a myriad of definitions have appeared in the literature, further contributing to the fuzzy character of metacognition and resulting in labels such as ill-defined, obscure, vague, faddish, messy, a many-headed monster and an epiphenomenon (Brown, 1987; Dinsmore, Alexander & Loughlin, 2008; Schoenfeld, 1992; Schunk, 2008; Veenman et al., 2006). A prominent researcher in the field of metacognition, Ann Brown (1987), highlighted two aspects which might contribute to

the complex nature of metacognition. Firstly, it is often a challenge to separate what is metacognitive from what is cognitive. Secondly, the term metacognition evolved from different historical roots, resulting in a single term for a multifaceted concept. Brown (1987) therefore simply refers to metacognition as “one's knowledge and control of own cognitive system” (p. 66).

John Flavell (1976), regarded as the father of metacognition, constructed the first formal and more comprehensive definition:

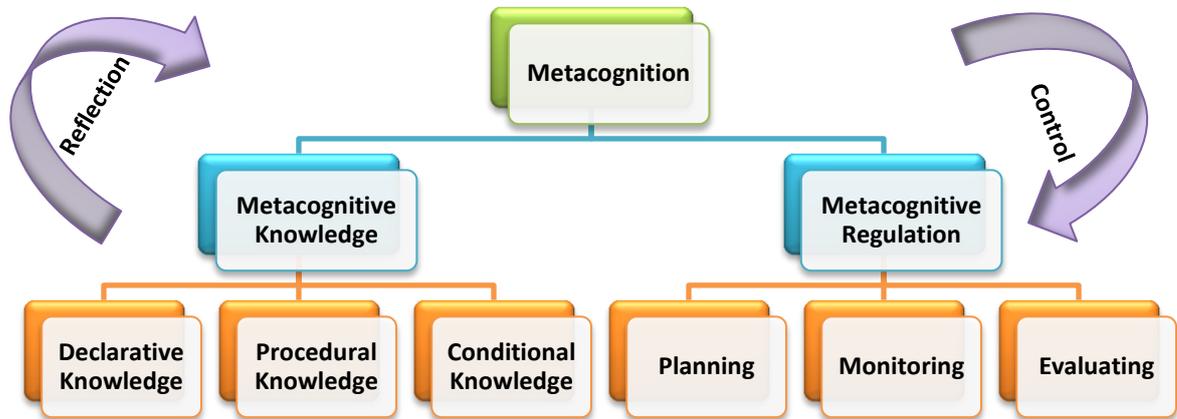
Metacognition refers to one's knowledge concerning one's own cognitive processes and products or anything related to them. Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete goal or objective. (p. 232)

Both Flavell's (1976) and Brown's (1978) definitions identify *knowledge of cognition* and *regulation of cognition* as the two main categories of metacognition. Brown (1987) argues that this divergence between *knowledge of cognition* and *regulation of cognition* helps to clarify the construct and is necessary for future research. For this study, I have accepted Brown's (1987) advice to separate the different components of metacognition in order to bring clarity to the construct as a whole.

#### **2.4.1 Components of metacognition**

Most researchers in the field of metacognition follow the foundation laid down by Flavell (1976) and Brown (1987), treating knowledge of cognition and regulation of cognition as the main elements of metacognition (Dinsmore et al., 2008;; Schneider, 2008; Serra & Metcalfe, 2009; Wilson & Clarke, 2004). For this study, the components of metacognition as explained by Schraw and Moshman (1995) as well as Schraw, Crippen and Hartley (2006) will be used as a conceptual framework for this concept. This framework classifies metacognition into the same two main categories as did Flavell (1976) and Brown (1987), namely knowledge of cognition and regulation of cognition (Schraw et al., 2006). Figure 2.5 illustrates how metacognitive knowledge is further divided into three sub-categories, enabling the reflective aspect of metacognition and metacognitive regulation, which is also divided into three sub-

processes that enable the control aspect of metacognition (Lai, 2011; Schraw et al., 2006; Schraw & Moshman, 1995).



**Figure 2.5. Diagram of metacognitive components**

#### **2.4.1.1 Metacognitive knowledge**

Metacognitive knowledge refers to the knowledge of cognitive tasks and strategies, but also to the knowledge that learners or problem solvers possess about themselves and others (Flavell, 1979). Panaoura and Philippou (2007) explain it as knowledge which learners have (1) about their cognitive capacities (for example: I have a bad memory), (2) about cognitive strategies (for example: to remember a phone number I should rehearse it), and (3) about tasks (for example: categorized items are easier to recall). Metacognitive knowledge must be viewed as a person's explicit awareness of the specific cognitive processes utilized in a particular situation (Zohar, 2006). De Jager, Jansen and Reezigt (2005) point out that it can be enhanced by reflecting on learning experiences and can then be used in future learning tasks. It is thus continuously supplemented, updated and reorganized through the integration of new information (Efklides, 2008). In Table 2.1 the three components of metacognitive knowledge, declarative, procedural and conditional knowledge, are described.

**Table 2.1.*****Components of metacognitive knowledge that enable the reflective aspect of metacognition***

<b>Component of metacognitive knowledge</b>	<b>Description</b>
<b>Declarative knowledge</b>	Knowledge about <i>what</i> we know. This includes knowledge about ourselves as learners, as well as the factors that limit or enhance our performance during a specific task (Schraw et al., 2006).
<b>Procedural knowledge</b>	The knowledge about strategies and procedures to solve a problem or achieve a goal (Schraw et al., 2006). It therefore involves knowledge on <i>how</i> to use specific skills and strategies during particular cognitive tasks (Thomas & Mee, 2005) and how this will impact performance (Misailidi, 2010).
<b>Conditional knowledge</b>	The <i>why</i> and <i>when</i> to use a particular strategy that is most appropriate for the situation (Schraw et al., 2006; Thomas & Mee, 2005). A high degree of conditional knowledge therefore enables us to better gauge the demands of a specific learning situation and change behaviour accordingly (Schraw et al., 2006).

**2.4.1.2 Metacognitive regulation**

The regulation category can be seen as the interactive dimension of metacognition and takes place in the action phase of the learning experience (Garrison & Akyol, 2013). During this phase, the learner employs certain strategies to regulate and control the learning process and to achieve meaningful outcomes (Garrison & Akyol, 2013). Thus metacognitive regulation occurs when learners modify their thinking (Wilson, 1998). Iiskala et al. (2011) refer to it as the executive processes, which include the activities involved in supervising one's own learning. As illustrated in Table 2.2, metacognitive regulation usually includes at least three components, planning, monitoring and evaluation (Hargrove, 2013; Larkin, 2010; Schraw et al., 2006; Veenman et al., 2006). It helps learners to gain executive control of behaviour and should take place before, during and after learning activities (Hargrove, 2013).

**Table 2.2.*****Components of metacognitive regulation that enable the control aspect of metacognition***

<b>Component of metacognitive regulation</b>	<b>Description</b>
<b>Planning</b>	This refers to how one approaches a given learning task, figuring out how to begin or continue (Shamir, Zion & Spector-Levi, 2008), identify obstacles (Hargrove, 2013), and predict outcomes (Iiskala et al., 2011). It includes activities such as organizing available resources, recognizing and selecting appropriate procedures, including the setting of goals, initiating prior knowledge and scheduling time (Lai, 2011; Schraw et al., 2006).
<b>Monitoring</b>	This emphasizes learners' ongoing control over the learning process, identifying any obstacles that emerge, and modifying behaviour or goals accordingly (Flavell, 1979; Jacobse & Harskamp, 2012). Monitoring can be identified as insights such as, 'I do not understand this' (Flavell, 1979).
<b>Evaluating</b>	This is the retrospective process where the outcomes and regulatory procedures of learning are reviewed. These procedures include retracing initial goals, reviewing predictions and acknowledging intellectual gains (Schraw et al., 2006).

**2.4.2 Metacognition from a sociocultural perspective**

Larkin (2009) notes an increasing acknowledgement of metacognition as socially situated, in contrast with the earlier individualistic cognitive and developmental models of metacognition. Vygotsky's theory on the development of higher mental functions provides an appropriate theoretical framework for the emergence of metacognitive processes (Ivic, 1994). Papaleontiou-Louca (2008) believes that Vygotsky pioneered a methodology to understand metacognition and further argues that several matters related to current metacognitive inquiry are fundamental to Vygotsky's (1978) concept of cognitive development. Sociocultural theory, according to Ivic (1994), is the only suitable theory to explain the origin of an individual's capacity to regulate and control his or her own internal processes. Vygotsky's (1978) detailed

explanation of the social origins of higher mental functions in his general genetic law of cultural development (see section 2.3.2) and the role of mediated means (see section 2.3.1) in the development of these functions clearly indicates that one cannot underestimate the role of the more knowledgeable other and of mediational means in the development of an individual's metacognition. Vygotsky (1978) states unequivocally that "[a]ll the higher functions originate as actual relations between human individuals" (p. 57). Social relations on the interpsychological plane guide one into aspects which require some degree of metacognition on the intrapsychological plane, such as independent thinking, reasoning and problem solving (Albert, 2000). Baker (2010) observes that several positive interventions aimed at the promotion of metacognition rely on Vygotsky's (1978) understanding of mediation, seen as the progression from other-regulation to self-regulation. Initially the more knowledgeable other will guide the learners to regulate their thoughts through planning, concentrating on what is important and evaluating, while progressively increasing their responsibility as they become more capable after internalization of these metacognitive tasks (Baker, 2010). Thus the development of metacognition is embedded in a social context (Albert, 2000; Iiskala et al., 2011), and in fact Vygotsky (1978) clearly specifies that mediation of higher-order functions (such as metacognition) through social interaction precedes a learner's solitary effort.

As noted in section 2.3.2.2, a significant feature of sociocultural theory, one which plays a crucial role in the mediation of higher mental functions, is imitation (Vygotsky, 1998). For the learner, however, metacognition is not easy to imitate, as it is mostly invisible. It is difficult to observe the process directly or to indirectly experience the changes that occur as a result of being metacognitive (Kayashima & Inaba, 2003; Perkins, 2003). The question therefore arises, how do teachers mediate metacognition in the classroom?

There is an emerging trend among researchers in the field of metacognitive discourse to explore the relationship between metacognition and the classroom as a social space, which can be attributed to sociocultural theory and specifically to Vygotsky's influence (Ader, 2013; De Jager et al., 2005; Doganay & Ozturk, 2011; Efkliides, 2008; Garrison & Akyol, 2013; Holton & Clarke, 2006; Mevarech & Amrany, 2008; Papaleontiou-Louca, 2003; Pennequin, Sorel, Nanty & Fontaine, 2010; Wilson & Bai, 2010). Wilson and Clarke (2004) agree that metacognition can emerge within a

social context such as a classroom and that experience, prior knowledge, skills, learning preferences and styles, as well as the values and expectations of each learner in the classroom will be unique. All these factors will influence each individual's development of metacognition, learning process and problem solving in a unique way (Wilson & Clarke, 2004).

Discourse, according to Akyol and Garrison (2011), is a fundamental aspect of the social context and is instrumental in the development of metacognition. It is through discourse that knowledge, misconceptions and learning strategies can be revealed (Akyol & Garrison, 2011). When learners realize through discourse that their peers interpret things differently, they are naturally enticed to examine alternative viewpoints, sharing and re-evaluating their own understandings and beliefs (Wade & Fauske, 2004).

Another observation by Vygotsky (1978), one directly linked to the development of metacognition, relates to the notion of inner speech, as discussed in section 2.3.2.1. Young children will often talk to themselves when faced with a challenging task in order to direct themselves. Termed egocentric speech, it is first observed as audible private speech, but will later become internalized as silent, inner speech (Vygotsky, 1978). Okoza and Aluede (2013) note a tendency of learners who talk to themselves during challenging tasks to be more successful than peers who do not consciously direct and monitor their thoughts using egocentric or inner speech.

### **2.4.3 Teachers' mediation of metacognition**

Research shows ample evidence of the benefits of teaching metacognition in the classroom. It enhances learning and academic outcomes for all learners, including those who display barriers to learning, specifically in the area of mathematics (Kramarski, Mevarech & Arami, 2002; Mevarech & Amrany, 2008; Mevarech et al., 2010; Özsoy & Ataman, 2009; Özsoy, 2011; Pennequin et al., 2010; Schneider & Artelt, 2010; Wilson & Clarke, 2004). From studies exploring what is essential for successful metacognitive mediation Veenman et al. (2006) derive three fundamental principles:

- Embed metacognitive strategies in the content matter of a subject, especially during the elementary school years, as these young learners' application of metacognition is still domain-specific.

- Help learners to understand the benefits of metacognitive activities and create opportunities where they can experience the fruit of employing metacognitive strategies.
- Continuously teach and practice metacognitive strategies to secure consistent use of metacognitive activity.

It is important to grasp the distinction between strategies and skills when dealing with the concept of metacognition. Okoza and Aluede (2013) describe skills as naturally recurring exercises or simple commands. They can be thought of as the cognitive behaviour one displays that is spontaneous, automatic and routine. Strategies, on the other hand, are more purposeful, process-driven, intentional and carefully selected to achieve a specific goal (Okoza & Aluede, 2013). Metacognitive strategies are used to monitor cognitive progress; therefore it could be argued that such strategies are intentional processes that one employs to monitor cognitive actions in order to reach a goal such as solving a mathematical problem (Flavell, 1979).

Learners need to observe these metacognitive strategies in action and be guided by the teacher as they implement them (Clark & Graves, 2005). They should be given ample opportunities to independently practice these strategies. To guide them, the teacher needs to create a classroom climate where the application of metacognitive strategies is specifically required and reflection on thinking processes is unequivocally expected (Leat & Lin, 2003).

These findings clearly demonstrate the need for teachers to engage in mediational strategies which help learners to become more metacognitive. Not all learners develop metacognition automatically (De Jager et al., 2005). Lower-achieving learners have inadequate metacognitive processes (Zohar, Degani & Vaaknin, 2001). However, Anderson (2002) found that, particularly among struggling learners, the significance of teaching metacognitive strategies should not be underestimated, as they can stimulate thinking, leading to more reflective learning and better achievements. Evidently teachers are essential catalysts in the development of learners' metacognition. They should therefore include the explicit teaching of metacognitive strategies, which learners can utilize and which will offer them more equal opportunities to be successful in school. Flavell already envisaged the power of teaching learners to be more metacognitive in 1979 when he suggested that:

It is at least conceivable that the ideas currently brewing in this area could someday be parlayed into a method of teaching children (and adults) to make wise and thoughtful life decisions as well as to comprehend and learn better in formal educational settings. (p. 910)

Since teachers are regarded as important role-players in the development of learners' dispositions and learning strategies, they should be encouraged to explore and mediate metacognition in the mathematics classroom (Goos, Galbraith & Renshaw, 2002). Ader (2013), however, maintains that the significant role teachers play in the infusion of metacognition in mathematics has been poorly explored. This is echoed by Jacobse (2012), who states that, even though it is recognized that metacognition can play a vital role in learners' performance in mathematics and their journey to become self-regulated, teaching it appears to be an undervalued practice. Van der Walt and Maree (2007) confirm this argument, maintaining that the lack of understanding of metacognition and the application of metacognitive strategies in mathematics in South African teacher training institutions, as well as in schools, is a major concern. It seems that few teachers understand or apply these strategies in South African mathematics classrooms. Questions still need to be raised therefore on how teachers can mediate metacognition in mathematics classrooms.

Griffith and Ruan (2005) argue that for teachers to engage in metacognitive mediational strategies they should be familiar with the learners' background knowledge, as well as with the practice and implementation of metacognitive strategies in the classroom. To support learners to become more metacognitive the teacher should play the role of mediator, guiding them in the discovery of the effectiveness of metacognitive strategies, helping them to acquire and apply them (Bosson, Hessels, Hessels-Schlatter, Berger, Kipfer & Buchel, 2010).

Not all teachers are able to help their learners to become metacognitively aware of their own learning (Joseph, 2010). Veenman et al. (2006) further reveal that many teachers display an insufficient knowledge of metacognition. On the other hand, Papaleontiou-Louca (2003) argues that many teachers are already using metacognitive strategies in the classroom, but are not always consciously aware that they do so. They do not intentionally plan strategies with the goal of encouraging learners to become more metacognitive. Joseph (2010) notes that most teachers have well-refined metacognitive skills, as their daily practices require highly conscious and perceptive

cognitive action. They naturally self-reflect, frequently questioning their own thinking and actions while teaching (Joseph, 2010).

Ader (2013) finds a strong reciprocal relationship between teachers' understanding of metacognition as a construct and the extent to which they promote it in their teaching practices. This is where their pedagogical understanding of metacognition becomes important, since without such knowledge they will be unable to effectively teach their learners to be metacognitive (Wilson & Bai, 2010). According to Wilson and Bai (2010), three types of knowledge are involved in teachers' pedagogical understanding of metacognition, as explained in Table 2.3.

**Table 2.3.**

*Types of knowledge indicating teachers' pedagogical understanding of metacognition*

<b>Types of knowledge</b>	<b>Description</b>
<b>Declarative knowledge</b>	Teachers' knowledge of <i>what</i> they should teach to help learners to become more metacognitive.
<b>Procedural knowledge</b>	Teachers' knowledge of <i>how</i> they should teach to help learners to become more metacognitive.
<b>Conditional knowledge</b>	Teachers' knowledge of <i>when</i> they should teach metacognitive strategies, as it is dependent on the situation.

*Note: Adapted from Wilson and Bai (2010)*

Table 2.4 presents a summary of a study conducted by Wilson and Bai (2010), the aim of which was to investigate teachers' understanding of metacognition, their pedagogical understanding of the concept, and what it means to teach learners to be metacognitive. The table will be followed by a discussion of the two themes as identified by Wilson and Bai (2010) and linked to other research studies which confirm and/or elaborate on these findings.

**Table 2.4.***Summary of a study conducted by Wilson and Bai (2010)*

Topic of research study:	The relationships and impact of teachers' metacognitive knowledge and pedagogical understandings of metacognition (Wilson & Bai, 2010).
Participants:	105 teachers (K-12 teachers majoring in different areas in education).
Research methodology:	Mixed-method.
Instrumentation:	Two-part survey Part One: Demographic questions, followed by two open-ended questions (1.What is metacognition? 2. What are metacognitive thinking strategies?) Part Two: Teacher metacognition scale (20 Likert Scale questions)
Emerged themes:	<b>Theme 1:</b> Teaching metacognition is an active process of engaging learners in sharing thinking processes through the teaching of declarative, procedural and conditional knowledge, while making learners accountable for using metacognitive skills. <b>Theme 2:</b> The awareness of metacognition, where teachers touch the surface of metacognitive thinking strategies to support the development of learners' declarative and procedural metacognition.

**2.4.3.1 Metacognition as an active process requiring engagement**

The first broad theme identified by Wilson and Bai (2010) determines that teachers should actively involve learners in thinking about how they think and learn, empowering them with strategies to increase their understanding, task completion and control of their own cognitive processes. To actively engage learners, thinking should be visible and shared among teachers and learners. Thus dialogue can be regarded as a principal feature in a classroom where learners are encouraged to use metacognitive strategies. Martinez (2006) emphasizes the importance of social interaction in the classroom, since it creates a space in which the metacognitive capacity of learners can be cultivated. This may sound self-evident, but Colcott, Russell and Skouteris (2009) remind us that our thoughts are usually invisible to others, even to ourselves, since we do not naturally reveal our inner speech and the sequence of the thoughts which

empower us to achieve a certain goal. Schraw et al. (2006) identify three reasons why metacognition is not explicit in many learning situations:

- Metacognitive processes are already highly automated for most teachers, and are thus taken for granted as something that everybody does.
- The development of some metacognitive processes may occur without deliberate reflection and are therefore difficult to teach.
- An accessible language or appropriate vocabulary of metacognitive processes is absent, limiting the discourse in the classroom about metacognition.

As Vygotsky (1978) asserts, language has a significant role in the meaning-making process. In particular, the concept of inner speech can assist teachers to better understand how they can support learners to plan, regulate and evaluate their thinking when challenged with a problem solving task (Zakin, 2007). Teachers should therefore be educated on how to empower learners to access their inner speech. This pedagogical technique fosters two sought-after educational goals: creating critical thinking and self-regulated learners (Zakin, 2007).

Vygotsky (1978) argues that higher-order thinking originates as social discourse and that these discourse patterns are internalized over time and through experience. This emphasis in sociocultural theory on the interdependence between the group and the individual (Vygotsky, 1978) reinforces the fundamental role of discourse in a classroom where metacognition is to be nurtured. Vygotsky (1978) proposes that:

Learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and with his peers. (p. 90)

Larkin (2010) therefore promotes collaborative group work for the development of metacognition. She argues that learners who participate in group work are required to reflect on their own understandings and beliefs if they want to explain their thoughts. Learners working in collaborative group settings often outperform those who work on their own (Kramarski & Mevarech, 2003); this can be credited to the high quality of discourse between learners who work collaboratively. Vygotsky (1994, p 350), however, cautions that “in order for any auspicious and successful development of the higher specific human traits to occur”, where children interact with their peers (the

rudimentary form), the ideal or final form (such as a teacher or parent) must be present in the environment.

[Whenever] the interaction between the final form which exists in the environment and the rudimentary form which a child possesses, becomes disrupted, the development of the child turns out very limited, and what results is a more or less completely underdeveloped state of the child's proper forms of activity and traits. (Vygotsky, 1994. p 350)

It can be concluded that, for group work to be truly successful in a classroom, the active role of the teacher as the ideal or final form is central. Perkins (2003) and Ritchhart and Perkins (2008) explicitly state that the development of thinking is a social enterprise. The sociocultural character of schools, and specifically the classrooms, should provide a space where thoughtful learning is constantly encouraged. Teachers should seek opportunities to make their own thinking visible, encouraging their learners to imitate a thinking behaviour.

The participants in the study of Wilson and Bai (2010) identified two strategies that could be useful in promoting metacognition and making thinking visible. The first is to explicitly model metacognition, while the second is the strategy of debriefing. These strategies will now be discussed in more detail.

#### **2.4.3.1.1 Modelling**

Modelling means that the teacher, rather than simply telling learners about metacognition, gives them a careful explanation of the mental processes involved (Wilson & Bai, 2010). The importance of teaching through modelling is reiterated by Martinez (2006) and Mayer (2001) who urge teachers to seek opportunities to model metacognitive strategies during authentic learning tasks. Martinez (2006) particularly emphasizes the importance of teachers' verbalizations or *think alouds*, especially during problem solving, which can operate as a catalyst in the process of internalizing learners' metacognition. Huff and Nietfeld (2009) argue that thinking aloud during problem solving can help learners to monitor and regulate their own problem solving strategies in real time. When teachers model effective strategies, learners can develop a better understanding of which metacognitive strategies will best complement their specific learning styles (Shannon, 2008). Zakin (2007) argues that modelling how to access inner speech as a metacognitive strategy in order to develop self-reflective

thought is of utmost importance and should therefore be at the centre of any teacher training curriculum. Hargrove (2013), however, advises that when teachers are modelling through thinking out loud, they should be careful not to only model their cognition, for example discussing how to solve the problem, but should also model their metacognition, in particular how they think about and regulate the problem solving process. Teachers' mediation of cognitive operations is mostly characterized by highly structured, teacher-directed tasks with several closed-ended questions, while the mediation of metacognitive operations is mainly through teachers offering metacognitive strategies and modelling them in order to encourage learners to activate their own metacognition (Ader, 2013).

#### ***2.4.3.1.2 Debriefing***

Debriefing is the second strategy highlighted by Wilson and Bai (2010) to make metacognitive thinking visible and create opportunities for dialogue in the classroom. Leat and Lin (2003) define debriefing as a reflective discussion taking place after the main learning activity, creating an opportunity where learners, either in a small group or in the whole class, can intentionally broaden their learning and thinking. According to Wilson and Bai (2010), it is a tool that can be used to promote the learner's awareness of which strategies are most effective when working towards a specific goal.

#### ***2.4.3.2 Promoting metacognitive awareness***

The second theme identified by Wilson and Bai (2010) is concerned with the development of learners' declarative and procedural metacognition. In the development of declarative metacognition, Wilson and Bai (2010) recognize the central role of the teacher in helping learners become aware of their actions. This is not the same as active learning, since awareness only requires learners to realize when a problem is faced and that they are indeed thinking (Wilson & Bai, 2010). A study conducted by Azevedo, Greene and Moos (2007) found that, when learners are given external metacognitive hints by a human mediator such as a teacher, they reach higher levels of declarative metacognitive knowledge. Schneider (2008) monitored 174 children from the ages of three to five and found that declarative metacognitive knowledge tended to increase with age.

The role of the teacher as mediator is vital in improving learners' procedural metacognitive knowledge. It mainly relies on giving appropriate assignments that will require learners to intentionally select those metacognitive strategies which will enable them to complete the given assignment (Wilson & Bai, 2010). Teachers can mediate procedural metacognitive knowledge by asking questions that trigger learners to think about why they are doing what they are doing while solving a problem (Hacker & Dunlosky, 2003). The questions should be aimed at the learners' planning of the task at hand, the monitoring of the strategies they use, as well as the evaluation of the whole problem solving process (Kramarski & Mevarech, 2003). Thus the aim of procedural knowledge is to monitor and control thinking, helping one to solve problems and make good judgements (Larkin, 2010).

#### **2.4.4 Challenges teachers face in mediating metacognition**

Research indicates that some of the reasons why teachers fail to guide learners to become more metacognitive include time constraints and the difficulty of working with other type of problems, such as open-ended problems, which promote metacognition, when learners are used to finding the correct answer in the shortest possible time (Larkin, 2010). Furthermore, the teacher's own level of experience can influence the activities which promote metacognition in the classroom (Doganay & Ozturk, 2011). In a case study comparing how experienced and inexperienced elementary school teachers implemented metacognitive strategies in their classrooms, Doganay and Ozturk (2011) found that experienced teachers employed more metacognitive strategies and activities related to metacognition than did their less experienced colleagues. Most teachers struggle to implement metacognitive intervention programmes productively, as it is generally a challenge for them to change their conventional ways of teaching, often reinforced by the curriculum and culture of the school (Larkin, 2010). Designing more intervention programmes aimed at developing metacognition in learners and their teachers may not be the solution to the problem. Instead, teachers should be skilled to recognize situations which offer opportunities for the development and practice of metacognition in their day-to-day teaching (Larkin, 2010).

Papaleontiou-Louca (2003) acknowledges that the teaching of metacognitive strategies requires time and effort, but maintains that this investment is not in vain, as it

results in more focused, flexible and creative problem solvers. Okoza and Aluede (2013) argue that a collaborative effort by relevant role-players should be made to equip teachers as well as student teachers with the knowledge and skills they need to mediate metacognitive strategies in the classroom.

This call has also been made in South Africa. Van der Walt and Maree (2007) state that teaching metacognition and applying metacognitive strategies should be promoted in South African mathematics classrooms as a matter of urgency. If we truly want to transform classroom practice, metacognition should be introduced through in-service training for teachers and be taught to student teachers at all universities in South Africa. This intervention should ideally take place in the space familiar to teachers, their own classrooms. This would allow them to share their classroom practices, possibly opening up opportunities for reflection and evaluation (Van der Walt & Maree, 2007).

## **2.5 SUMMARY**

This chapter contextualized the study, drawing on the current and relevant literature related to sociocultural theory and its constructs, as well as metacognition and the indispensable role of the teacher in mediating metacognition in the classroom. In the next chapter the literature on mathematical problem solving and differentiated instruction will be reviewed, with the aim of further exploring the sophisticated interwovenness between metacognition, mathematical problem solving and differentiated instruction through the lens of sociocultural theory.

# CHAPTER 3

## LITERATURE REVIEW: INSIGHTS INTO MATHEMATICAL PROBLEM SOLVING AND DIFFERENTIATED INSTRUCTION

### 3.1 INTRODUCTION

The literature review in this chapter will firstly aim to gain insight into mathematical problem solving and how it is positioned in the new Curriculum and Assessment Policy Statements (CAPS) for the Foundation Phase and the Intermediate Phase. A review of empirical studies that explore the link between metacognition and mathematical problem solving, as well as the role of the teacher during these processes will also be presented.

The second part of the chapter will consist of a review of the literature on the philosophy of differentiated instruction and its constructs, seen as a possible solution to the growing diversity in classrooms. Since sociocultural theory (see section 2.2) is the theoretical framework that informs this study, its relevance to the constructs explored in this chapter will often be noted.

### 3.2 MATHEMATICAL PROBLEM SOLVING

The importance of mathematical problem solving is well documented in research papers, international tests and curricula across the world (Damianova et al., 2012; English, Lesh & Fennewald, 2008; Kramarski, 2009; Lester, 2013; Mullis et al., 2012; National Council of Teachers of Mathematics, 2000; Schoenfeld, 1985, 1992, 2013). These sources, as well as the most recent version of the South African curriculum (DBE, 2011a, 2011b), generally accept that the primary goal of mathematics teaching should be to help learners to become competent problem solvers (Schoenfeld, 1992). It is explicitly stated in the National Council of Teachers of Mathematics (NCTM) standards that:

Solving problems is not only a goal of learning mathematics but also a major means of doing so.... In everyday life and in the workplace being a good

problem solver can lead to great advantages.... Problem solving is an integral part of all mathematics learning. (NCTM, 2000, p. 52)

Mathematical problem solving in school is important in preparing learners to become successful adults later in life. It enables them to think in a creative and flexible way, further enabling them to control their thoughts metacognitively, in line with the demands of life after school (Otten, 2010).

There are numerous beliefs about what the concept of mathematical problem solving precisely entails (Wilson, Fernandez & Hadaway, 1993). According to Schoenfeld (1983), problem solving is needed when an individual or a group do not know how to solve a problem easily with known procedures.

A problem is only a problem (as mathematicians use the word) if you don't know how to go about solving it. A problem that has no 'surprises' in store, and can be solved comfortably by routine or familiar procedures (no matter how difficult!) is an exercise. (p. 41)

Thus any definition of problem solving should acknowledge that it requires a range of cognitive actions which involve specific knowledge and skills, some of which are non-routine (Lester, 2013). Cognitive actions are influenced by non-cognitive factors (Lester, 2013). In 2003, Lester and Kehle developed a statement to capture the concept of *problem solving* which Lester (2013) believes is the most comprehensive in the literature:

Successful problem solving involves coordinating previous experiences, knowledge, familiar representations and patterns of inference, and intuition in an effort to generate new representations and related patterns of inference that resolve some tension or ambiguity (i.e., lack of meaningful representations and supporting inferential moves) that prompted the original problem solving activity. (Lester & Kehle, 2003, p. 510)

Problem solving can therefore be seen as everything learners do to find a solution to a novel problem for which they do not have a known method (Hoosain, 2003). To find a solution, they will need to tap into their prior knowledge, skills and strategies. The emphasis is therefore on the processes and not on the answer (Hoosain (2003). If learners have encountered a certain mathematical problem before and the process to solve the problem is known to them, solving it in the future will be a mere

exercise (Orton & Frobisher, 2005). Many so-called mathematical problems appearing in school textbooks are in fact only exercises (Hoosain, 2003). Vygotsky emphasized the importance of problem solving for cognitive development, showing in a range of investigations on the development of primates, children and traditional inhabitants that cognitive development occurs when a problem is encountered for which previous procedures have been insufficient (Vygotsky & Luria, 1993, as cited in Schmittau, 2004).

Most discussions on the topic of problem solving start with the Hungarian mathematician George Pólya's seminal work from his first edition of *How to Solve It* in 1945, which created a deep interest in the study of how problem solving should be taught and learned (English et al., 2008; Erbas & Okur, 2012; Kuzle, 2013; Schoenfeld, 2007, 2013). Pólya (1945) introduced the notion of heuristics into the context of problem solving. Heuristics, which means *serving to discover*, originates from the same Greek root as *eureka*, meaning *to find* (Erbas & Okur, 2012). Pólya suggested that effective problem solving consists of four main phases: (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back. Another prominent scholar in the field of mathematical problem solving, Schoenfeld (1992), criticized Pólya's four phases as being too descriptive rather than prescriptive, in that they did not provide people who were unfamiliar with the heuristics enough detail to implement them successfully. Instead, Schoenfeld (1992) identified four categories of problem solving activity that he believed were necessary and sufficient to analyse the success of someone's problem solving attempt: (1) the individual's knowledge, (2) the individual's use of problem solving strategies, (3) the individual's metacognitive behaviour, and (4) the individual's belief systems about self, mathematics and problem solving. Schoenfeld (1992) identified these categories in order to achieve more prescriptive power. According to English et al. (2008), problem solving teaching should therefore:

- Guide learners to develop more specific problem solving strategies for more specific problem types.
- Deliberately teach metacognitive strategies to enable learners to know when to use their problem solving strategies and content knowledge.
- Develop ways to improve learners' beliefs about their own personal competencies, problem solving, and the nature of mathematics.

### 3.2.1 Problem solving in the Foundation Phase and Intermediate Phase

South Africa implemented a revised curriculum, the Curriculum and Assessment Policy Statement (CAPS), beginning in 2012 with the Foundation Phase (Grades R-3), followed in 2013 by the Intermediate Phase (Grades 4-6). (For the purpose of this study Grade R is not included when referring to the Foundation Phase). For both the Foundation Phase and the Intermediate Phase, the CAPS document for mathematics is rigid, assigning a detailed description of content and related topics, concepts and skills that must be covered in an exact order to each grade. It also indicates the precise duration in hours and minutes that should be spend on each topic (DBE, 2011a,b).

The teaching time allocated by the DBE (2011a) for mathematics in the Foundation Phase is seven hours per week, with six hours per week for the Intermediate Phase. Mathematics in both phases is divided into five content areas: (1) numbers, operations and relationships, (2) patterns, functions and algebra, (3) space and shape, (4) measurement, and (5) data handling (DBE, 2011a,b). The DBE (2011b, p. 296) defines mathematical problem solving as:

- Unseen, non-routine problems (which are not necessarily difficult).
- Higher order understanding and processes are often involved.
- Might require the ability to break the problem down into its constituent parts.

In every content area for both phases of the CAPS mathematics documents (DBE, 2011a,b), the importance of problem solving, specifically in a context where the calculation competencies and number range of the learners must be considered, are strongly emphasized (DBE, 2011a,b). It is believed that solving problems in context empowers learners to present their own thinking orally or in writing through drawings and symbols (DBE, 2011a). One guideline suggested for classroom management in the Foundation Phase is that learners be exposed to oral and practical problem solving on a daily basis (DBE, 2011a). Even though the Intermediate Phase CAPS document does not specify the frequency of problem solving during mathematics lessons, the *Annual National Assessment: 2013 Diagnostic Report and 2014 Framework for Improvement* (DBE, 2014) does indicate that, since word problems are related to every content area, teachers should provide opportunities for learners to practice them almost daily.

The Foundation Phase CAPS mathematics document (DBE, 2011a) includes a specific topic, *Problem solving techniques* that advises teachers on techniques which could be used to support learners to solve problems. The Intermediate Phase CAPS document (DBE, 2011b) does not have a specific topic related to problem solving techniques. However, it does state that, in order to help learners to gain more confidence and independence when solving mathematical problems, educators should teach them how to check their own solutions and judge the reasonableness of their results, for example by using estimation and inverse operations (DBE, 2011b). In both phases, teachers are guided by long lists of examples of important mathematical problem types (mostly word problems), adjusted for each grade that learners need to master (DBE, 2011a,b).

The Intermediate Phase CAPS mathematics document (DBE, 2011b) indicates that the questions posed in formal assessments should be tailored to suit the abilities of all learners. They are therefore based on four cognitive levels, distributed according to specific percentages: knowledge 25%, routine procedures 45%, complex procedures 20% and problem solving 10%. The latter two levels will require a learner to execute higher-order reasoning and thinking (DBE, 2011b). Thus, for learners to answer 30% of the questions of any formal assessment in the Intermediate Phase will require them to have access to and be proficient in strategies which enable them to reflect upon and control their cognitive processes.

An interesting remark in the Foundation Phase CAPS document for mathematics (DBE, 2011a), under the heading *Mathematics in the Foundation Phase*, states, “In the early grades children should be exposed to mathematical experiences that give them many opportunities ‘to do, talk and record’ their mathematical thinking” (p. 10). While acknowledging the significance of this provision, the question that immediately comes to mind is, why is this limited to the Foundation Phase? Is there any age at which a child does not need to be exposed to mathematical experiences that give them many opportunities “to do, talk and record” their mathematical thinking?

### **3.2.2 The role of metacognition during mathematical problem solving**

Metacognition is acknowledged as one of the most significant predictors of success in complex learning tasks (Dignath & Buttner, 2008; Van der Stel & Veenman, 2010). Kramarski, Mevarech and Arami (2002) further emphasize the importance of

metacognition in supporting learners to develop the confidence needed to tackle authentic, challenging tasks. The field of mathematical problem solving is considered one of the areas where metacognition can play an indispensable role in learners' success (Desoete, 2007; Jacobse & Harskamp, 2009; Kramarski et al., 2002; Veenman et al., 2006).

Kuzle (2013) maintains that the underperformance of learners in mathematical problem solving cannot simply be attributed to insufficient mathematical content knowledge. Such underachievement is strongly related to the failure to analyse the problem, to comprehend the totality of the problem, to evaluate the appropriateness of given information, to organize information in order to formulate a plan, or to evaluate the viability of the plan and the probability of the final solution (Kuzle, 2013). All these require a learner to be metacognitive, specifically taking into account knowledge, awareness, control, regulation and evaluation of cognitive functions (Schraw et al., 2006). Metacognition enables the problem solver to identify the extent of the problem, determine precisely what the problem is, and realize how to go about solving it (Kuzle, 2013).

According to Kennedy (2009), the main element in Schoenfeld's (1992) model to determine one's problem solving ability (see section 2.2) is the capacity to monitor the solution as it unravels and to reconsider each new step as one's understanding of the problem and its constraints emerges. It is important to note, however, that research also indicates that metacognitive processes during mathematical problem solving are linked to numerous non-cognitive influences, such as beliefs, attitudes, affect and motivation (Malmivuori, 2006; Schoenfeld, 2010; Zimmerman, 2008). This interaction between metacognition, cognition and non-cognitive factors will influence the learner's problem solving performance (Carlson & Bloom, 2005; Wilson & Clarke, 2004). Jagals and Van der Walt (2013) found a possible connection in the social, psychological and intellectual domains between metacognitive reflection and the regulation of mathematics confidence. The participants in their research (Grade 8 and 9 learners) reflected upon their mathematical problem solving experiences, both successful and unsuccessful. They recalled that when their confidence levels were high the result was successful mathematical problem solving. This contrasted with the times when their confidence levels were low and their problem solving attempts were unsuccessful (Jagals & Van der Walt, 2013). Thus successful solution of a problem will involve a

complex back-and-forth interplay between different non-cognitive, cognitive, and metacognitive processes (Kuzle, 2013).

Garofalo and Lester (1985), building in part on Pólya's problem solving phases (see section 2.2) and Schoenfeld's (1992) emphasis on metacognition during problem solving, developed a *cognitive-metacognitive framework* to illustrate the cognitive-metacognitive behaviours in which learners would ideally engage during mathematical problem solving. It includes four categories of activities: orientation, organization, execution and verification. However, the type of problem, the learner's ability, experience, knowledge and available strategies will all determine when and where metacognitive actions will take place during the problem solving process, and it will therefore not necessarily follow a strictly linear route (Garofalo & Lester, 1985). Artzt and Armour-Thomas (1992) propose another cognitive-metacognitive framework (see Table 3.1) consisting of eight episodes, specifically to analyse mathematical problem solving in small groups.

**Table 3.1.**

*Framework episodes classified by predominant cognitive level*

<b>Episode</b>	<b>Predominant cognitive level</b>
<b>Read</b>	Cognitive
<b>Understand</b>	Metacognitive
<b>Analyse</b>	Metacognitive
<b>Explore</b>	Cognitive and metacognitive
<b>Plan</b>	Metacognitive
<b>Implement</b>	Cognitive and metacognitive
<b>Verify</b>	Cognitive and metacognitive
<b>Watch and listen</b>	Level not assigned

*Note: Adapted from Artzt and Armour-Thomas (1992, p. 142)*

More recently, Yimer and Ellerton (2010) analysed 17 task-based interviews, from which they identified five phases in the problem solving process and the cognitive and metacognitive behaviours that could be associated with each phase. The five cognitive-metacognitive phases were:

- Phase 1: Engagement – Initial confrontation and making sense of the problem.
- Phase 2: Transformation-formulation – Transformation of initial engagements to exploratory and formal plans.
- Phase 3: Implementation – A monitored carrying out of plans and explorations.
- Phase 4: Evaluation – Passing judgments on the appropriateness of plans, actions and solutions to the problem.
- Phase 5: Internalization – Reflecting on the degree of intimacy and other qualities of the solution process.

From their interview data, Yimer and Ellerton (2010) concluded that each phase was demonstrated by all the problem solvers in the study, but that various pathways were possible between the phases. Yimer and Ellerton (2010), Artzt and Armour-Thomas (1992) and Garofalo and Lester (1985) all conclude that problem solving does not necessarily follow a strictly linear path. Yimer and Ellerton (2010) also noticed that re-reading the problem influenced the metacognitive decisions and/or actions a problem solver would take.

Leading scholars in the field of mathematical problem solving, such as Garofalo and Lester (1985) and Schoenfeld (1983) believe that the failure of most efforts to improve learners' problem solving abilities can be attributed to an overemphasis on teaching heuristic skills at the expense of metacognitive skills. A number of studies have been carried out which indicate that learners' ability to solve mathematical problems improves when metacognition is mediated (Jacobse & Harskamp 2009; Schoenfeld, 1992). Lester (1994) even goes as far as to consider metacognitive processes as the driving forces at all stages of problem solving.

Effective problem solvers will constantly organize and monitor the implementation of their plans, make adjustments or consider alternatives if necessary (Schoenfeld, 1992). On the other hand, learners who do not monitor their work, recognize their mistakes, select appropriate strategies or express their thinking are frequently unsuccessful in mathematical problem solving (Carlson & Bloom, 2005). Schoenfeld (1992) further identifies a clear distinction between the approach taken to problem solving by novices and that adopted by experts, which reinforces the significance of metacognition in successful problem solving. Novices spend most of

their time haphazardly jumping to calculations early on in the process, without questioning the adequacy of their solution plan. Experts, on the other hand, spend most of their time making sense of what the problem is about, usually monitoring their solution process as they proceed (Schoenfeld, 1992). Learners can however become more effective at these kinds of metacognitive behaviours (Schoenfeld, 2013), with the mediational role of the teacher probably the most important link in making learners metacognitively more aware during mathematical problem solving.

### **3.2.3 Empirical studies related to metacognition in mathematical problem solving**

Pennequin et al. (2010) conducted research to determine whether mediation of metacognition could enhance the metacognitive knowledge and skills as well as the mathematical problem solving abilities of third grade learners. The study also explored whether mediation of metacognition had a differential effect according to the learners' mathematics level. The 48 participants were randomly divided into a control group and an experimental group, each group consisting of twelve average achievers and twelve lower achievers. The experimental group received five metacognition mediation sessions based on an interactive approach. The results revealed that all the learners in the experimental group, the low achievers in particular, had meaningfully higher post-test metacognitive knowledge, skills and mathematical problem solving scores. The low achievers solved the same number of problems on the post-test as the average achievers solved on the pre-test. The findings of this study emphasize the positive relation between metacognition and problem solving and the importance of explicitly teaching metacognitive strategies for solving mathematical problems, to the benefit of all learners and especially those who experience difficulties with mathematical problem solving.

A further study, carried out by Desoete et al. (2003), involved 237 third grade learners from seven elementary schools. It set out to assess the effectiveness of a short metacognitive intervention, combined with algorithmic cognitive instruction, in solving mathematical problems. The participants were randomly distributed into five different groups. Only one group received explicit metacognitive strategy instruction with algorithmic direct cognitive instruction. The second group received only algorithmic direct cognitive instruction. The third group took part in a motivational program, while

the fourth group was exposed to a quantitative-relational condition. The last control group was only exposed to small group intervention.

Learners in the metacognitive group showed considerable improvement in their post-test mathematical problem solving scores. This positive outcome was obtained by adding an aspect of offline metacognition to the mathematical problem solving treatments. Offline metacognition refers to those metacognitive aspects which can be measured before or after the solving of exercises such as prediction and evaluation (Desoete et al., 2003). Prediction, the aspect of offline metacognition used in the study by Desoete et al. (2003), appears to be an adjustable metacognitive skill, as the metacognitive group was the only group which had higher post-test prediction scores. Evidently, offline metacognitive strategies need to be taught explicitly and cannot be assumed to develop through spontaneously experiencing mathematics.

Özsoy and Ataman (2009) conducted a study with a quasi-experimental design to explore the effect on mathematical problem solving achievement of using metacognitive strategy teaching. A total of 47 fifth grade learners from the same public primary school in Turkey participated in the study, which took place over a nine-week period. The learners were assigned either to a treatment group ( $n = 24$ ) or a control group ( $n = 23$ ). The pre-test concluded that there was no significant difference between the two groups. Only learners in the treatment group received metacognitive strategy instruction. The control group solved the same problems as the treatment group, but without any metacognitive strategy instruction. Learners were pre-tested and post-tested using the Mathematical Problem Solving Achievement Test and the Turkish version of the Metacognitive Skills and Knowledge Assessment. The post-test results showed that learners in the metacognitive treatment group significantly improved in both their mathematical problem solving and their metacognitive skills. This study also indicated that metacognitive behaviours were triggered when learners were asked questions about their own thinking processes during problem solving activities.

Iiskala et al. (2011) believe that individual metacognition is not the same as inter-individual metacognition in collaborative learning situations, and have coined the term “socially shared metacognition” (p. 379). This refers to the unified monitoring and regulation of shared cognitive processes during challenging cooperative problem solving (Iiskala et al., 2011). A vast range of research on individual metacognition has been gathered over the last four decades, starting with the ground-breaking work of

Flavell (1976) and Brown (1987). Iiskala et al. (2011) argue that most learning and problem solving take place in social situations and that social relations influence learning and problem solving in many ways, a conclusion which strongly resonates with Vygotsky's sociocultural theory (see section 2.2). Even though interest in metacognition as a social process is still relatively new, it has recently gained increased attention from researchers. Larkin (2009), for example, acknowledges the shift from the earlier individualistic models of metacognition towards a view of how it might be socially mediated. Iiskala et al. (2011) critically recognize that initial definitions of metacognition only give credit to the *self* and the *individual* and suggest that it should rather be described as the product of interaction between an individual and the surrounding social and cultural context.

Given this view of metacognition as socially mediated, several studies have recently been conducted to look at the social influence on metacognitive development. Kim et al. (2013), for example, conducted a single-case naturalistic case study to explore individual and social metacognition during a Model-Eliciting Activity (MEA). An MEA is a team-oriented, interdisciplinary and realistic problem solving task which exposes participants' thinking. The participants were four learners from the eighth grade class in an all-girls middle school in South Korea. They were purposefully selected because of their positive attitudes and well verbalized understanding during problem solving. The MEA was designed in such a way that multiple levels of metacognitive functions were invoked during the complex problem solving experience. The study aimed at identifying the sources that trigger metacognition at the individual level, the social level and the environmental level. It was believed this would resolve the paradox of metacognition, that metacognition is personal but cannot be interpreted entirely by individualistic conceptions.

The results of this study emphasized the different levels of complexity in problem solving when metacognitive learning environments are adopted in order to trigger metacognition on the individual as well as the social level. From a sociocultural perspective, one could argue that the teacher should ensure that the level of complexity of the mathematical problem should be within the zone of proximal development (see section 2.3.3) in order to activate metacognition. The study further stressed the value of interactions with peers as social sources for improving metacognitive learning environments. The researchers regarded social sources as catalysts which empower

individuals to surpass their limited ability to self-monitor and self-evaluate their problem solving, thus increasing opportunities to develop metacognition. This conclusion mirrors Vygotsky's general genetic law of cultural development in the internalization of an individual's metacognitive development (see section 2.3.2). Kim et al. (2013) propose that teachers should consider individual, social and environmental levels when developing metacognitive activities focusing on problem solving.

A further study investigating the differential effects of cooperative learning, with or without metacognitive instruction, on lower and higher achievers' solutions of mathematical problems was conducted by Kramarski et al. (2002). A total of 91 seventh graders (mean age 12.3 years) from two schools in Israel took part in the study. The participants studied mathematics under one of two conditions: cooperative learning embedded within metacognitive instruction (COOP+META) and cooperative learning with no metacognitive instruction (COOP). Each of the small groups within the two larger groups consisted of one high achiever, one low achiever and two middle achievers. Participants from the COOP+META condition were trained to formulate and answer comprehension, connection, strategic and reflection questions. The findings of the study indicated that the COOP+META learners significantly outperformed the COOP learners on all problem solving tasks. Even though both higher and lower achievers benefited from the metacognitive instruction, the relative effect was much larger for lower than for higher achievers in the standard tasks.

These studies demonstrate the importance of employing teaching approaches which mediate metacognitive strategies, helping learners become more metacognitive during problem solving. It is also encouraging to notice the positive effect such metacognitive mediation has on learners who usually achieve at a lower standard.

#### **3.2.4 The role of the teacher during mathematical problem solving**

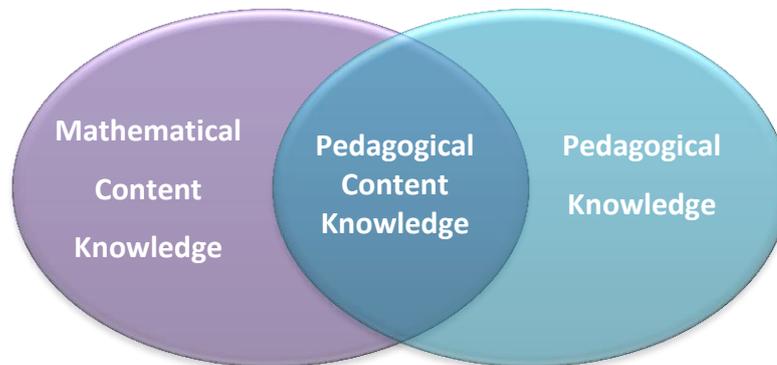
Against the background of the theoretical framework of Lev Vygotsky's sociocultural theory (see section 2.2), mathematical problem solving should be viewed as a multi-layered model, with a dynamic interplay between cognitive, psychological and sociocultural factors in the learning process. This multi-layered model influences the way in which learners will experience the mathematics being taught to them (Lester, 2013). It includes the teacher's role, the classroom environment, type of tasks, the social culture of the classroom, the use of mathematical tools to support learning, as

well as issues of equity and accessibility (Lester, 2013). Such a model, according to Kennedy (2009), indicates that the type of activities in which learners participate in the classroom have a significant impact on the development of their cognitive, metacognitive and communicative functions, either to encourage or obstruct successful problem solving. The importance of the more knowledgeable other during the process of mathematical problem solving in the micro-culture of the classroom cannot be overemphasized (Kennedy, 2009). Veenman et al. (2006) confirm that learners gain metacognitive knowledge from their parents, peers and teachers in informal settings, as Vygotsky proposes in his sociocultural theory. However, the metacognitive knowledge gained from these different circumstances will vary; the intentional mediation of metacognition in the classroom is therefore essential to ensure that all learners have equal opportunities to gain metacognitive knowledge.

Kennedy (2009) observes that most research on mathematical thinking, teaching and learning is devoted to the study of learners and that the role of the teacher is less studied. This was already a concern for Lester and Charles in 1992 and they identified four areas of weakness in the research of mathematical problem solving undertaken at that time: (1) limited research on the role of the teacher, (2) insufficient studies on what happens in real classrooms, (3) a focus on individual learners rather than small groups or whole classes, and (4) the largely atheoretical nature of problem solving research. The aim of the present study will therefore be to contribute to the body of existing knowledge in the discipline of mathematical problem solving specifically by exploring the *role of teachers* as mediators in *real classrooms* focusing on *small groups* and *whole classes* from a *sociocultural perspective*.

Recently researchers such as Schoenfeld and Kilpatrick (2008) and Lester (2013) have focused more on the role of the teacher, maintaining that those who teach mathematical problem solving must themselves be proficient in the required knowledge and range of skills. If the goal of teaching problem solving is the development of metacognition, then the teacher's role will be threefold: (1) as an external monitor, (2) as a mediator of learners' metacognitive knowledge, and (3) as a model or ideal form of a metacognitively proficient problem solver (Lester, 2013). Extant research indicates that teachers need different types of knowledge in order to successfully teach mathematics (Anthony & Walshaw, 2009; Ball, Thame & Phelps, 2008; Carnoy & Chisholm et al., 2008; DHET, 2011; Hill & Ball, 2009; Hill, Ball & Schilling, 2008;

Lester, 2013). Most researchers in the field of mathematical teaching agree that teachers need to be proficient in at least three types of knowledge, as illustrated in Figure 3.1.



**Figure 3.1. Types of knowledge that underpin mathematics teachers' practice**

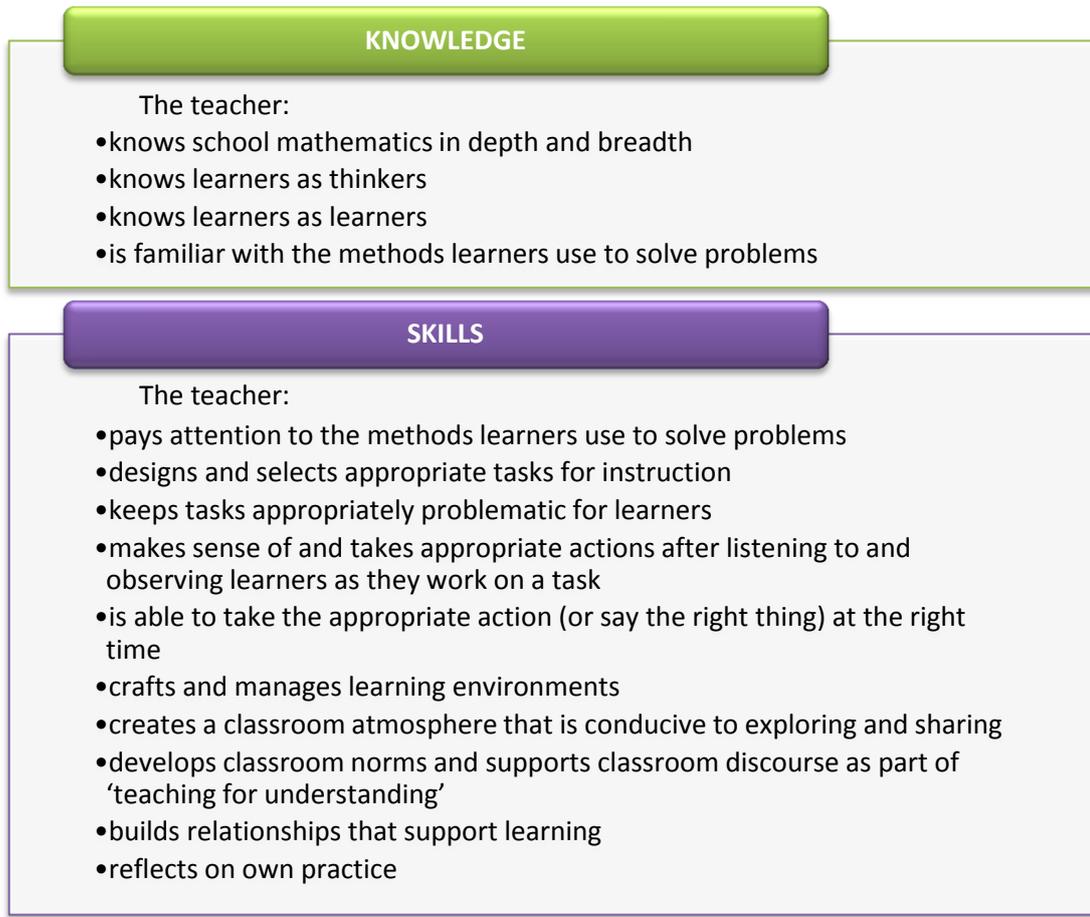
*Mathematical content knowledge* generally refers to a teacher's knowledge of the subject content of mathematics, while *pedagogical knowledge* relates to classroom management and the teaching repertoire, which are not subject-specific. At the intersection of mathematical content and pedagogical knowledge lies a specialized hybrid type of knowledge, *pedagogical content knowledge*. The DHET (2011) refers to this as "knowing how to represent the concepts, methods and rules of a discipline in order to create appropriate learning opportunities for diverse learners, and how to evaluate their progress" (p. 8). In a study conducted by Carnoy et al. (2008) among Grade 6 mathematics teachers in the Gauteng Province of South Africa, it was identified that many of them possess neither high mathematical content knowledge nor pedagogical content knowledge. When teachers with poor content knowledge make mistakes learners can feel frustrated and perceive mathematics either as ineffectively taught or too difficult (Carnoy et al., 2008).

It is not always an easy task for a teacher to precisely tailor the support learners need during mathematical problem solving (Goos et al., 2002). A teacher's mediation can even guide learners in the wrong direction and can obstruct instead of clarifying their thought processes during problem solving (Goos et al., 2002). Teachers should therefore be conscious about the timing of intervention and indeed whether to intervene

at all. Larkin (2009) argues that teachers can sometimes deny learners the opportunity to activate or develop their metacognition by not allowing them enough time to reflect on their thinking. For this reason, prescriptive instruction should not be given during problem solving (Holton & Thomas, 2001). A clear pedagogical understanding of metacognition is needed in order to teach learners to be metacognitive (Wilson & Bai, 2010). Unfortunately, many teachers lack sufficient knowledge about metacognition (Veenman et al., 2006). Many teachers are eager to invest effort in the mediation of metacognition (Veenman et al., 2006), but they need tools and strategies or, as Wilson and Bai (2010) refer to it, a pedagogical understanding of metacognition.

Schoenfeld and Kilpatrick (2008) and Lester (2013) suggest a framework for proficiency in teaching mathematics that illuminates a few aspects they believe could make a mathematics teacher more proficient. Lester (2013) considers teachers who demonstrate these knowledge and skills to be *craftsmen*. In this context, a true craftsman can be distinguished from others by the quality and quantity of planning and reflection that are done both before and after a lesson, as this has a valuable impact on classroom teaching (Lester, 2013). Effective teachers plan mathematical learning experiences and make teaching decisions around learners' present knowledge and interests (Anthony & Walshaw, 2009). This relates to Vygotsky's (1978) notion of the zone of proximal development (see section 2.3.3). If learners have insufficient prior knowledge to make a breakthrough in solving a problem they may become disengaged (Collins, 2012). The teacher therefore needs to keep learners engaged within their zones of proximal development, where they will be appropriately challenged but without feeling overwhelmed.

Effective mathematics teachers acknowledge the significant role they can play in giving learners opportunities to improve their ability to communicate, reflect and think critically about their problem solving practices (Watson, 2001). Their theoretical perspectives on how learners learn can influence what they regard as relevant and appropriate, and in effect can restrict the way they teach in the classroom (Schoenfeld & Kilpatrick, 2008). Figure 3.2 shows a synthesis of the knowledge and skills a proficient mathematics teacher should display, as suggested by Schoenfeld and Kilpatrick (2008, p. 322) and Lester (2013, p. 263).



**Figure 3.2. A provisional framework for proficiency in teaching mathematics (Schoenfeld & Kilpatrick, 2008, p. 322; Lester, 2013, p. 263)**

Whether the teacher's epistemological position is unequivocal or not, the mathematical atmosphere that teachers create can directly be attributed to what they think mathematics is, and in turn this will shape the understandings of their learners (Schoenfeld, 1992). However, it is essential to recognize that there can often be a discrepancy between what a teacher claims to believe is important in classroom teaching and what he or she actually practices (Schoenfeld & Kilpatrick, 2008).

All learning is culturally shaped and defined. Learners develop their conceptions of what they learn from their involvement in the community of practice where the learning takes place (Schoenfeld, 1992). This mirrors Vygotsky's (1978) sociocultural theory, which claims that learners not only acquire knowledge and skills about mathematics as prescribed by a curriculum, but are fundamentally influenced by the culture of the community of practice. The teacher as mediator plays an indispensable role in this community of practice, enabling all learners to become

creative, flexible and independent problem solvers destined to be successful citizens in an ever-demanding 21<sup>st</sup>-century.

It is therefore not surprising to find that one of the policy suggestions in the SACMEQ III report is that higher education institutions in South Africa should educate student teachers to develop appropriate tasks and assessments which include all levels of learning and that these students should demonstrate a practical ability in supporting learners to solve higher-order questions (Moloi & Chetty, 2010). Furthermore, in-service teachers should be granted in-service training opportunities that specifically focus on answering their questions on how they can support their learners in attaining higher levels of achievement (Moloi & Chetty, 2010).

### **3.3 DIVERSITY IN THE CLASSROOM**

Today teachers face classrooms that include a wide variety of learners, each with their own specific educational needs. Learners in the same classroom can differ in many ways, such as their gender, cultural background, experiences, abilities, interests, or home language. All have the right to education, as proclaimed in Article 1 of the declaration adopted by the World Conference on Education for All (WCEFA) convened in Jomtien, Thailand (1990), “Every person - child, youth and adult - shall be able to benefit from educational opportunities designed to meet their basic learning needs” (p. 3). This proclamation is further endorsed by the Salamanca Statement, from the World Conference on Special Needs Education in 1994 in Salamanca, Spain (UNESCO, 1994). The Salamanca Statement underscores the fundamental right of every child to education and recognizes that each learner is a unique individual with his or her own interests, abilities and learning needs. Education systems should inclusively meet the diverse learning needs of all learners when implementing educational programmes (UNESCO, 1994). South Africa has followed suit and produced its own policy documents, among them *Education White Paper 6: Special Needs Education – Building an inclusive education and training system* (DoE, 2001), *Guidelines for Full-Service/Inclusive Schools* (DBE, 2009), *Guidelines for Inclusive Teaching and Learning* (DBE, 2010) and *Guidelines for Responding to Learner Diversity in the Classroom through Curriculum and Assessment Policy Statements* (DBE, 2011d). All these documents direct educational institutions towards inclusive education. White Paper 6 (DoE, 2001) places emphasis on the importance of providing education that is

responsive and sensitive to the diverse range of learning needs in schools. *The Guidelines for Responding to Learner Diversity in the Classroom through Curriculum and Assessment Policy Statements* (DBE, 2011d) stresses the vital importance of differentiated instruction in giving all learners access to the curriculum. The very notion of respecting diversity directly implies an acceptance that all learners have the potential to learn (DBE, 2011d).

Teachers, however, need to know how to respond to this growing diversity in their classrooms (DBE, 2011d; Edwards, Carr & Siegel, 2006; Huebner, 2010; Levine, 2003; Martin, 2006; Subban, 2006; Tomlinson, 2001, 2004, 2005; Tomlinson & Imbeau, 2012; Wallace, 2007). A one-size-fits-all curriculum and lessons delivered using a unitary instructional style disregards the diversity in classrooms and thus fails to meet the needs of most learners (Tomlinson, 2001). Probably one of the greatest weaknesses of traditional instruction is that teachers *teach to the middle* (Rock, Gregg, Ellis & Gable, 2008), meaning that the needs of many learners in the classroom are not addressed. Or as Vygotsky (1997, p. 324) boldly states, “To force everybody into the same mould represents the greatest of all the delusions of pedagogics”.

A one-size-fits-all approach to instruction makes learners who experience barriers to learning particularly vulnerable, leading many of them to perform poorly on standardized tests, followed by high dropout rates, low graduation rates and high levels of unemployment (Lipsky, 2005). On the other hand, gifted learners may experience learning as boring and repetitious, since they have probably already mastered the work *taught to the middle*, and they too therefore often do not reach their full potential (Lee & Olszewski-Kubilius, 2006). The Salamanca Statement (UNESCO, 1994) criticizes the poor quality of teaching and a one-size-fits-all mentality, seeing them as a waste of resources and leading to the shattering of hopes.

One response to the growing diversity of learners' needs is the philosophy of differentiated instruction. The Salamanca Statement advocated this approach, since it has been proved to considerably reduce dropout and repetition rates, while confirming higher average levels of achievement (UNESCO, 1994). Enthusiasts of differentiated instruction and its effectiveness declare that it is the only way to successfully teach all learners in an inclusive classroom (Koutselini, 2006; Tomlinson, 1999, 2001).

### 3.4 DIFFERENTIATED INSTRUCTION

The DBE (2010) *Guidelines for Inclusive Teaching and Learning* defines curriculum differentiation as follows:

It is the process of modifying or adapting the curriculum according to the different ability levels and learning styles of learners in one class. Differentiation is intrinsic to all aspects of flexible curriculum delivery, namely the content selection, the way in which it is taught or presented and the way in which the learner's performance is assessed. (p. 6)

The *Guidelines for Responding to Learner Diversity in the Classroom through Curriculum and Assessment Policy Statements* (DBE, 2011d) states that differentiation is concerned with thinking about learning and teaching in different and novel ways. It should be seen as an innovative process which constantly evolves, as opposed to a recipe. Carol Ann Tomlinson (2005), a leading expert and advocate of this approach, regards differentiated instruction as a teaching philosophy, rather than a teaching strategy. It is based on the premise that learners do best when their teachers adapt their teaching to accommodate the differences in their learners' readiness levels, interests and learning preferences. Tomlinson (2001, 2003) believes that differentiated instruction *liberates learners from labels*, creating an ideal platform for teachers to provide them with opportunities to succeed. This philosophy of differentiated instruction mirrors the child-centred pedagogical view of the Salamanca Statement, which accepts human differences as normal and proposes that teaching be adapted to the needs of the learner, rather than expecting them to fit into the predetermined pace and teaching of the teacher (UNESCO, 1994). Child-centred schools are envisioned as the training ground for a people-oriented society, one which respects the differences and dignity of all human beings (UNESCO, 1994).

The philosophy of differentiated instruction is based primarily on Vygotsky's (1978) sociocultural theory (see section 2.2) which regards the active involvement of learners and their interaction with their environment as defining factors in the learning process (Subban, 2006; Valiande, Kyriakides & Koutselini, 2011). The significant influence that language, culture, social interaction and context have on learning and development, as emphasized by sociocultural theory, is particularly relevant when determining how to support diverse learners most effectively (Mahn & John-Steiner,

2013). Differentiated instruction is in essence social and reciprocal, regarding the teacher as primarily responsible for what happens in the classroom, but placing a high value on the response of the learner (Tomlinson, 2004). Kanevsky (2011) is in favour of 'differentiated differentiation', in which learners are welcomed to make their own learning preferences known and are subsequently considered when adjustments are made to the curriculum.

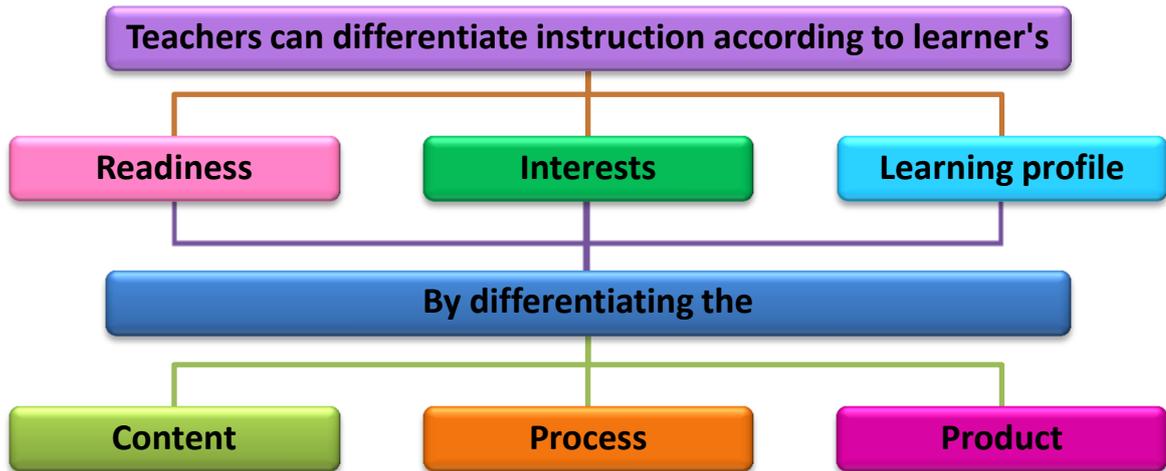
Most teachers naturally employ aspects of differentiated instruction to a greater or lesser degree in their classrooms (Alberta Education, 2010). However, when they commit to the philosophy of differentiated instruction, they will need to intentionally focus on the best teaching practices in an explicit and systematic manner, to the benefit of all learners in the classroom (Alberta Education, 2010).

### **3.4.1 The role of the teacher in differentiated instruction**

The teacher is the qualified professional in the classroom, the person expected to use strategies that will help all the learners in the classroom to reach their potential and find success in their learning journey (Tomlinson, 2004). Teachers are legally and ethically responsible for mediating learning in a way which is sensitive to the diverse needs of their learners and which will lead them to full development (DHET, 2011; Lawrence-Brown, 2004; Tomlinson, 2004).

The role of the teacher in a differentiated classroom differs significantly from that of a more traditional teacher (Tomlinson, 2001). Teachers who differentiate their teaching see themselves as organizers of learning opportunities, as opposed to their more traditional colleagues who see themselves as keepers and dispensers of knowledge (Tomlinson, 2001). One of the most important factors in successfully differentiating instruction is teachers' awareness of and response to the individual strengths, needs, prior knowledge, attitudes, learning styles and readiness of their learners (Edwards et al., 2006; Gregory & Chapman, 2013).

The fundamental notion of differentiated instruction envisages a teacher who is flexible in content, process and product and who can identify each learner's readiness level, interests and learning profile, and then mediate learning accordingly (Levy, 2008; Tomlinson, 2003). Figure 3.3 illustrates how teachers can differentiate instruction, either by content, process or product, according to a learner's readiness levels, interests, learning profiles or any combination of these.



**Figure 3.3.** Teachers' differentiation of instruction (Gregory & Chapman, 2013; Levy, 2008; Tomlinson, 2001)

#### **3.4.1.1 Differentiation of content, process and product**

What we teach and what we want learners to learn is the *content*; that is, the curriculum (Levy, 2008; Rock et al., 2008; Tomlinson, 2001). The content, however, should be differentiated in such a way that learners are appropriately challenged, finding the content neither too easy nor too difficult, so that they are working in their zones of proximal development (Tomlinson & Kalbfleisch, 1998). The central goal of differentiated instruction is to ensure that all learners have cognitive access to a high-quality curriculum (Rock et al., 2008).

The *process* can be seen as the activities in which learners engage in order to make sense of the content (Tomlinson, 2001). When the process is differentiated, the learners should all be able to make sense and take ownership of what is being taught, progressing from their current level of understanding to a higher level of understanding (Gregory & Chapman, 2013; Tomlinson, 2001).

The learners' personal interpretation of what they have learned and made their own is demonstrated by the *product*, such as a test, project or paper (Gregory & Chapman, 2013; Levy, 2008; Pierce & Adams, 2005). Tomlinson (2001) suggests that teachers should allow learners different options, with clear guidelines as to the elements required to express their acquired learning.

### 3.4.1.2 *Learners' readiness levels, interests and learning profile*

It is essential for a teacher to know where to start in order to ensure that each learner's learning experience is meaningful and enriching (Martin, 2006). Tomlinson (2001) believes that learners are more successful in school when tasks are aligned with their prior knowledge and skills in a topic (readiness), trigger curiosity and attention (interest), and enable them to work in a favoured way (learning profile). To discover the individual qualities learners bring to the class, the teacher should introduce activities such as pre-tests, observations, questioning, and interest surveys as ways of gathering information (Martin, 2006).

Vygotsky (1978) asserts that new learning takes place in an individual's zone of proximal development (ZPD). Therefore a task, designed according to a learner's *readiness*, should be just beyond what the learner can manage without support. The teacher or more knowledgeable other will then need to mediate between the known and unknown of the task, moving the learner towards the area of independence (Tomlinson et al., 2003).

All learners have *interests*, preferences and passions. Their motivation and learning are enhanced when teachers create opportunities in the classroom for them to explore and express their interests and relate them to their learning (Lawrence-Brown, 2004; Siegle & McCoach, 2005; Subban, 2006). Looking at a topic of study through the lens of their own interests helps them to see the links between school and the things which fascinate them, giving them a sense of the connectedness between all learning (Tomlinson, 2001).

*Learning profile* refers to the ways in which an individual learns best and can be used as an umbrella term for at least four often overlapping factors which can impact on learning: gender, culture, learning style, and intelligence preference (Tomlinson & Stone, 2009). The two main objectives of differentiating according to learning profile are to help learners understand which mode of learning suits them best and to offer them different learning opportunities in the classroom through which they can find a way which best fits their learning profile (Tomlinson, 2001).

While Tomlinson (2001) believes there is no recipe for differentiated instruction, she does identify three broad principles: (1) the use of respectful activities, (2) flexible grouping, and (3) ongoing assessment that a teacher can apply to establish a

differentiated classroom. Firstly, *respectful activities* means suggesting interesting and engaging tasks which offer equal access to essential knowledge and skills to all learners (Little, Hauser & Corbishley, 2009; Pierce & Adams, 2005). The learners will not all be expected to deliver the same product; instead, they will work towards the same objectives, but at levels appropriate to their developmental learning needs and readiness (Little et al., 2009). Although their tasks are differentiated, no learner or group should be expected to do *busywork* while other learners in the class are doing something *jaw-dropping* (Pierce & Adams, 2005).

*Flexible grouping* is one of the cornerstones of a classroom where differentiated instruction is valued and practised (Tomlinson, 2001). It is more fluid and effective than static grouping by ability, since it allows for frequent assessment of learners' growth; depending on the assessment, a learner can be moved to a different group (Tieso, 2002; Tomlinson, 2006). The variety of scenarios allows learners to be grouped according to their readiness levels, interests or learning profiles at different times (Chapman & King, 2005). Apart from times when they work with peers who are on the same level of readiness, have the same interests or who learn in the same way, learners can be assigned randomly by the teacher to different work groups, select their own work groups, be taught as part of a whole group, or even work individually (Tomlinson, 2001). They can also be divided into groups that are completely heterogeneous in terms of readiness levels, interests or learning profiles (Tomlinson, 2001).

Gregory and Chapman (2013) use the acronym TAPS (T=Total groups, A=Alone, P=Partners and S=Small groups) as a guide to the different types of groups in a differentiated classroom where flexible grouping is practised. Regular flexible grouping arrangements help to avoid the fixing of static roles, where some learners are always seen as the helpers and others as the helped (George, 2005). Groups can be modified from lesson to lesson or day to day, depending on the learners' readiness and interests as revealed by on-going assessments (Little et al., 2009).

The principle of formative or *on-going assessment* also informs teaching (Tomlinson, 2001). A teacher can purposefully select a variety of formal and informal tools to assess learning before, during and after teaching (Gregory & Chapman, 2013).

Such on-going assessment should be practised during teaching/learning<sup>1</sup> to determine learners' levels of understanding and skill and to inform the next instructional steps (Gregory & Chapman, 2013). On-going assessments do not always have to be graded, as their main goal is to ensure that learning is optimal. Moreover, grading consumes a teacher's time, and can also inhibit learners from taking mental risks (Tomlinson, 2005; Gregory & Chapman, 2013).

### 3.4.2 Obstacles in the way of differentiated instruction

Even though the benefits of differentiating instruction are well documented, the literature also indicates that there is a lack of differentiated instruction in schools and that many teachers resist using differentiated instruction (Cusumano & Mueller, 2007; Lewis & Batts, 2005; McQuarrie & McRae, 2010; Reis, McCoach, Little, Muller & Kaniskan, 2011; Servilio, 2009; Tomlinson, Brimijoin & Narvaez, 2008; Valiande et al., 2011). One reason for this is that many teachers do not have an image of what such a classroom looks like, as they teach in the way they themselves were taught (Tomlinson, 2005). Even when teachers indicate the need to attend to learners' individual differences, they often do not turn these insights into practice since most people do not welcome change (Tomlinson & Imbeau, 2012). A further factor in this resistance is the lack of training for teachers in the field of differentiated instruction. An in-depth understanding of the philosophy behind it could transform their thinking and engender change (Subban, 2006; Tomlinson, 2005).

Stetson, Stetson and Anderson (2007) asked 48 primary school teachers who had spent a semester experimenting with differentiated instruction to identify challenges they had experienced in implementing it. Among these were shortages of resources, limited time to prepare, teach and assess in a differentiated manner, on top of an already overwhelming time schedule (Stetson et al., 2007). However, all unanimously agreed that the benefits of differentiated instruction significantly overshadowed the challenges of time and planning (Stetson et al., 2007).

Certain misconceptions about differentiated instruction can lead teachers to resist implementing such an approach (Wormeli, 2005). Prevailing myths include the belief that learners will be unprepared for standardized tests when teaching is

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<sup>1</sup> Teaching/learning is used as a translation of the Russian word *obuchenie* which refers to both teaching and learning as a joint process involving teachers and learners (Kozulin, 2011).

differentiated, that teachers have to individualize teaching, resulting in unbalanced workloads, and that the standard of learners' performance will decline leaving them ill prepared for the real world (Wormeli, 2005).

Research by Wormeli (2005), however, found quite the opposite. Firstly, learners will be better prepared for standardized tests, as they learn the content in a way that is easiest for them. Secondly, differentiated instruction is not the same as individualized teaching, and no teacher is expected to individualize teaching for all learners all the time. Lastly, teachers who differentiate their teaching do not teach things in just one way. They maximize learning wherever possible, encouraging learners to be even more competent in their contributions to real life (Wormeli, 2005).

In South Africa, a study conducted by Oswald and De Villiers (2013) on teachers' and principals' perceptions of how the gifted learner is included in the classroom mirrors many of the same concerns researchers found in other regions of the world. Obstacles identified by Oswald and De Villiers (2013) that hinder differentiation in the classroom include high teacher-learner ratios, the growing diversity among learners; a shortage of resources such as suitable learning materials and equipment such as computers, and teachers' increasing administrative burden. The teachers admitted that differentiated instruction could be advantageous to all learners, but that the obstacles they faced prevented them from becoming the great teachers they would like to have been (Oswald & De Villiers, 2013).

### **3.4.3 Differentiated instruction in mathematical problem solving**

One of the concerns identified by the DBE (2013) is that too many teachers in the Foundation Phase are unaware of the level at which each of the learners in their class is working. As a result, they are unable to offer suitably differentiated activities to meet the needs of each learner. This lack of knowledge by the teacher can be partly attributed to the effect of too much whole-class teaching. To gain a better understanding of the mathematical level of each learner, Foundation Phase teachers need to work with small groups of learners on the mat on a regular basis (DBE, 2013).

Problem solving is a good place to attempt differentiating teaching in the mathematics classroom, as each part of the problem solving process allows opportunities for differentiation (Murray & Jorgensen, 2007). Murray and Jorgensen (2007) take a clear Vygotskian stance when they remind teachers that learning is most

effective when the challenge is moderate, thus placing it in the zone of proximal development. The process of mediation is also reinforced, as differentiation and guidance can take place at all stages of the problem solving process, when the problem is posed, during the exploration stage, and at the end when the process is summarized, reflected upon and new understanding is assessed (Murray & Jorgensen, 2007).

A common misunderstanding among teachers is that differentiation takes place when some learners are assigned more work than others (Tomlinson, 2001). It seems logical to think that learners who are struggling with mathematical problem solving should be presented with fewer problems, while the more advanced learners should be given more. In reality, this is usually an ineffective strategy (Tomlinson, 2001). Differentiated instruction should rather be seen as more qualitative than quantitative (Tomlinson, 2001). A struggling learner will still need support to solve a problem, even if the number of problems is reduced, while a more advanced learner who can solve a certain type of problem will be ready to move to a new type of problem. Assigning more of the same problem to such a learner reduces it to a mere exercise (Schoenfeld, 1992; Tomlinson, 2001). This notion is echoed in the *Guidelines for Inclusive Teaching and Learning* (DBE, 2010) when it refers to mathematical problem solving:

The number of examples and activities to be completed should be adapted to accommodate learners experiencing barriers to learning. However, the thought process used to do the calculation or solve the problem should not be compromised. The quality of the skills to solve problems should not be comprised for the quantity of problems solved. (p. 29)

Small (2010) proposes that teachers use parallel tasks, or as many other authors refer to them, tiered assignments, as a strategy in mathematical teaching (Adams & Pierce, 2004; Levy, 2008; Tomlinson, 2001). The key concept in a problem is retained, but the teacher creates different levels of difficulty in the tasks according to the variations in the learners' readiness (Small, 2010). Thus learners with different interests, readiness levels and learning profiles arrive at the same understanding of the concept, but are allowed to follow different pathways to get there (Adams & Pierce, 2004). Using the differentiation strategy of tiering, mathematics teachers can present all their learners with challenging tasks, ensuring sufficient mediation for those who are struggling while simultaneously minimizing repetition for the more advanced (Little et

al., 2009). Metacognitive knowledge is especially important when learners' select which tiered assignment will best meet their own understanding (Frey, 2005).

Differentiating mathematical problems in this way will encourage learners to be more engaged and motivate them in solving problems to which they can relate (Cotic & Zuljan, 2009; Murray & Jorgensen, 2007). The learner experiences the problem as something real which creates cognitive tension, not merely a routine or exercise to be completed (Cotic & Zuljan, 2009). If the problem is tailored to their needs, taking into account their readiness levels, they are more likely to make an effort to solve it (Murray & Jorgensen, 2007). While some learners in a class will be able to go beyond the solution and make their own assumptions and generalizations, others may only manage a part of the solution (Murray & Jorgensen, 2007). The latter group are however included in the discussion when classmates explain their thinking of how the problem can be solved, offering them another opportunity for conceptual development (Murray & Jorgensen, 2007). Worthy role-models, such as teachers who share their thinking processes through modelling, can help learners to learn more easily and accelerate their learning (Wallace, 2007). The importance of discussion in a differentiated classroom during mathematical problem solving is supported by sociocultural theory, with its emphasis on the mediational role of language as the tool through which learners make sense of their environment and the development of higher-order thinking such as problem solving (Vygotsky, 1986).

More than ever before, the effectiveness of teachers will depend on their capacity to meet the diverse needs of all the learners in their classrooms (Frey, 2005). Research by the National Research Council (2005) on which aspects are the most critical for effective learning in history, mathematics and science established three vital factors: (1) understanding learners' initial level of knowledge and anticipating their misconceptions, (2) developing a solid foundation of factual knowledge, and (3) teaching for metacognition to encourage more active learning. Frey (2005) believes these pedagogical objectives can be achieved by employing teaching strategies such as summative and formative assessments, mediation and flexible grouping that allow the teaching/learning process to be adapted to each learner's needs. However, only under the umbrella of the philosophy of differentiated instruction can these teaching strategies be implemented in an organized and consistent manner (Frey, 2005).

### 3.5 SUMMARY

The literature review in this chapter aimed to gain insight into what exactly mathematical problem solving is and how it is positioned in the new Curriculum and Assessment Policy Statements (CAPS) for the Foundation and the Intermediate Phase. It highlighted the importance of the interplay between cognition and metacognition in enabling learners to successfully solve a mathematical problem and the indispensable role of the teacher in mediating this process in the classroom.

The philosophy of differentiated instruction and its constructs, seen as a possible solution to the growing diversity in classrooms, were explored. The body of knowledge reviewed in Chapters 2 and 3 of this thesis will help in understanding the meaning of the data gathered during the research process.

Most research on mathematical thinking, teaching/learning is devoted to the study of learners, and the role of the teacher is seldom explored. No extant studies were found examining the mediation of metacognition by teachers who had no prior formal metacognitive strategy training. While there is evidence from national and provincial assessments in South Africa of a significant decline in mathematical performance from the beginning of the Foundation Phase to the end of the Intermediate Phase, no studies could be found that addressed this elephant in the room.

It is these gaps in the literature that this research study will address. I will explore how teachers mediate metacognition during mathematical problem solving in diverse classrooms, focusing on a school where results from national and provincial assessments indicated an above-average performance. The next chapter will discuss the research design and methodology that will be implemented in order to collect the data needed to answer the research questions.

# CHAPTER 4

## RESEARCH DESIGN AND METHODOLOGY

### 4.1 INTRODUCTION

The review of the literature, as discussed in the previous two chapters, offers ample evidence for the powerful impact that the mediation of metacognition during mathematical problem solving can have on learners' performance. It also highlights the benefits they can derive from differentiated instruction. Exploring how the teachers mediate metacognition during mathematical problem solving and how they differentiate their teaching in a school whose results show evidence of better performance than in most other South African schools can provide valuable insights in answering the research questions.

The following research questions, introduced in section 1.4, underlie all aspects of this inquiry:

1. How do Foundation and Intermediate Phase teachers mediate metacognition during mathematical problem solving?
2. How do Foundation and Intermediate Phase teachers differentiate the mediation process during mathematical problem solving in such a way as to support all the learners, given their diverse abilities and needs?
3. How do teachers in the Foundation and Intermediate Phases differ in the way they mediate metacognition during mathematical problem solving?

Answering these questions is both relevant and necessary in an ever-changing and *ever-challenging* educational environment. Teachers are increasingly expected to support learners with different abilities, while simultaneously improving their results on standardized assessments. In this study, I accept that I have a responsibility both to my colleagues and to the learners, all of whom I believe could benefit from my findings. To this end, I will do my best to address the research questions as thoroughly as possible.

It is essential to bear in mind that researchers differ in the way they experience and view the world in which they live. This means that there are various possible

approaches to how a study can be conducted. Why and how a researcher selects a certain approach, one which will best suit the purpose of a study, will depend on his or her own paradigm or worldview. To explain my own approach, I will first discuss the research paradigm and the philosophical assumptions which underpin the study. I will then shift the focus to the research design and discuss the case study approach I have selected for this inquiry. The proposed methodology and data collection methods will then be outlined. This will be followed by an overview of the means by which the data will be verified and confirmed as trustworthy, before clarifying the way in which the data will be analysed. The chapter will conclude with a discussion of all the ethical aspects involved, from the genesis of the research idea to the completion of the thesis.

## 4.2 RESEARCH PARADIGM

A research paradigm encompasses the beliefs or philosophical assumptions that the researcher holds about the nature of the research being undertaken (Willis, 2007). These not only guide the researcher's philosophical assumptions but, according to Denzin and Lincoln (2011), also direct the selection of tools, the choice of participants and the methods used for the study, as well as positioning the enquiry in its context:

They matter because they tell us something important about *researcher standpoint*. They tell us something about the researcher's proposed *relationship to the Other(s)*. They tell us something about what the researcher thinks *counts as knowledge*, and *who can deliver the most valuable slice of this knowledge*. They tell us how the researcher intends to *take account of multiple conflicting and contradictory values* she will encounter. (Lincoln, 2010, p. 7[original emphasis])

A paradigm is thus central to a research design, since it impacts both on the nature of the questions being asked and on the way in which the questions are to be studied (Durrheim, 2006). Mack (2010) maintains that researchers' views of social reality and knowledge will influence (1) how they reveal the knowledge they gain of connections between phenomena and social behaviour, (2) how they review others' research, and (3) how they evaluate their own research. To ensure coherence, the research questions and methods used in the study must fit logically within the paradigm (Durrheim, 2006).

Authors differ in the names they use to refer to certain paradigms, as well as in the number of research paradigms (Babbie & Mouton, 2001; Creswell, 2007; Denzin & Lincoln, 2011; Durrheim, 2006; Grix, 2002; Henning et al., 2004; Lincoln, Lynham & Guba, 2011; Mack, 2010; Suter, 2012; Tuli, 2011; Willis, 2007). It is important, therefore, to understand what is assumed by the term *paradigm*. Denzin and Lincoln (2011) refer to it as representation of a belief system which connects the individual to a certain worldview. Jonker and Pennink (2010), however, give a more comprehensive description, one which I have adopted for this study:

Basically, a paradigm can be seen as a coherent whole of assumptions, premises and self-evident facts as shared by a certain group of professionals (consultants, researchers, teachers, managers, etc.) with regard to a specific (a) *domain of reality*, either (b) *a certain object or subject of research*, or (c) *the way in which research can be conducted*. (p. 26 [original emphasis])

These basic assumptions and beliefs include the ontology, epistemology and methodology of a paradigm (Willis, 2007). Many scholars today believe that axiology should be included with these (Christ, 2013, Lincoln, 2010; Lincoln et al., 2011; Maxwell, 2011; Ponterotto, 2005). Philosophical understanding lends colour to the research and our responses to it (Ferrero, 2005). The underlying philosophical assumptions that will guide this study are laid out in Table 4.1.

**Table 4.1.**

*The philosophical assumptions that underpin this inquiry*

<b>Paradigm</b>	<b>Interpretivist</b>
<b>Ontological assumptions</b> – beliefs about reality and being	<b>Relativist</b> – there are multiple context-dependent realities
<b>Epistemological assumptions</b> – beliefs about knowledge	<b>Subjectivist</b> – researcher and subject create understandings together
<b>Methodological assumptions</b> – beliefs about methods	<b>Naturalistic</b> – in the natural world which is interactive and qualitative
<b>Axiological assumptions</b> – beliefs about values	<b>Formative</b> – Inseparable from the inquiry and outcomes

#### 4.2.1 Interpretivist paradigm

Table 4.1 indicates that this study is informed by an interpretivist paradigm with the aim of exploring how teachers mediate metacognition during mathematical problem solving and how they differentiate this process to accommodate all the learners in their classrooms. The interpretivist paradigm favours the experience and interpretation of those involved in the study, as it is primarily concerned with understanding certain situations (Henning et al., 2004). This contrasts with the positivist paradigm, which is concerned with finding the truth as verified by empirical evidence (Henning et al., 2004). Some of the philosophical foundations of interpretivism can be traced back to Immanuel Kant's *Critique of Pure Reason*, in which he argued that people interpret their perceptions and do not directly experience the reality of the world *out there* (Willis, 2007). The assumptions related to the interpretivist paradigm influence my own worldview and will consequently guide this inquiry.

The interactions between epistemology, ontology, methodology and axiology within a paradigm can help researchers select suitable methods, research questions, data gathering and analysis techniques (Christ, 2013). The underlying assumptions on which the interpretivist paradigm is grounded will be discussed next.

#### 4.2.2 Ontological assumptions

Researchers following the interpretivist paradigm hold that the social world can only be explored from the point of view of those taking part in an investigation, thus it creates multiple and equally valid versions of reality (Cohen et al., 2007; Ponterotto, 2005). From an interpretivist standpoint, reality is understood as subjective and shaped by the context of the situation. This includes the individual's own perceptions, experiences, and social environment, as well as the dynamic interaction between the individual and the researcher (Denzin & Lincoln, 2011; Ponterotto, 2005). Thus for the interpretivist researcher, the participants themselves define social reality (Cohen et al., 2007).

Interpretivists subsequently reject the assumption that human behaviour is directed by universal laws, controlled by fundamental predictabilities, or detached from the researcher (Cohen et al., 2007; Henning et al., 2004). Social phenomena can never be objectively observed from the outside. To understand and demystify social reality, it

must be observed from inside, that is, through the direct experience of the participants (Cohen et al., 2007; Ponterotto, 2005).

In the 18th century, Wilhelm Dilthey argued that the aim of social science research was *verstehen* (understanding) (Willis, 2007). This argument is mirrored in conclusions by Cohen et al. (2007) and Willis (2007) that the central endeavour of interpretivist research is to understand the subjective world of human experience, not to discover universal, lawlike truths, as pursued by positivist researchers in the field of natural science.

#### **4.2.3 Epistemological assumptions**

Interpretivists believe that there are multiple ways of knowing and attaching meanings, admitting that, “Objective reality can never be captured. We know a thing only through its representations” (Denzin & Lincoln, 2011, p. 5). Some ascribe this lack of objectivity in a social context to the belief that the social environment conveys meaning to individuals and is created by deliberate human perceptions and behaviour (Blumberg, Cooper & Schindler, 2008; Denzin & Lincoln, 2011). In the interpretivist paradigm, knowledge is inducted from the subjective interpretation of social phenomena. These can generate unexpected findings not previously known to general scientific knowledge (Blumberg et al., 2008). Knowledge is not just derived from what is observed, but is also influenced by the beliefs, intentions, values, self-awareness and discourses of the individuals involved in a study, including those of the researcher. This leads to a deep level of understanding, generating thick and rich descriptions of the phenomena studied (Henning et al., 2004). It is therefore logical, as Denzin and Lincoln (2011) assert, that researchers working in an interpretivist paradigm co-create understanding with their participants.

#### **4.2.4 Methodological assumptions**

A researcher’s choice of methodology is inherently informed by her or his ontological and epistemological assumptions (Grix, 2002; Tuli, 2011). Methodology can be understood as the process of transforming the researcher’s ontological and epistemological assumptions into a research activity (Tuli, 2011). Those working in an interpretivist paradigm always conduct their research in natural settings, which contributes to the capturing of insider knowledge and contextual data (Henning et al.,

2004). Interpretivists typically favour qualitative methods as these offer better ways of assessing how participants interpret their world (Willis, 2007). The researcher who utilizes qualitative methods can be thought of as the key *instrument* in the data gathering process, which takes place in natural settings, making meaning by using exploratory, descriptive procedures (Suter, 2012).

#### **4.2.5 Axiological assumptions**

Interpretivist researchers and their participants each contribute their own axiological beliefs, exchanging their mutual interpretations and their views about the value of the research process (Christ, 2013). Interpretivists admit the impact of their own values on all phases of the process and do not assume that they are capable of depersonalizing their research (Greenbank, 2003). Ferrero (2005) emphasises that it is their values helping them to make a purposeful inquiry. The predisposition for belief or theory to precede the research activity is not an indication of intellectual dishonesty or irregularity, but rather enables the researcher to make sense of ambiguous data (Ferrero, 2005).

### **4.3 RESEARCH DESIGN**

A research topic originates from the researcher's existing knowledge and from those aspects of it about which they are still curious (Henning et al., 2004). To merge what they want to know with what they already know calls for a plan of action in the form of a research design (Henning et al., 2004). This is a logical procedure that connects the data to be collected and the subsequent conclusions to the initial research questions (Yin, 2009). Denzin and Lincoln (2011) identify three main characteristics of a research design:

- The research design links theoretical paradigms to the strategies of inquiry and methods for collecting data in a flexible way.
- It positions researchers in relation to specific locations, individuals, groups, establishments and relevant material that will be used to answer the research question(s).
- It indicates the way in which the researcher will pursue the crucial issues of portraying the research findings and providing legitimacy to the study.

A research design entails more than just a logistic work plan (Yin, 2009). Its main purpose is to ensure that the data which is collected and analysed does in fact answer the initial research questions. There is no single universal blueprint for planning research, so the design of a study will ultimately be determined by how it will best fit the research purpose (Cohen et al., 2007). I chose a qualitative collective case study design as the best fit for exploring how teachers mediate metacognition during mathematical problem solving and how they differentiate this process to accommodate all the learners in their classrooms.

#### **4.3.1 Case study design**

A case study is commonly understood as an investigation of a certain social unit or system (Richards & Morse, 2012). Most definitions agree that a case is *bounded* and studied in its natural context (Cohen et al., 2007; Creswell, 2007; Guest, Namey & Mitchell, 2013; Hancock & Algozzine, 2006; Merriam, 2009; Saunders, Lewis & Thornhill, 2009; Stake, 2008; Yin, 2009). For this study, I have adopted Creswell, Hanson, Clark Plano and Morales's (2007) view of case study research:

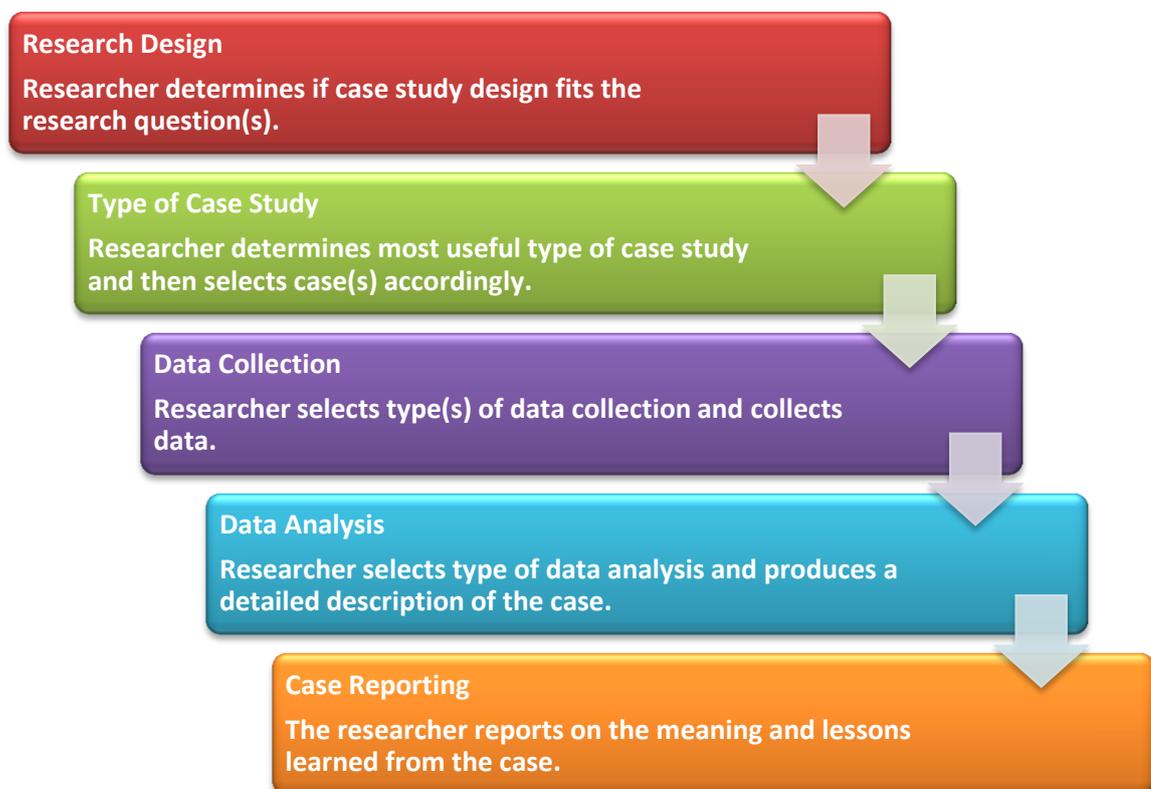
Case study research is a qualitative approach in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time through detailed, in-depth data collection involving multiple sources of information (e.g., observations, interviews, audiovisual material, and documents and reports) and reports a case description and case-based themes. (p. 245)

In a qualitative case study, the researcher is the main instrument for collecting and analysing data using an inductive approach, resulting in a rich descriptive product (Merriam, 2009). Thomas (2010) concurs with Merriam's view (2009) and remarks on the crucial role of the researcher in (re)presenting a case study, noting that the "case study offers understanding presented from another's horizon of meaning but understood from one's own" (p. 579).

One of the strengths of case study research is its ability to establish cause and effect in real contexts, for example in the field of school education, reinforcing the dominant role of context when considering causes and effects (Cohen et al., 2007). Yin (2009) acknowledges that the large scale of public schooling makes it an ideal arena for statistical research, but also argues against this type of research in educational settings:

[S]tatistics is not what education is really about. Starting to understand the world of education means bringing to life what goes on in classrooms and in schools and how both are connected to a broader panoply of real-life [environments]. Case studies eminently fill this need. Properly done, they can provide both descriptive richness and analytic insight into people, events, and passions as played out in real-life environments. (p. xiv)

Creswell (2007) notes a number of variations in the procedures a researcher can take for conducting a case study, but relies on Stake's procedure (1995 as cited in Creswell, 2007) for conducting such a study, summarized in Figure 4.1.



**Figure 4.1.** Creswell's (2007) suggested procedure for designing a case study.

One can distinguish between different types of qualitative case studies, either by the size of the bounded case or in terms of the intent of the case analysis (Creswell, 2007). The type of qualitative case study that one adopts will also influence the design of the research. Stake (2005) proposes three variations in terms of intent: (1) the *intrinsic case study*, where there is an intrinsic interest in a specific case; (2) the *instrumental case study*, where the focus is usually on an issue or phenomenon within

the case; and (3) *the collective case study*, which is an instrumental study extended to several cases and designed to compare cases and identify patterns. According to Stake (2005), the instrumental case study offers the best way to gain an insider's view of a particular phenomenon or issue.

Given the aims of this study, which involves both Foundation Phase and Intermediate Phase teachers, I chose as the most appropriate design a collective case study, that is, one which involves more than one instrumental study. Here, the specific cases are secondary to the phenomena under investigation (Stake, 2005). Nevertheless, they are thoroughly described to produce a thick and rich account that will facilitate the readers' understanding of what is of primary interest. The case study here will consist of two cases. The first will involve a sample of six mathematics teachers in the Foundation Phase of a particular urban primary school in the Western Cape Province, while the second case will include a sample of six mathematics teachers in the Intermediate Phase in the same school.

According to Rowley (2002), case selection is determined by the research problem, questions and theoretical context, but she warns that there may be other constraints, such as accessibility, resources and the time available. In the next section, I will describe the way in which participants were selected for this study.

#### **4.3.2 Participant selection**

A crucial factor in the research process is selecting, or *sampling*, the participants who will contribute to a study (Fraenkel & Wallen, 2009). In a qualitative study, they are intentionally selected according to specific criteria, ensuring the most relevant and information-rich data possible, enabling a detailed exploration of the studied phenomena, and ultimately answering the research questions (Morrow, 2005; Yin, 2011). This type of sampling, where participants or sites are intentionally selected, is referred to as *purposive sampling* or *purposeful selection* (Boeije, 2010; Yin, 2011).

The school where the research will take place was chosen because its mathematics results showed a better performance than in most other South African schools. The school is well-known in the community for supporting learners who experience specific learning barriers. It was also selected for its convenience, since I am a private learning support teacher at the school. This type of sampling is known as convenience sampling (Cohen et al., 2007; Fraenkel & Wallen, 2009). One of the

disadvantages of convenience sampling is that its results cannot be generalized to the larger population, since the sample is not representative (Cohen et al., 2007). However, it was not the aim of this study to generalize findings, but rather to explore how the teachers in this particular school mediate metacognition during mathematical problem solving and how they differentiate this process to accommodate all the learners in their classrooms. Convenience sampling is often used for case studies since it usually requires the researcher to make frequent visits to the site where the study takes place (Cohen et al., 2007).

I used purposeful recruitment and selection of the participants for this study. When opting for purposeful sampling, the researcher must first decide what criteria are crucial to the selection process (Merriam, 2009). In this study, the overarching criterion was that it should focus on mathematics teachers in either the Foundation Phase or Intermediate Phase. The second criterion was that there should be two teachers from each grade in the sample group, while the third criterion was that there should be one teacher from each grade teaching mathematics in Afrikaans and one from each grade teaching mathematics in English. The total population of mathematics teachers in these two phases at the school in question are twelve Foundation Phase teachers and nine Intermediate Phase teachers. All the mathematics teachers in these two phases were female. The target number of participants, already decided during the design phase of this study, was six Foundation Phase teachers (case one) and six Intermediate Phase teachers (case two). This approach, where the researcher already decides on the number of participants when designing the study, is referred to as quota sampling (Mack et al., 2005). The sample size here was influenced by the decision to conduct two focus group interviews as part of the data collection. It is generally recommended that a focus group consist of between 6 and 12 participants (Onwuegbuzie, Dickinson, Leech & Zoran, 2009). This study therefore required at least six teachers from each phase in the focus group interviews, dedicated to each phase.

All those teaching mathematics in the Foundation and Intermediate Phases will be invited to an informational session to discuss their contribution to the research process. This will allow them to make an informed decision in terms of the selection criteria on whether or not to take part in the study. In Chapter 5 a detailed description of the selection process, the participants as well as the context of the school will be presented.

#### 4.4 RESEARCH METHODOLOGY

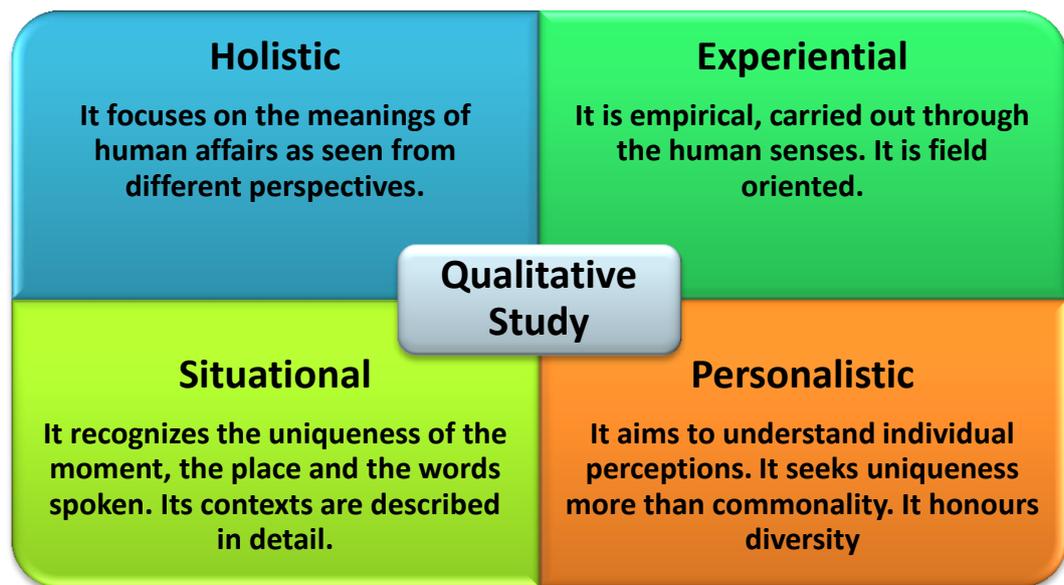
At this point, it should be noted that I regard *methodology* and *method* as two distinct concepts, even though they are often used interchangeably in the research literature. In this, I agree with Grix (2002) who holds that methodology is concerned with the science and study of methods and the underlying philosophical assumptions on which knowledge is created. Method, on the other hand, refers to the specific procedures or techniques that are used to gather data (Cohen et al., 2007).

It is thus reasonable to conclude that the methodology one subscribes to will inevitably be influenced by one's underlying philosophical assumptions. Given the interpretivist paradigm which informs this study, I assume a relativist ontology, a subjectivist epistemology and a formative axiology, all of which fit logically with a naturalistic methodology which is both interactive and qualitative. Scholars in the field of classroom research who subscribe to an interpretivist paradigm require a methodology which is subjective, flexible and holistic in order to take into account the naturalistic setting and multiple layers of classroom life (Klehr, 2012). Such a methodology allows participants to make sense of their worlds, acknowledging the influence of the researcher as data is generated from the interactions between the researcher and participants within a specific context (Ravenek & Rudman, 2013). The type of methodology which will best suit the present study must be consistent with that of a qualitative research methodology, using methods that can offer the quality and depth of data required to explore and better understand the phenomena under study (Klehr, 2012; Ravenek & Rudman, 2013).

However, in order to understand the phenomena in question, the qualitative researcher needs to organize the confusion of experiences and events of the participants as they occur in natural settings (Richards & Morse, 2012). Klehr (2012) maintains that an "approach that allows one to coherently bring together seemingly disparate pieces of important classroom information into an analysable whole is not only useful, but refreshing" (p. 124). She further argues that this is the reason why scholars in the field of classroom research "find the intellectual spaces opened up by qualitative methodology so appealing" (Klehr, 2012, p. 124).

Cooley (2013) describes qualitative research as "the most robust and inclusive means of attempting to understand the complexities of education and processes of

schooling” (p. 248). Quantitative research, on the other hand, mostly uses experiments and surveys in its design; these can be treated as blueprints which can easily be translated to another research study. The design of qualitative research, however, is more flexible and open (Durrheim, 2006). Stake (2010) identifies four special characteristics that he attributes to a qualitative study as illustrated in Figure 4.2.



**Figure 4.2.** Special characteristics of a qualitative study (Stake, 2010, p. 15)

The flexibility of the qualitative methodology allows the researcher to respond more readily to the unpredictability that is often present in institutions such as schools, pursuing issues and producing meaningful data as it emerges (Sallee & Flood, 2012). Stake (2011) eloquently describes the nature of qualitative research, again emphasizing the flexibility of this type of methodology, “In qualitative research, we observe the ordinary practice of human interaction, seeking its complexity, sometimes following plan and deliberation, sometimes following intuition, to gain greater understanding of activity in a particular habitat” (p. 8).

The strong emphasis on context here reflects a major strength of qualitative research (Creswell, 2007). However, in order to generate meaningful data which does justice to the complexity of the context in which it is gathered, the qualitative researcher needs specific methods (Richards & Morse, 2012). These are designed to help in exploring and understanding the meaning of data which would remain concealed in the statistical anonymity of quantitative data (Richards & Morse, 2012).

Cooley (2013) further emphasizes that the allegedly unimportant events happening daily in classrooms may not emerge with the methods used by quantitative researchers and strongly believes that “qualitative methods can continue ... to advance our understanding of education and improve pedagogical techniques” (p. 251).

In the next section, I will discuss the qualitative methods I will use to advance my understanding of how teachers mediate metacognition during mathematical problem solving and how they differentiate this process to accommodate all the learners in their classrooms.

## **4.5 METHODS**

As argued in the previous section, methodology is determined by the paradigm and the philosophical assumptions which guide a particular research study. Method, on the other hand, refers to the specific techniques the researcher employs to gather empirical evidence. The researcher needs to know about the different types of qualitative methods available, as the methods chosen will directly determine the shape of the data (Richards & Morse, 2012). This knowledge will contribute to the achievement of the research goals, ensure that the assumptions of the study have not been violated, and ensure the rigour of the procedure (Richards & Morse, 2012). To develop a more holistic understanding of the complex realities and practices taking place in schools, methods should be sought that bring the qualitative case study researcher into close proximity with the participants and the context in which the research takes place (Klehr, 2012; Sallee & Flood, 2012). Case study research draws on several sources of data which delve deeply into the phenomena being explored (Creswell, 2007).

After familiarizing myself with the different qualitative methods, I identified three as most suitable to answer the research questions of this collective case study: semi-structured individual interviews, non-participant observations, and focus group interviews. The motivation for selecting these methods and a description of each method will be discussed in more detail below.

### **4.5.1 Interviews**

Interviews are a common method of collecting data in case study research (Hancock & Algozzine, 2006). The popularity of qualitative interviews is attributed to

their effectiveness in giving a human face to research problems (Mack et al., 2005). They offer a better understanding of the meaning of people's behaviour in any particular context (Seidman, 2006). Not only are they a flexible method for collecting qualitative data, but they also enable the researcher to tap into the multiple aspects of the interview, such as verbal and non-verbal communication, listening and speaking (Cohen et al., 2007; Bell, 2005). These offer the kind of information which would be concealed in a written response. The nature of an interview allows the researcher to follow up on certain responses, motives or feelings from the participant, to better understand and record them (Bell, 2005).

The qualitative interview is based on one of the fundamental assumptions of qualitative research: the perspective of the participant on the phenomenon being explored should be recorded as the participant perceives it and not as it is viewed by the researcher (Marshall & Rossman, 2006). A qualitative researcher should thus always respect the view of the participant as valuable and meaningful (Marshall & Rossman, 2006).

Some authors divide interviews into three main types: structured, semi-structured or unstructured (Bryman & Bell, 2007; Cohen et al., 2007; Creswell, 2009; Guest et al., 2013; Hancock & Algozzine, 2006; Marshall & Rossman, 2006; Richards & Morse, 2012). An interview can be imagined as being somewhere on a continuum (Merriam, 2009; Seidman, 2006). The structured interview, which normally takes the form of a survey with standardized closed questions, is at one end of the continuum, while the unstructured interview, with its open-ended conversational type of questions, is at the other end. The semi-structured interview is somewhere between these two extremes, probably more towards the unstructured interview end (Merriam, 2009; Seidman, 2006). Yin (2009), for example, categorizes interviews into structured interviews and qualitative interviews, so semi-structured and unstructured interviews will both belong to the qualitative interview group.

For this research, I am interested only in qualitative interviews and specifically in semi-structured individual and focus group interviews, as they are the most appropriate ways of gathering the kind of qualitative data that could best answer my research questions. Next the semi-structured individual interview will be discussed, followed by a discussion of the focus group interview.

#### ***4.5.1.1 Semi-structured individual interview***

Kvale (2007) defines the semi-structured interview as “an interview with the purpose of obtaining descriptions of the life world of the interviewee with respect to interpreting the meaning of the described phenomena” (p. 8). Most interviews in qualitative research are semi-structured, since this is one of the most appropriate methods of gathering data in a case study (Hancock & Algozzine, 2006; Merriam, 2009). To gather useful data in a semi-structured interview the researcher needs to ask well-chosen, open-ended questions which can be explored further (Merriam, 2009). Such questions give the interviewer the opportunity to follow up and clarify a participant’s responses through probing (Brenner, 2006). Cohen et al. (2007) recommend the use of an interview schedule when conducting semi-structured interviews, including the topics and open-ended questions the researcher wants to cover with each respondent, to ensure continuity. The precise wording and sequence of questions need not necessarily be followed with each participant. This allows the researcher the flexibility to probe and follow up on the data as it emerges during the interview (Cohen et al., 2007; Hancock & Algozzine, 2006; Merriam, 2009). In this way, semi-structured interviews encourage participants to articulate their own perspectives openly and spontaneously, contributing to a clearer picture of their view of the phenomena and not simply the interpretation of the researcher (Hancock & Algozzine, 2006). The researcher should, however, ensure that all the topics and questions from the interview schedule have been addressed by the end of the interview.

For the semi-structured interviews for this study I prepared an interview schedule (see Appendix A) and will arrange the time and place that will best suit the participants, once they have signed the letter of informed consent (see Appendix G). The individual interviews will be audio-recorded and transcribed verbatim. The themes which emerge from the data will then be analysed and discussed in this thesis.

#### ***4.5.1.2 Semi-structured focus group interview***

The term *focus group* is used when participants are grouped together on the grounds either of a common experience or of shared views on a common phenomenon (Yin, 2011). The focus group interview as a qualitative method is growing in educational research (Cohen et al., 2007). The role of the researcher in such an interview is that of a moderator who creates a supportive environment and asks focused

questions about a specific topic, stimulating an active discussion among all the members of the group (Marshall & Rossman, 2006; Yin, 2006). Therefore the data emerge from the interaction between the participants (Cohen et al., 2007). As the moderator, the researcher must be aware of the dynamics within the group, managing it in such a way as to ensure that all the participants are given the chance to voice their opinions. The aim is to explore how individuals within a social context make sense of a specific issue and how they relate to each other's views, even though consensus on the issue is not required (Fraenkel & Wallen, 2009). In this way, a focus group interview can increase the depth of the research findings (Lambert & Loisel, 2008).

The value of a focus group interview can be enhanced by triangulating the findings with those from other methods of data collection that are used in a study (Cohen et al., 2007). Focus groups and individual interviews as data collection methods are both valuable in their own right (Lambert & Loisel, 2008). Taken together, however, they can create complementary views of the research topic, adding to the completeness and validation of the data, and leading to a more comprehensive understanding of the findings (Lambert & Loisel, 2008).

I will first conduct semi-structured individual interviews with all the participants. This will be followed by observation of all the participants in their natural contexts (see section 4.5.2). The themes which emerge from the individual interviews and observations will be discussed in the two focus group interviews (one group for Foundation Phase teachers and one for Intermediate Phase teachers) to validate the findings and my interpretation of them. I will use a focus group interview guide to ensure that all the topics are covered before I conclude the interview (see Appendix C). The interview guide will include the research objectives and subsequent questions, developed in such a way that there is a natural flow during the interview from one topic to another (Grumbine & Lowe, 2010). This implies that the focus group interview in this study could also be seen as semi-structured.

The focus group interviews will also be audio-recorded and transcribed verbatim. The data will be analysed and used to validate the findings from the individual interviews and observations.

Observation is a further qualitative data gathering method employed in this inquiry. Combining interviews with observation gives the researcher a deeper understanding of the meanings that everyday activities hold for people (Marshall &

Rossman, 2006). In the next section, I will discuss observation as a method for collecting qualitative data.

#### 4.5.2 Observation

Observation is a popular method of collecting data in case study research (Hancock & Algozzine, 2006). It is an essential and central method in all qualitative inquiry as it promotes the researcher's understanding of the intricacies of human interactions in natural social settings (Marshall & Rossman, 2006). What makes it unique is that it enables a researcher to collect first-hand *live* data in its *natural* context (Cohen et al., 2007). Yin (2011) agrees with the last claim:

[W]hat you see with your own eyes and perceive with your own senses is not filtered by what others might have (self-) reported to you or what the author of some document might have seen. In this sense, your observations are a form of primary data, to be highly cherished. (p.143)

Observation is especially valuable in the field of education, where the researcher has to document and describe the complexity of events taking place in classrooms (Marshall & Rossman, 2006). Observing the participants in their natural context can yield insights not available with other forms of data collection (Guest et al., 2012). Yin (2011) identifies four phenomena which can be observed, (1) characteristics of individual people (for example, their appearance or non-verbal behaviour); (2) interactions between individuals; (3) activities taking place, whether human or mechanical; and (4) physical surroundings, including visual and audio stimuli. The salience of these items, however, will be determined by the focus of the qualitative research study (Yin, 2011). In this study, the activities of mediation and differentiation, the interactions between the teacher and the learners, as well as the physical organization of the classroom, will be among the most important items to be observed in addressing the research questions.

The degree to which the researcher as observer participates will vary, from that of a complete participant on the one end of the range to that of a complete observer at the other end (Fraenkel & Wallen, 2009). For the purpose of this study, I will take on the role of a non-participant observer, which is somewhere around the middle of the range. Here the observer is not directly involved in the activity being observed, but the individuals in the study are fully aware of the role of the observer (Fraenkel & Wallen,

2009). As a non-participant observer, the researcher is not interested in manipulating or controlling any variables or activities, but is only concerned with observing and recording the activities as they occur in their natural settings (Fraenkel & Wallen, 2009). The record of observation is commonly referred to as *field notes*, which Marshall and Rossman (2006) describe as “detailed, nonjudgmental, concrete descriptions of what has been observed” (p. 98). The researcher should consider using an observation guide displaying a list of all those things that should be looked at during an observation and that could generate data. Recorded as field notes, these could illuminate possible answers to the research questions (Hancock & Algozzine, 2006).

The researcher who considers using observation as a research method should be aware of the *observer effect*. This refers to the impact one’s presence as a researcher can have on the behaviour of those being observed and consequently on the outcomes of the study, often referred to as the *Hawthorne effect* (Fraenkel & Wallen, 2009). Inevitably, the inferences the researcher draws from the observations will to some degree reveal own biases and perspectives in the data (Fraenkel & Wallen, 2009). The researcher can, however, reinforce the inferences by employing additional data collection methods such as interviews, as I will in this inquiry (Yin, 2011).

During the non-participant classroom observations, lessons will be audio-recorded with the participants’ consent. I will use an observation schedule (see Appendix B) and make field notes which will be analysed in conjunction with the other data.

#### **4.6 DATA VERIFICATION**

“*Verification* [original emphasis] is the process of checking, confirming, making sure, and being certain” (Morse, Barrett, Mayan, Olson & Spiers, 2002, p. 9). During a qualitative inquiry, verification is integrated into every step of the research process, contributing to the rigour and validity of the study (Creswell, 2003).

The term *trustworthiness* is often preferred over *validity* in qualitative research, since concepts such as validity and reliability are predominantly associated with quantitative research (Denzin & Lincoln, 2011; Maxwell, 2011; Suter, 2012). In their seminal work, *Naturalistic Inquiry*, Lincoln and Guba (1985) present four alternative terms, transferability, dependability, confirmability and credibility, that can be paralleled to validity and reliability but are more appropriate in qualitative research and

can serve as criteria in verifying the trustworthiness of such research. To gain a better understanding of how the qualitative researcher pursues the trustworthiness of a study these four criteria will be discussed.

#### **4.6.1 Transferability**

*Transferability* corresponds to the quantitative researcher's notion of generalization or external validity (Given & Saumure, 2008; Morrow, 2005; Shenton, 2004). The external validity of a study is determined by the extent to which the results can be generalized. In a qualitative inquiry, there is no one *true* interpretation. The transferability of such a study will be determined by the readers who have to decide to what extent the research findings are applicable to their own contexts (Jensen, 2008).

To improve transferability, I will report thick and rich details on all aspects of the research process, including the context, participants and research design (Tobin & Begley, 2004; Suter, 2012). A second strategy I will employ is to increase the transferability of a qualitative inquiry is purposeful sampling. This ensures the selection of information-rich cases, maximizing the likelihood that the data will adequately address the research question(s) (DiCicco-Bloom & Crabtree, 2006; Jensen, 2008; Patton, 2005).

#### **4.6.2 Dependability**

*Dependability* correlates with the concept of reliability in quantitative research (Given & Saumure, 2008; Morrow, 2005; Shenton, 2004). An instrument is regarded as reliable when it produces the same outcomes under similar circumstances on all occasions (Bell, 2005). This can be challenging for qualitative inquirers conducting research in an ever-changing social context (Given & Saumure, 2008). Research in dynamic social settings will rarely yield exactly the same results, as would be the case in a quantitative inquiry. Thus a qualitative researcher repeating another person's research should not expect to obtain the exact same results (Suter, 2012). However, dependability can be achieved by audit trails, reporting a complete and detailed explanation of the research design, as well as by making the process followed in deriving at the findings as transparent as possible (Morrow, 2005; Shenton, 2004; Suter, 2012). To achieve dependability I will give an accurate, transparent and detailed

description of my research procedure and research instruments in such a way that others will be able to collect data in the same way (Given & Saumure, 2008).

#### **4.6.3 Confirmability**

*Confirmability* is the parallel term for objectivity in more traditional research designs, where data and findings are expected to be unbiased (Given & Saumure, 2008). In qualitative research bias is always a concern, as the researcher is also the main instrument of data collection (Suter, 2012). However, through self-reflection researchers are able to recognize any predispositions, such as their philosophical assumptions underpinning the decisions they make and the methods they employ, and can factor these into the research report (Shenton, 2004; Suter, 2012).

Establishing the confirmability of a research report mainly depends on the interpretation of the findings and on ensuring that they are not just figments of the inquirer's imagination, but can be unequivocally supported by the data and sources (Given & Saumure, 2008; Tobin & Begley, 2004). The researcher's task is to connect the data, analyse it and derive findings in such a way that it is possible for a reader independently to confirm the integrity of the findings (Morrow, 2005). To ensure confirmability, I will triangulate data by using observations and interviews as data collection methods, promoting confirmability and reducing my researcher's bias. I will also provide the reader with a thorough description of how the analysis and findings of the data are tied together (Shenton, 2004). Confirmability can also be improved through consensus reached by peer review (Suter, 2012). I will therefore confirm the analysis of my data and findings with the two supervisors of this study. Once again, the audit trail will be used to reinforce the confirmability of the research findings in this qualitative inquiry (Morrow, 2005; Shenton, 2004).

#### **4.6.4 Credibility**

Central to determining the value of a study is the concept of internal validity. This refers to positivist researchers' goal of ensuring that a study measures or tests what it is actually intended to measure or test. On the other hand, researchers who assume reality as socially constructed or recognize the existence of multiple realities are more interested in capturing an authentic view of the reality of the participants, and consequently prefer the term *credibility* rather than internal validity (McGinn, 2010).

Credibility thus applies to a study where the methods and findings, as well as the interpretation of the findings, adequately answer the research questions (Sampson, 2012). It also reflects how accurately the data is represented by the qualitative researcher. A study can be regarded as credible when the researcher has meticulously and richly described the studied phenomenon (Given & Saumure, 2008). It tells the reader that the discussion and implications of the findings can be trusted.

Several strategies are available to the qualitative researcher to ensure the credibility of a study (McGinn, 2010). The researcher can interlink the collection and analysis of data and constantly compare data to determine the emergence of new codes, categories or themes until the data is saturated (McGinn, 2010). When describing a case study, the researcher should aim at bringing the case to life for the readers by describing the case in a thick and rich manner (McGinn, 2010). To establish the credibility of this inquiry, triangulation of multiple data collection methods will be employed. This will confirm the data findings and expose discrepancies or incoherence in the data (McGinn, 2010; Shenton, 2004). The credibility of a qualitative study can also be improved through prolonged engagement in the field, member checks, peer debriefing and persistent observation (Lincoln & Guba, 1985). I will therefore spend a considerable amount of time in the research setting, conducting interviews and observations. To further add credibility to the study, all the participants will receive a printed copy of the transcripts of the events in which they were directly involved confirming the accuracy of the data.

From this, one can conclude that triangulation plays an integral part in establishing the trustworthiness of a study.

#### **4.6.5 Triangulation**

Triangulation has been described as “the principle [that] pertains to the goal of seeking at least three ways of verifying or corroborating a particular event, description, or fact being reported by a study” (Yin, 2011, p. 81). It involves the cross-checking of data using multiple data collection methods or multiple data sources in order to improve the accuracy of the researcher’s interpretations (Cohen et al., 2007; Fraenkel & Wallen, 2009; Merriam, 2009; Saunders et al., 2009; Suter, 2012). Stake (2010) boldly describes it as “the grand strategy for testing the quality of the evidence” (p. 132).

It is thus reasonable to assume that triangulation is based on the epistemological position that multiple knowledge sources are significant in acquiring an inclusive understanding of the complexity of the explored phenomena (Lambert & Loiselle, 2008). Triangulation underscores the case study principle of exploring phenomena from multiple perspectives, enriching the quality of the data as it assists in the convergence of ideas and the corroboration of findings (Baxter & Jack, 2008; Suter, 2012; Yin, 2011). Farquhar (2012) sees triangulation as a vital principle of case study research as it “provides robust foundations for the findings and supports arguments for its contribution to knowledge” (p. 7).

Some scholars describe triangulation as a way of strengthening the validity of an inquiry (Fraenkel & Wallen, 2009; Yin, 2011). However, Frost (2011) believes that qualitative researchers should not be primarily concerned with validating statements about experiences. They should rather be concerned with exploring how the understanding of the others’ experiences can be improved, using triangulation as a way of accomplishing this. Additionally, qualitative researchers do not think of reality as a fixed entity, but assume a relativist ontology which honours individuals’ unique perspectives on how they understand and view their worlds (Frost, 2011). Frost (2011) relates the use of triangulation to the enhancement of the researcher's understanding of the data, illuminating the corresponding, inconsistent or missing findings within the data. It grants researchers the opportunity to interpret the data from more than one angle, encouraging them to be sceptical about what they have perceived and to check or expand their interpretations further against different sources (Stake, 2010).

The collection of data for this inquiry will be carried out by triangulating three data collecting methods: classroom observations, semi-structured individual interviews and semi-structured focus group interviews. In doing so, I aim to disentangle the complexity of human behaviour in order to qualitatively describe the depth and richness of the phenomena of the inquiry (Cohen et al., 2007).

#### **4.7 ANALYSIS AND INTERPRETATION OF DATA**

Qualitative researchers’ distinctive ability to think in a divergent and creative way is essential to analysing and interpreting the rich data they collect, ultimately creating a better understanding of the phenomena under study (Suter, 2012). For the qualitative researcher, the craft of data analysis is used to transform the *messy* raw data

into an elegant understanding (Richards & Morse, 2012). This process requires the qualitative researcher to work in a “creative, iterative, nonlinear, holistic fashion”, in contrast to the quantitative researcher, who analyses data in a “prescribed, standardized, linear fashion” (Suter, 2012, p. 348).

While qualitative data analysis does not follow a prescribed *recipe*, it is far from disorderly (Yin, 2011). Yin (2011) concludes that, regardless of the specific qualitative orientation the researcher adopts, the analysis of qualitative data can be reduced to five phases, (1) compiling, (2) disassembling, (3) reassembling (and arraying), (4) interpreting, and (5) concluding. However, although five phases can be identified, analysis takes place in a nonlinear, back-and-forth fashion (Yin, 2011; Suter, 2012).

Such analysis usually involves an inductive approach, as opposed to a hypothetical-deductive approach (Boeije, 2010; Cohen et al., 2007; Creswell, 2007; Fraenkel & Wallen, 2009; Guest et al., 2013; Suter, 2012; Yin, 2011). In an inductive approach, the researcher does not know prior to data collection what will be generated from the data, as this will only surface during the research process (Boeije, 2010). Data collection and analysis are carried out simultaneously throughout the study (Merriam, 2009). This allows the researcher to use the initial analysis of the first data set to guide the next data collection episode. The process calls on the qualitative researcher to be flexible and creative, improvising along the way in order to gain the most from the data collection and analysis, building a comprehensive understanding of the explored phenomena (Boeije, 2010). This further supports Suter’s (2012) claim that a qualitative design cannot be fully predetermined, but should rather be regarded as an *emergent* design, since it continuously evolves as the research progresses.

An inductive approach to the analysis of data calls for qualitative researchers to immerse themselves in the particulars and details of the collected data in order to discover the main ideas and connections within the data (Fraenkel & Wallen, 2009). Suter (2012) maintains that in an inductive approach “the data are allowed to ‘speak for themselves’ by the *emergence* of conceptual categories and descriptive themes” (p. 346). During the task of inductive data analysis, the researcher will often move back and forth between the raw data, codes, categories and themes as they emerge (Suter, 2012). To prevent a disorderly analysis of the data, Zhang and Wildemuth (2009) suggest using Glaser and Strauss’s *constant comparative method* (1967, as cited in Zhang & Wildemuth, 2009) to develop categories and themes inductively from raw

data, since this not only inspires new insights but also helps to expose the differences between categories and themes. The task of reducing data, identifying categories and themes and awarding well-argued, reflective conclusions is the qualitative researcher's greatest analytic challenge (Suter, 2012).

The constant comparative method is regarded as the method of choice when the researcher plans to use the data to answer overarching questions, as is the case in this study (Leech & Onwuegbuzie, 2007). In this method, every bit of data is constantly compared and contrasted with all other bits of the data, enabling the researcher to explore variations, similarities and differences in data which will help to reveal the nature of the meanings and practices of the phenomena being explored (Frost, 2011; Hallberg, 2006). This ensures that all the data will be analysed and that none will be disregarded on the grounds of predetermined themes (O'Connor, Netting & Thomas, 2008). Flick (2006) maintains that "comparing all the data throughout the analytic process is the most elucidating way to knowledge" (p. 37). The task of analysing data according to the constant comparative method requires the researcher to frequently juxtapose all new data with the tentative structure which has evolved from analysing the initial data, until the data makes sense and becomes holistic (Suter, 2012). After it has been coded, it is not *done with* but is constantly integrated into a further process of comparison (Flick, 2006).

Table 4.2 reveals the practical analysis of data using the constant comparative method, as synthesized in the work of Flick (2006), Fram (2013), Hallberg (2006), Leech and Onwuegbuzie (2007), O'Connor et al. (2008), Suter (2012) and Zhang and Wildemuth (2009). The synthesis is linked to the five phases identified by Yin (2011), introduced at the beginning of this section. Yin (2011) concludes that, regardless of the specific qualitative orientation the researcher implements, the analysis of qualitative data can be deduced to these five phases.

Table 4.2.

*Five phases of analysing data using the constant comparative method*

Five phases as identified by Yin (2011)	Analysis of data using the constant comparative method
<b>Phase 1: Compiling</b>	<ul style="list-style-type: none"> <li>The researcher sorts the gathered data in some organized way and reads through the data.</li> </ul>
<b>Phase 2: Disassembling</b>	<ul style="list-style-type: none"> <li>The researcher <i>chunks</i> the data into smaller meaningful parts and labels each chunk with a descriptive <i>code</i>.</li> <li>The researcher compares every new chunk of data with previous codes, labelling similar chunks with the same code.</li> </ul>
<b>Phase 3: Reassembling</b>	<ul style="list-style-type: none"> <li>After all data are coded, the codes are grouped by similarity as a <i>category</i>.</li> <li>After all codes are categorized, the categories are grouped by their related significance and presented as a <i>theme</i>.</li> </ul>
<b>Phase 4: Interpreting</b>	<ul style="list-style-type: none"> <li>These themes are then embedded in a structure of interrelated ideas which the researcher relates to the literature in an effort to make sense of the studied phenomena.</li> </ul>
<b>Phase 5: Concluding</b>	<ul style="list-style-type: none"> <li>The researcher then draws conclusions from the entire study.</li> </ul>

While progressing from codes to categories to themes in the analysis of the data, the analysis reaches higher levels of abstraction (Suter, 2012). The goal of the qualitative researcher who is working in an interpretive paradigm is thus to identify important categories and themes from the data sources, then provide a rich interpretation of the social reality generated by the identified themes as they are experienced in a particular setting (Zhang & Wildemuth, 2009). It is because of this in-depth understanding of social phenomena offered by qualitative analysis that many educational researchers favour the constant comparative method as the most appropriate to understanding the intricacies associated with educational practice (Suter, 2012).

The power of this process lies in the merging of all the data sources, as opposed to analysing and representing each data source separately (Baxter & Jack, 2008). This again confirms the constant comparative method as the most appropriate method to analyse the data for this study, since it promotes the principle that the whole is greater than the sum of its parts (Baxter & Jack, 2008). Analysis of a case study involves the convergence of data that were collected from multiple sources, where each data source can be thought of as a piece of the *puzzle*, which when put together illuminate a holistic understanding of the studied phenomena in a rich, descriptive way (Baxter & Jack, 2008). Suter (2012) powerfully captures the process of qualitative data analysis as:

[T]earing apart and rebuilding abstract conceptual linkages, requiring synthesis and creative insight, changing one's "lens" to reconstruct an interpretation, and definitely carefully documenting the process to enhance the credibility of findings. (p. 353)

Even though some researchers (among them, Flyvbjerg, 2006) argue that the findings from qualitative case studies can be generalized, the purpose of the present study is not to generalize the findings to a larger population or to develop a theory. The aim is to provide a highly detailed description of how teachers mediate metacognition during mathematical problem solving and how they differentiate this process to accommodate all learners in their classrooms in the Foundation Phase and Intermediate Phase of a particular urban school in the Western Cape. However, given that this is a collective case study, the rich description of these particular cases might well inform other situations or similar cases (Stake, 2005). In Chapter 5 the data collection and analysis process will be comprehensively reported.

#### **4.8 ETHICAL CONSIDERATIONS**

The ethical considerations for this study are primarily grounded in the basic principles and values as outlined in the *Framework Policy for the Assurance and Promotion of Ethically Accountable Research at Stellenbosch University* (Stellenbosch University [SU], 2009). These apply to all types of research conducted at Stellenbosch University and are taken as the foundation of the academic research enterprise at the university. Seven fundamental principles of research ethics and scientific integrity are identified to which researchers have to adhere namely: (1) integrity, (2) respect, (3)

beneficence and non-maleficence, (4) responsibility, (5) scientific validity and peer review, (6) justice, and (7) academic freedom and dissemination of research results (SU, 2009). These principles and how they relate to this study will briefly be discussed.

#### **4.8.1 Integrity**

Integrity underpins the ethical practice of all aspects in a qualitative study and reflects the researcher's moral honesty and rejection of any form of deception (Watts, 2008). In the context of this study, the reader should be aware that the researcher has a professional relationship with the participants, working with them as a private learning support teacher at the same school, but with no supervisory authority over them. Another aspect which could be seen as a threat to the integrity of the researcher is that of funding. Even though full funding was received, the research was not limited by any obligatory requirements from the funders. Integrity is further strengthened by the participants' letters of consent which, among other things, inform them that their participation will be voluntary, and that no form of remuneration will be provided.

#### **4.8.2 Respect**

Respect is strongly associated with an ethic of care and researchers' behaviour towards their participants and its consequences (Tracy, 2010). A genuine respect for the participants who are willing to share their world and their views, enhancing the researcher's understanding of the studied phenomena, is fundamental to the ethical practice of the researcher (Austin, 2008). Researchers should be respectful towards themselves, their colleagues, the research community, as well as society when conducting research (SU, 2009). In this regard, any information that is obtained in this study and could be directly identified with any participant will remain confidential and will be disclosed only with the permission of the participant concerned or as required by law. Confidentiality and the anonymity of the participants will be maintained by using pseudonyms instead of participants' real names.

#### **4.8.3 Beneficence and non-maleficence**

Beneficence and non-maleficence are rooted in the Hippocratic Oath. The principle of *primum non nocere* (first of all, do no harm) guides the practice of those in the medical field, but can also be a guiding principle in research (Brill, 2008; Cohen et al., 2007). Beneficence requires the researcher to ensure that every effort is made to

ensure minimal risk and optimum benefits, both to the participants and to society as a whole (Mack et al., 2005). Owens (2010) emphasizes the protection of human participants in research and believes that informed consent is an important factor in such protection, since it involves a continuous interchange between the researcher and the participants to ensure their wellbeing. A letter of consent to participate in this study (see Appendix G) was approved by the Research Ethics Committee of Stellenbosch University (see Appendix D). The letter of consent will be distributed to those who volunteer to take part in the inquiry. It provides the information they will need to make an informed decision whether or not to participate. They will only be able to take part in the study once they have signed the letter of informed consent. This will safeguard their welfare, confirm that they volunteered to take part and that they are aware of the extent of their contribution, and encourage a positive attitude towards the study (Owens, 2010). Given the nature of the study, it is highly unlikely that they will encounter any risks or discomfort. Nevertheless, they will be informed that if they feel uncomfortable at any time, they can withdraw without consequences of any kind. They can also refuse to answer any questions they do not want to answer, while still remaining in the study. Even though there will be no direct financial benefit to them, it can contribute to a deeper understanding of the important mediation process during mathematical problem solving and the complex interplay between cognition and metacognition. The findings of this study could be valuable in professional development programmes for teachers, empowering them to support diverse learners to improve their metacognitive ability during mathematical problem solving. Ultimately, such learners will be able to take control of their own learning, defining their learning goals and monitoring their progress in achieving them. Potentially, this research could expand teachers' pedagogical repertoires, equipping them to work more effectively with disengaged or reluctant learners.

#### **4.8.4 Responsibility**

Responsibility means “to be able to be held accountable for whatever decisions are taken, on the basis of the assumption that reasons can be provided, that they have been thought through, and even though they might be fallible” (Van Niekerk & Nortjé, 2013, p. 28). This statement is linked to the notion of the ethics of responsibility, by which researchers themselves take responsibility for all aspects of their research and its effects (SU, 2009). In this, they are accountable to all who are involved in the research

process, whether directly or indirectly, including the participants, any affiliated institutions, the research sponsor(s), as well as the society at large (SU, 2009).

#### **4.8.5 Scientific validity and peer review**

Scientific validity and peer review of the research study, supported by a solid methodology, play a crucial role in ensuring that research is ethical (SU, 2009). To accomplish this, I first had to provide the Department of Educational Psychology at Stellenbosch University with a research proposal, which was then reviewed by a panel to determine the viability of the study. In addition, the Research Ethics Committee of Stellenbosch University, the principal of the school where the study would take place, as well as the Western Cape Education Department, approved my application. Only after receiving written approval from the relevant stakeholders could the research be undertaken. Given that this is a qualitative study, the term trustworthiness is preferred to describe its validity, as discussed in detail in section 4.6.

#### **4.8.6 Justice**

The principle of justice ensures that the risks and benefits resulting from a research are shared in a reasonable manner (Mack et al., 2005; SU, 2009). It is important that the participants have the opportunity to share in the benefits of the knowledge gained through an inquiry (Mack et al., 2005). The principle of justice in research is directly related to the selection of participants, ensuring that the procedure is fair and without any bias or discrimination (Marczyk, DeMatteo & Festinger, 2005). The selection criteria for this study were explained in section 4.3.2.

#### **4.8.7 Academic freedom and dissemination of research results**

The principles of academic freedom and intellectual freedom are strongly supported by Stellenbosch University (2009). Researchers at the university are obliged to publicly disseminate their results as transparently and precisely as possible, without allowing any stakeholders or funders to withhold or influence the results in any way (SU, 2009). In the letter of consent, participants are informed that an audio recording of the interviews, observations and focus group discussions will be made to facilitate the gathering of accurate and complete data. The researcher and the two supervisors of this study will, however, be the only ones with access to these recordings. To confirm agreement on the data, the researcher will give each participant a printed transcript of

the events in which she was directly involved. The participants will be invited to make any necessary amendments and to approve the accuracy of the data before it is used in the study. The audio-recordings will be stored for five years on the researcher's computer, which is password-protected. The findings will be reported in a master's thesis, with no identifiable data about the participants or the school where the research takes place.

#### **4.9 SUMMARY**

In this chapter, the study was positioned within an interpretivist paradigm, on the assumption that there are multiple realities through which one can understand the world. In order to understand the phenomena covered by this inquiry, the researcher and the participants will create data together, using methods which will locate the researcher in the natural world of the participants and which will be understood as interactive and qualitative. These values will be infused into every aspect of the inquiry and its outcomes. This worldview plays a central role in all aspects and decisions made in the design, methodology, methods for collecting data, verification and analysis of data and the ethical considerations which will be adhered to in this research journey.

In this chapter, I explained why I selected a collective qualitative case study design as the most appropriate way to explore how teachers mediate metacognition during mathematical problem solving and how they differentiate this process to accommodate all the learners in their classrooms.

In the next chapter, a thick and detailed account of the context and the data collection and analysis process will be reported. The themes that emerge from the data will be presented, discussed and supported by direct quotes from the participants' own words in order to enhance the authenticity of the study.

# CHAPTER 5

## PRESENTATION AND DISCUSSION OF RESEARCH

### PROCESS AND FINDINGS

#### 5.1 INTRODUCTION

In this chapter, I will firstly provide a thick and detailed account of the context and cases of this inquiry. This will be followed by a reflective report on the data collection and analysis process. The aim of this report is to ensure that the process that was followed in arriving at the findings is as transparent as possible, since this contributes to the trustworthiness of the study.

The findings will then be thematically presented. The three themes will be supported by direct quotes from the participants' own words in order to enhance the authenticity of the study and to provide thick and rich descriptions representing the participants' perspectives. To situate the themes within the broader context of the existing corpus of knowledge, I will draw on the literature related to the findings.

#### 5.2 THE RESEARCH SETTING

The twelve teachers who participated in this case study were all from the same school, thus a detailed description of the school will offer the reader a vicarious experience of the setting (Merriam, 2009). This will enable readers to determine for themselves to what extent the research findings could be transferred to their own contexts (Jensen, 2008).

The school is situated in a suburb of the greater Cape Town area in the Western Cape Province of South Africa. It opened its doors for the first time in 1969, specifically to serve the white Afrikaans and English-speaking community of the suburb. In line with the many socio-political transformations that have happened in South Africa, the school today accommodates 967 boys and girls from grade R to grade 7 from several cultural backgrounds and is served by 34 educators, teaching in English or Afrikaans. Afrikaans is the home language of all the teachers at the school. Each

grade consists of four classes, one English class and three Afrikaans classes. All English classes have more learners than the Afrikaans classes. The school is classified as a Section 21 school under the South African Schools Act. This means that it receives a small subsidy from the government and charges school fees. The school is administered by the School Governing Body. It has a proactive leadership and management team and the school and parent community is well represented on the School Governing Body. Since the DBE calculates the teacher-learner ratio at 1:40 only some of the teachers are paid by the DBE. In an attempt to reduce the teacher-learner ratio, the School Governing Body employs and remunerates almost a third of the teachers at the school. All teachers have extracurricular responsibilities enabling learners to participate in the numerous sporting and cultural activities offered by the school.

There is adequate provision for frequent communication, both formal and informal, among all staff members. All the teachers attend a daily ten-minute meeting in the staffroom before school. During breaks most teachers who are not on school ground duty or otherwise occupied have a cup of tea in the staffroom, where the atmosphere is mostly relaxed. Although there is no formal sitting arrangement in the staffroom, it is interesting to note that spontaneous group formation takes place. Three groups can usually be identified, with the Foundation Phase teachers sitting together, the Intermediate Phase teachers and support staff sitting in another group, and the male teachers forming their own group.

Even though I have overheard teachers complaining about a shortage of resources at the school, the school is well provided with both physical and human resources, compared to many other schools. Apart from the 34 educators, the school has one full-time learning support teacher appointed by the DBE, a computer teacher, an art teacher, a music teacher, a sport coordinator, three teaching assistants and two secretaries. Excluding the support provided at an on-going basis by the District Based Support Team, there are several other professionals who provide support to learners in their private capacity, such as occupational therapists, speech therapists and a social worker. As a private learning support teacher at the school, I am part of the latter group.

All learners have access to the school library, which is open during breaks and after school. Furthermore, all learners receive computer lessons on a weekly basis and the computer class is available after school to learners for research on school projects.

There is one computer allocated to teachers in the staffroom. The teachers have access to the computer class as well, but here they have to share the computers with the learners. Together with all these facilities the school has well-kept and fully utilized grounds and sport facilities.

Most learners live in the same suburb and their parents are employed in the area or in the city bowl. The learners are from single or two-parent families, predominantly in the middle-income group, with one or both parents employed. There is a strong involvement of parents in the day-to-day life of the school, whether they are volunteering or attending school functions, teacher-parent evenings and sport days. However, teachers often comment that there are parents who are never involved in school activities.

The overall academic performance of the learners in the school varies according to their specific learning abilities and barriers that they may experience. The results indicate that a number of learners achieve above average, but there are also some who underachieve, because they have to face specific barriers to learning. The school is well-known in the area for the good support it provides to learners who experience such barriers. It therefore often happens that learners who start their school career at other schools in the area will enrol at this school when it becomes evident that they are experiencing some learning challenges. This, together with the policy changes regarding inclusive education (see section 3.3), results in teachers often having to accommodate a wide range of learners. Despite the wide variety of learner needs, the school still manages to attain very good results in the yearly assessments done by the provincial and national education departments. This is clearly illustrated in tables 5.1 to 5.4 on the next page. The information used in these tables were obtained from the *Report on the annual national assessments 2013* (DBE, 2013) and information related to the school were provided by the school. The school gave me copies of the official documents showing the systemic mathematics results sent to the school by the Western Cape Education Department. They also gave me a printout, retrieved from the Centralised Educational Management Information System (CEMIS) database, of the school's 2013 ANA results.

**Table 5.1.***Foundation Phase 2013 ANA mathematics results*

	Grade 1		Grade 2		Grade 3	
	Average %	Pass %	Average %	Pass %	Average %	Pass %
<b>School</b>	77	91	85	98	74	89
<b>District</b>	63	77	62	74	55	62
<b>Provincial</b>	61	73	62	75	56	65
<b>National</b>	60	71	59	70	53	59

*Note: Pass % is 50%*

**Table 5.2.***Grade 3 Provincial systemic mathematics results for 2013*

	Average %	Pass %
<b>School</b>	74	90
<b>District</b>	52	56
<b>Provincial</b>	51	55

*Note: Pass % is 50%*

**Table 5.3.***Intermediate Phase 2013 ANA mathematics results*

	Grade 4		Grade 5		Grade 6	
	Average %	Pass %	Average %	Pass %	Average %	Pass %
<b>School</b>	64	80	65	82	63	78
<b>District</b>	41	34	38	28	42	33
<b>Provincial</b>	42	37	40	31	44	37
<b>National</b>	37	27	33	21	39	27

*Note: Pass % is 50%*

**Table 5.4.***Grade 6 Provincial systemic mathematics results for 2013*

	Average %	Pass %
<b>School</b>	59	71
<b>District</b>	39	26
<b>Provincial</b>	39	28

*Note: Pass % is 50%*

Against this backdrop, this school was considered as a suitable context for a study that could contribute to our understanding of how to improve the mathematics

results in a wider spectrum of schools. A significant phenomenon, and the one that sparked my curiosity to embark on this research journey, is also evident in the tables above. These statistics reveal that the Foundation Phase outperforms the Intermediate Phase by several percentage points in both national and provincial assessments. Interestingly enough, however, is that the discrepancy between the results of the two phases from the school under discussion is considerably smaller compared to the difference between the two phases in the provincial and national results. This school then appears to be an ideal setting for a case study to specifically explore and compare how Foundation and Intermediate Phase teachers mediate metacognition during mathematical problem solving. Henning et al. (2004) explain that a research topic originates from researchers' existing knowledge and from that about which they are still curious. From my existing knowledge, I knew that if learners are able to solve mathematical problems they generally perform well in mathematics. However, my knowledge and interest in Vygotsky's sociocultural theory further convinced me that in order for learners to develop the necessary higher-order strategies, such as metacognition, to solve mathematical problems they need a mediator. In this case I specifically focused the lens on the teacher as mediator. I decided to explore how both Foundation Phase and Intermediate Phase mathematics teachers view and practise mediation during mathematical problem solving and provide for the diverse learning needs among the learners. By comparing the views and practices of mathematics teachers in these two phases I hope to gain a better understanding of why the performance of learners in mathematics deteriorates as they progress from the Foundation Phase to the Intermediate Phase. For this purpose, I present the Foundation Phase mathematics teachers and the Intermediate Phase mathematics teachers of this school as two cases, thus making this a collective case study

### **5.2.1 Description of Case 1: Foundation Phase mathematic teachers**

The new CAPS curriculum was implemented in the Foundation Phase in 2012 (see section 3.2.1). The twelve teachers in the Foundation Phase all have their own classes to whom they teach mathematics and all other subjects, except for the computer literacy lesson given once a week by the computer teacher. The three English classes in the Foundation Phase have more learners than the Afrikaans classes, and the school therefore provides each English class with a classroom assistant (see Table 5.5). Learners who experience barriers to learning, specifically in their first language and in

mathematics, receive support twice a week from the learning support teacher at the school. She does this in her own classroom or in the learners' classroom during school hours.

Eight of the Foundation Phase teachers have more than 25 years of teaching experience at the school. Three teachers in the Foundation Phase are Heads of Department. The teachers of each grade meet at least once a week, but usually more often than once a week, for planning.

Learners' workbooks are marked after school every day, and they have to do corrections the following day. They are continuously assessed, both formally and informally, during the year. The findings are recorded and where appropriate support is provided. Teachers mainly use the formal assessment tasks provided by the Western Cape Education Department on a termly basis. Amendments to the tasks are however made to fit the level of the grade. Grade 1 learners have seven formal assessment tasks per year, while Grade 2 have eight and Grade 3 have ten.

The Foundation Phase follows the time allocation prescriptions as set out in the CAPS document (DBE, 2011a), spending seven hours of teaching time per week on mathematics. The duration of mathematics lessons is usually between 60 and 90 minutes per day. All Foundation Phase teachers make use of small group activities and independent activities. Some teachers also include whole class activities during their lessons. Learners work independently at their desks on tasks that have already been explained to them, while the teacher works with a small group of learners, usually on the mat. Except for Marli[F], all the teachers usually group learners with similar abilities together. Marli[F] works with groups of four learners with mixed abilities. The learners in each class are grouped according to the results obtained from a baseline assessment conducted in the first term. Groupings are, however, changed during the year according to the progress of the learners.

Teachers specifically, but not exclusively, use the time on the mat to introduce learners to mathematical problem solving. During this process, the learners write or draw either on A5-size workbooks or on white boards. The small group activities are interactive and the learners are encouraged to share and explain their mathematical thinking. They are allowed to make use of the many counting aids and artefacts available in the classroom. To practise and consolidate the work, they receive a graded task card, with work similar to that done in the small group, which they have to

complete independently at their desks. The work done each day therefore differs from group to group. Mathematics at the desks is done in A4-size workbooks. The DBE provides all learners with a series of mathematics workbooks, known as the Rainbow workbooks, which consist of worksheets based on the curriculum. Learners receive homework, such as mental mathematics and counting exercises, which they have to practise at home.

### **5.2.2 Description of Case 2: Intermediate Phase mathematic teachers**

The new CAPS curriculum was implemented in the Intermediate Phase in 2013 (see section 3.2.1). In the Intermediate Phase, learners have different teachers for different subjects. Grade 4 teachers all teach mathematics to their own class. In Grade 5 there are two teachers who teach mathematics and in Grade 6 there are three mathematics teachers. The three English classes in the Intermediate Phase have more learners than the Afrikaans classes (see Table 5.6). There are no classroom assistants in the Intermediate Phase. Learners who struggle to learn, specifically in their first language and mathematics, receive support twice a week from the learning support teacher at the school. She provides support in her own classroom during school hours.

Six out of the nine mathematics teachers in the Intermediate Phase have less than five years of teaching experience at the school. None of the teachers in the Intermediate Phase is a Head of Department. The teachers of each grade meet once a week on a Friday afternoon for planning. In each grade, one teacher does the planning for mathematics. The mathematics teacher who is responsible for the planning provides the other mathematics teachers in her grade with the written weekly plan.

All learners have a textbook, partly subsidized by the DBE, a Rainbow workbook and two A4-size workbooks. This enables teachers to mark one of the workbooks every day after school, while the learners have the other book for doing their homework. The books can thus be alternated every other day. Teachers give feedback to the learners on their marked work the following day, and learners make corrections accordingly. They are continuously assessed, both formally and informally, during the year; the findings are recorded and where necessary support is then provided. The teacher responsible for the mathematics planning also has the task of setting up the eight formal assessment tasks per the year.

The Intermediate Phase follows the allocation of time as prescribed in the CAPS document (DBE, 2011b), spending six hours of teaching time on mathematics per week. Mathematics lessons last between 60 and 90 minutes a day. The Intermediate Phase teachers mainly use whole class activities and independent activities when teaching mathematics. Small group activities are rarely offered for mathematics in the Intermediate Phase. Learners work independently at their desks on tasks which have already been explained to them. There are no formal groupings in the Intermediate Phase. Class teachers do however arrange learners in the class according to their needs. For example, learners with visual or hearing impairments sit in the front of the classroom, while those who are left-handed sit on the left side of the desk. Learners with Attention Deficit and/or Hyperactivity Disorder (ADHD) or behavioural problems sit in areas of the classroom where they are least likely to be distracted. Some teachers group learners who experience learning barriers with more advanced peers to facilitate peer support. Learners are rearranged at least once a term.

Mathematical problem solving usually starts as a whole class activity, with the teacher explaining the type of problem on the board. The teacher will usually involve the learners by asking questions. Sometimes learners are offered the opportunity to do a similar problem on the board, while the rest of the class observe and discuss the process afterwards. Teachers have access to several mathematical resources which are made available by the learning support teacher. However, only a few teachers make use of these. Except for a few posters and wall clocks, there are limited mathematical resources in the Intermediate Phase classrooms, compared to those in the Foundation Phase.

To practise and consolidate the work explained during the whole group activity, all the learners do the same exercises independently at their desks, usually from their textbooks. The teacher will then normally walk around in the classroom or sit at her table and offer support where needed. Those who do not complete their work in class have to do it for homework. All the Intermediate Phase mathematics teachers ensure that all their learners have homework, even if they have completed their work in class. Only Emma[I] does not give learners mathematics homework, as she believes that parents confuse learners at home and she prefers to explain the work herself when they encounter problems.

In order to explore and compare how teachers in both the Foundation and Intermediate Phases at this particular school mediate metacognition during mathematical problem solving, I collected data using various qualitative methods. In the next section, I will give a detailed account of the data generating process.

### 5.3 THE DATA GENERATING PROCESS

The recruitment of participants only commenced after ethical clearance had been obtained from the Research Ethics Committee of Stellenbosch University (see Appendix D) and permission had been granted both by the Western Cape Education Department (see Appendix E) and by the school where the research was to take place (see Appendix F). I presented the principal of the school with a copy of my research proposal and he was enthusiastic about the study. He wrote a personal note wishing me well for the study, thanking me for involving the school in my research and attached it to the letter permitting me to conduct my research at his school. The deputy principal, who is also the subject head for mathematics, was also supportive of the study. He sent me an email with all the latest information on the school's mathematics results from the ANA and provincial assessments. Later he sent me a further email with a link to a document titled *A deeper look at the ANA results in 2012* (<http://www.gbf.org.za/wp-content/uploads/In-depth-look-at-ANAs-2012.pdf>).

In order to recruit the participants, I arranged with the principal to meet the twelve Foundation and nine Intermediate Phase mathematics teachers in the library during break time. All Foundation and Intermediate Phase mathematics teachers at this school were women. I prepared a PowerPoint presentation (see Appendix H) to inform them of the aims of the study, the criteria (see section 4.3.2), and their possible role as participants. The presentation was displayed on the whiteboard using a data projector. I told them that I will need two teachers from each grade to participate, one teacher who teaches mathematics in the English class and one teacher who teaches mathematics in an Afrikaans class. All teachers who teach mathematics in the English class of each grade were thus automatically selected as a participant. The remaining teachers who teach in the Afrikaans classes in each grade could then decide who would participate. I allowed time for questions, and then distributed the letters of consent (see Appendix G) to the twelve participants. I asked them to read the letter carefully and said that I was available to answer any further questions. All the participants returned the signed letter

for written consent to me within a couple of days. After the first interview, I asked each participant to complete a biographical information form (see Appendix I). Table 5.5 presents the biographical details of all the Foundation Phase participants. The biographical details of all the Intermediate Phase participants are given in Table 5.6.

**Table 5.5.**

*Biographical details of Foundation Phase participants*

Participant*	Retha[F]	Marli[F]	Sonja[F]	Sue[F]	Lea[F]	Amy[F]
Grade currently teaching	1	1	2	2	3	3
Number of learners in class	25	36	31	35	23	34
Language of learning and teaching	Afrikaans	English	Afrikaans	English	Afrikaans	English
Home language of teacher	Afrikaans	Afrikaans	Afrikaans	Afrikaans	Afrikaans	Afrikaans
Years teaching mathematics	27	3	25	42	28	3
Highest qualification	HED (Jr.Prim)	BEd (FP)	HED (Jr.Prim)	HED (Jr.Prim)	HED (Jr.Prim)	BEd (FP)
Formal training in differentiated instruction	No	Yes	Yes	No	Yes	No
Formal training in metacognition	No	No	No	No	No	Briefly during studies

**Note:** \*Pseudonyms are used instead of real names to preserve the anonymity of the participants. [F]= Foundation Phase teacher.

**Table 5.6.***Biographical details of Intermediate Phase participants*

Participant*	Santie[I]	Mia[I]	Emma[I]	Faye[I]	Adri[I]	Carin[I]
Grade currently teaching	4	4	5	5	6	6
Number of Learners in Class	23	33	28	34	25	31
Language of learning and teaching	Afrikaans	English	Afrikaans	English	Afrikaans	English
Home language of teacher	Afrikaans	Afrikaans	Afrikaans	Afrikaans	Afrikaans	Afrikaans
Years teaching mathematics	25	½	30	4	½	2
Highest qualification	BEdHons	BEdHons	PED	BEd (IP)	BEd (IP)	BEd (IP)
Formal training in differentiated instruction	Yes	Yes	No	No	No	No
Formal training in metacognition	Yes	Yes	No	No	No	Yes (Leesnet Course)

**Note:** \*Pseudonyms are used instead of real names to preserve the anonymity of the participants. [I]= Intermediate Phase teacher.

The participants were cooperative and supportive throughout the study. Carin[I] sent me a text message after the initial presentation, saying, “I’m very excited about your research! Letter is completed.” Santie[I] sent me a text message informing me of her availability for the interview, in the last sentence adding, “Good luck with the big challenge”. After the focus group interview, Sonja [F] sent me a text message saying, “Thank you that I could be part of this process. You’re really an inspiration, not to

study further, but just to stay passionate about what I do. Good luck with the final process". In the next section a detailed report of how the data collection took place will be presented.

### **5.3.1 Semi-structured individual interview procedure**

Semi-structured individual interviews were selected as the first method for gathering information from the participants. An interview schedule consisting of open-ended questions (see Appendix A) was used as a guideline, ensuring the collection of data related to the inquiry. The questions were structured around the main issues raised in the review of the literature. The open-ended type of questions allowed the participants to express their ideas and perceptions freely within the broad scope of the topic. The schedule was thus constructed in such a way that it both related to the research topic and encouraged a progressive interaction during the interviews. After the initial interview schedule was prepared, I followed the advice of Fraenkel and Wallen (2009) who hold that a pre-test of the interview schedule can assist in determining whether the questions are formulated clearly enough to avoid any uncertainties. I therefore recruited a Grade 2 teacher who was not a research participant to take part in a pre-test of the interview schedule. I informed her of my reason for doing a pilot interview and assured her that none of the information she shared during the interview would be used as data. She was more than willing to assist in the interview. I conducted the interview with her after school. The process was insightful and I subsequently amended three questions on the interview schedule.

After written informed consent was obtained from all participants, an interview was arranged with each participant at a time that suited them. The interviews either took place after school or during their non-teaching time. Most were conducted in the teachers' own classrooms. Marli[F] insightfully explained that she would be more comfortable if the interview took place in the familiar environment of her own classroom. The other teachers followed suit, and I only interviewed Faye[I] in my classroom since hers was occupied at the scheduled time of the interview. All the interviews lasted between 50 and 90 minutes. Prior to the interviews, I informed all participants that there were no right or wrong answers, since the aim of the interviews was to understand their personal experience, understanding and interpretation of the phenomena studied.

The interviews were audio-recorded with the participants' consent and were transcribed verbatim. I did not make notes during the interviews, as I wanted to keep the process as natural as possible. Instead I wrote some observations and my own reflections immediately after the interviews, and transcribed the interviews as soon as possible afterwards. I intentionally chose not to seek assistance with this mammoth task, because I anticipated that it would give me more insight into the meaning of the participants' words and that it would ease the analysis of the data afterwards. This proved to be the case and the time I spent transcribing was not in vain.

To ensure agreement on the transcripts, I printed a copy of every participant's transcript and personally handed it to each of them, inviting them to make any amendments as they saw fit, before returning it to me within a couple of days. In fact, none of them altered the data in their transcripts. Only Amy[F] picked up two typing mistakes in her transcript, which I corrected. Sonja[F] said she had not realized how incoherent her responses to the questions had been, and even told her husband she did not think she had contributed anything of value to my study. I reassured her that the information she gave me was extremely valuable, as it was drawn from her own experience, understanding and interpretation. Sue[F] said reading the transcript was like listening to her own voice, and that she never had realized how often she used the word "*daai*" (*Afrikaans jargon for "that"*). Several of the other participants also commented on how incoherent their answers seemed. I nevertheless assured them that I had gained valuable insights from their interviews. Mero-Jaffe (2011) also noticed this concern of interviewees, but reminds us that written language differs from spoken language. When the speech of the interviewees is displayed as text, they tend to judge it against the formal conventions of written text and therefore perceive it as incoherent (Mero-Jaffe, 2011).

### **5.3.2 Non-participant observation procedure**

The second step in the data generating process involved a classroom observation of each participant while teaching mathematics. The participants were told that the only criterion for the observation was that the focus of the lesson should be on mathematical problem solving. I presented each participant with an information sheet about the observation (see Appendix J). Provision was made on the information sheet for teachers to indicate two possible times for their observation. After I had received all the

suggested times, I drew up a schedule to avoid double appointments. I confirmed the observation time with each participant and gave them a written note with the date and time. All but one of the observations took place at the arranged date and time. I had to reschedule a time for Santie's[I] observation, as she was absent on the day originally arranged.

I prepared an observation schedule (see Appendix B) based on the data categories which emerged from the individual interviews. This enabled me to keep my focus during the observations. During them, I sat somewhere in the classroom where I could have a clear view of what the teacher did, without being too intrusive. I did not get the impression that any of the learners found it odd to have me in the class. This was probably because I was known to them as the private learning support teacher who often visited their classrooms. They are also used to having student teachers in their classrooms, as the school accommodates many student teachers during the year. The principal also observes lessons each year. The learners are thus used to having other adults in their classrooms.

I audio-recorded the observations with the participants' consent and transcribed each observation verbatim as soon as possible after the observation. During this phase of the data collection process, the smartpen device I used to record the audio data was extremely valuable. With the aid of a special notebook with *Dot Positioning System* technology, I used the smartpen to synchronize all the field notes I wrote during the observation with the simultaneous audio recording. When transcribing the observations, I used this device to tap on any written word or graphic in the notebook, then played back the exact audio that was recorded at the moment I wrote it. The smartpen enabled me to focus on the non-verbal actions during the observations and to record them as field notes. I could then easily link non-verbal actions with verbal actions when transcribing the observations. The observations lasted between 60 and 90 minutes.

After I had transcribed the observations, I printed a copy of all the transcripts and personally handed them to the participants, inviting them to make any amendments before returning them to me. None of the participants altered the data in their transcripts. Several of them commented that I had observed things happening during the lesson of which they themselves were unaware.

### 5.3.3 Semi-structured focus group interview procedure

The focus groups took place at the school. The focus group including all the Foundation Phase participants took place after school. All the participants, with the exception of Amy[F] who had a baby in that week, attended the focus group. The other focus group for the Intermediate Phase teachers was conducted during assembly time with the principal's permission. Both focus groups lasted for approximately one hour.

I used a focus group interview guide (see Appendix C). The questions included in the guide were based on the themes which emerged from the data collected during the individual interviews and observations. This assisted in validating my findings and interpretation from the individual interviews and observations. The questions were developed in such a way as to provide for a natural flow from one topic to another. This had the anticipated result that the participants more than once spontaneously started discussing the next topic, even before I had asked the question.

Before starting, I once again made it clear to the participants that there were no right or wrong answers, but that I was interested in their experiences, knowledge and understandings of the relevant topics. I also explained my role as moderator and that I would like to hear everyone's view. I prepared a PowerPoint presentation (see Appendix K) with each question on a different slide. Each question was therefore visible to the participants during the discussion, and I noticed several times how they kept looking at the presentation while discussing a question. This contributed a great deal to keeping the interview focused and relevant to the topic of discussion. During both focus groups, as soon as I had raised a question the participants immediately started discussing the question and interacting with one another. The atmosphere was relaxed and they seemed to appreciate this opportunity to discuss and reflect with their colleagues on matters related to their everyday experiences. During the Foundation Phase focus group, there were a few laughs when the teachers shared some of the interesting experiences they had had while learners were busy solving mathematical problems. Sue[F], for instance, told the group that one of her learners who was the son of a motor mechanic counted in fives when he had to calculate the number of wheels six cars would have. When she asked him why he did this, he told her that he also counted the spare wheel. The group had a good laugh and thought that it was creative and indeed right. I appreciated the honesty of the participants, as some of them, especially the less experienced teachers, shared their weaknesses as teachers and how

they sometimes struggled with certain situations in the classroom. The more experienced teachers would then advise them on how to deal with those situations.

I did not find it necessary to make any field notes; I did however make some reflective notes afterwards. The participants were aware that the interviews were audio-recorded. I transcribed the data verbatim soon after the focus groups were completed.

All interviews were conducted and transcribed in Afrikaans since that was the mother tongue of all the participants. The observations were transcribed in accordance to the language of the observed lesson. My field notes for the observations, however, were transcribed in English. In order to improve the readability and access of the findings, the direct quotes used when presenting the data are translated into English. I however used a back translation strategy (Merriam, 2009), in which I asked a bilingual person to translate some of the English back into Afrikaans to ensure that the translation was reliable.

#### **5.4 DATA ANALYSIS PROCESS**

An inductive approach was used to analyse the data. This meant that the categories and themes according to which the data was organized and coded were not developed prior to collection, but emerged from the data as it was collected through a process of inductive reasoning. Even though an inductive approach was used, the research questions and key concepts from the literature review were taken into account when the data was analysed. Merriam (2009) confirms this approach when she points out that “our analysis and interpretation – our study’s findings – will reflect the constructs, concepts, language, models, and theories that structured the study in the first place” (p. 70). The *constant comparative method* (see section 4.7) was used to analyse the data gathered from the interviews and observations.

Once I had I transcribed all the individual interviews, I immediately started coding. Only after all the interviews were coded did I start transcribing and coding the observations. The focus group interviews only commenced after all observations were coded and merged with the data from the individual interviews. The focus group interviews were then coded and merged with the other data that was already coded.

In order to make meaning from the more than 100 000 transcribed words collected from the interviews and observations, I followed the five phases as suggested

by Yin (2011) (see section 4.7). In Table 4.2, I presented the practical analysis of data using the constant comparative method, dividing the process according to Yin's (2011) five phases. In the following sections I will describe the data analysis process as guided by the five phases.

### **Phase 1: Compiling**

Yin (2011) describes the compiling phase as arranging the data in some order which can then be used as a database for the analysis. For this phase, I colour-coded each participant's individual interview transcript with a different font colour. A word processing document was then created to compile each phase's individual interviews in a single document. I combined all the answers to the same question underneath the question (see Appendices L & M for extracts of the transcripts of the individual interviews in each phase). This already aided in identifying certain patterns in the data. I then made a six-centimetre right-hand margin on each document. Merriam (2009) recommends that data collection and analysis should be done simultaneously. I followed her advice, only conducting the observations once all the individual interviews had been coded (see Appendices N & O for transcripts of one observation in each phase). Once the observations were coded, the focus group interviews commenced (see Appendices P & Q for extracts of the transcripts of the focus group interviews in each phase). However, after each collection and transcription stage I colour coded and made a six-centimetre right-hand margin on each transcription.

### **Phase 2: Disassembling**

After compiling all the transcribed individual interviews, I printed them out and assigned a code to sentences, paragraphs or sections in the right-hand margin. The codes characterized an issue or idea with which each part of the data was associated. For example, the code *Individual support* was assigned to data that suggested that learners received individual support during mathematical problem solving.

After coding all the transcribed individual interviews, I disassembled the chunks of coded data and grouped together chunks with the same codes. For this phase, the word processing and spreadsheet programmes on my computer were valuable. A spreadsheet was then created with two sheets, one for all the data generated from the Foundation Phase participants and one for all the data generated from the Intermediate

Phase participants. To assist in the comparison of these two cases I used the same codes on both sheets. The different codes became the headings of separate columns. Each chunk of data related to a specific code was copied from the transcript in the word processing programme and pasted under that code heading in the spreadsheet, but in the font colour assigned to that participant. All the data related to a specific code was assembled together in the one column. The use of different colours for each participant helped to preserve the originality of the data and to an extent the context in which it was said. This way of chunking and coding using a spreadsheet made it possible to use the same chunk of data under different codes and to move chunks of data across codes when different associations appeared. For example, I grouped the chunk of data “Often when learners struggle with problem solving it is because they struggle with reading” (Retha[F], 353-354ii) under the codes *Teacher’s knowledge of learner* and *Reading*. The systematic process of coding by comparing, arranging and rearranging data continued until all relevant data was coded and a point of saturation was reached when no new codes emerged. The first cycle of coding all the individual interviews consisted of 116 different codes with nearly two thousand chunks of data for both the Foundation and Intermediate Phase data sets. Saldaña (2009) explains that coding is a cyclical process and is rarely done perfectly after the first attempt. Only during the subsequent cycles of recoding is the qualitative analyst able to filter, illuminate and focus on the salient structures of the data (Saldaña, 2009). During the subsequent cycles of coding, I copied both sheets to keep the original for later reference and merged some of the codes together to refine and reduce the number of codes without losing any data. I then coded all the observations, with only a few more codes emerging from this stage of the analysis. The codes in the spreadsheets were updated accordingly. When the focus group interviews were analysed, no new codes emerged.

### **Phase 3: Reassembling**

During this phase, I examined, compared and searched for patterns in the coded data in order to form categories. I then grouped the codes into categories according to their similarities. In the spreadsheet program, I created category headings. I then clustered all codes related to a certain category. Using the constant comparative method, I integrated the categories by their significance in relation to illuminating the themes which emerged across the cases. Saldaña (2009) defines a theme as “an

*outcome* [original emphasis] of coding, categorisation, and analytic reflection” (p. 13). The data from the different categories were then clustered together under the theme headings to which they belonged. Figure 5.1 shows a graphical representation of how data were reassembled from codes to categories to themes using spreadsheet software.

	A	B	C	D	E	F
1	Theme					
2	Category		Category		Category	
3	Code	Code	Code	Code	Code	Code
4	Chunk	Chunk	Chunk	Chunk	Chunk	Chunk
5	Chunk	Chunk	Chunk	Chunk	Chunk	Chunk
6	Chunk			Chunk		
7						

**Figure 5.1. Reassembling data from codes to categories to themes using spreadsheet software.**

One of the main advantages of using a spreadsheet to organize the data was that it gave me a holistic view of the magnitude of the data on only two sheets. I could thus immerse myself in the particulars and details of the data and discover the connections within the data that were subsequently reduced to three themes (see Appendix R for a sample of the chunks of data coded into categories and themes). I believe that Suter (2012, p. 348) would agree that this process, to a large extent, was done in a “creative, iterative, nonlinear holistic fashion” that led to an elegant understanding.

#### **Phase 4: Interpreting**

During this phase, the emerged themes are embedded in a structure of interrelated ideas and are related to the literature in order to make sense of the studied phenomena (Flick, 2006; Fram, 2013; Hallberg, 2006; Leech & Onwuegbuzie, 2007; O’Connor et al., 2008; Suter, 2012; Zhang & Wildemuth, 2009; Yin, 2011). Phase 4 will be presented in section 5.5, where I will describe the combined results of the analysis of the individual interviews, observations and focus group interviews.

### Phase 5: Concluding

In the fifth and final phase, I will draw conclusions from the entire study which are strongly related to the interpretations of the fourth phase. This phase will be presented in Chapter 6.

## 5.5 DATA PRESENTATION

Three themes emerged from the data collected from the participants' views and practices of mediation of metacognition during mathematical problem solving. The findings are subsequently presented according to these three themes. Each theme, with its associated categories and subcategories, will be related to the findings from both cases. The findings will be presented in such a way that the similarities and differences between the two cases will be illuminated. To enhance the authenticity of the study and offer the reader a vicarious experience, I will use direct quotes from the participants' own words. The source of the data from the analysis presented in the remainder of the thesis will be indicated as presented in Table 5.7.

**Table 5.7.**

### *Reference to source of data*

Pseudonym of participant	Phase	Line numbers on transcription	Individual interview	Observation	Focus group interview
Name	F=Foundation I=Intermediate	E.g. 5-6	ii	ob	fg

*Note:* For example when directly quoting something Mia said during the focus group interview, it will be cited as (Mia[I], 5-6fg). When paraphrasing, only the participant's name and phase will be indicated.

As indicated in Table 5.8, the three emerged themes are interpreted as three dimensions that are omnipresent when teachers mediate metacognition during mathematical problem solving in diverse classrooms.

Table 5.8.

*Themes, categories and sub-categories from the data analysis*

<b>THEME 1</b>	<b>Category</b>	<b>Sub-category</b>
<b>Knowledge dimension</b>	Professional knowledge	<ul style="list-style-type: none"> <li>• Subject content knowledge</li> <li>• Pedagogical knowledge</li> <li>• Pedagogical content knowledge</li> </ul>
	Knowledge of learner	<ul style="list-style-type: none"> <li>• Knowing learner as a learner/thinker</li> <li>• Perezhivanie</li> </ul>
	Knowledge of metacognition	
<b>THEME 2</b>	<b>Category</b>	<b>Sub-category</b>
<b>Strategies dimension</b>	Mediation of metacognition	<ul style="list-style-type: none"> <li>• Mediation of metacognitive knowledge</li> <li>• Mediation of metacognitive regulation</li> <li>• Strategies to mediate metacognition</li> </ul>
	Differentiated instruction in the mediational process	<ul style="list-style-type: none"> <li>• Differentiation of content, process and/or product</li> <li>• Differentiate to match learners' readiness, interests and/or learning profile</li> </ul>
<b>THEME 3</b>	<b>Category</b>	<b>Sub-category</b>
<b>Context dimension</b>	Extrinsic influences on teachers' mediation	<ul style="list-style-type: none"> <li>• Learners</li> <li>• Context of class/school</li> <li>• Professional collaboration</li> <li>• DBE</li> </ul>
	Intrinsic influences on teachers' mediation	<ul style="list-style-type: none"> <li>• Teacher reflection</li> <li>• Teacher autonomy</li> <li>• Teacher's beliefs/attitude</li> </ul>

### 5.5.1 Theme 1: The knowledge dimension

The sociocultural theory on which this study is grounded holds that mathematical concepts already exist as part of our culture. However, to guide the child

in becoming accustomed to these concepts a mediator or culturally *more knowledgeable other* (MKO) will be needed (Schmittau, 2004). From the analysis of the data of this study, knowledge emerged as a major theme. It will now be further explored through its related categories and sub-categories.

### ***5.5.1.1 Professional knowledge***

In section 3.2.4, it was indicated that teachers need at least three types of knowledge (subject content knowledge, pedagogical knowledge and pedagogical content knowledge), to successfully teach mathematics. In the analysis, these three types were grouped under professional knowledge, since this refers to the knowledge expected from any proficient teacher.

- *Mathematical content knowledge*

Mathematical content knowledge as it related to problem solving was specifically explored when I asked the participants during their respective individual interviews what they regarded as mathematical problem solving. See section 1.6.6 for the basic tenet in this inquiry on what mathematical problem solving means. Half of the participants from both phases related mathematical problem solving to word problems. Marli[F] (ii) said that, in their planning, problem solving specifically referred to word problems. Sue[F] (ii) explained that problem solving was when a learner already knew, for example, that seven plus eight is fifteen, but then built a story around the problem. Lea[F] said that it was an inference learners had to draw from words given to them, and that they had to convert it to a calculation. Some of the Intermediate Phase teachers also referred to mathematical problem solving as word sums. Mia[I] (ii) described it as a process where learners had to convert words to numbers and plan what they would do to find the solution. Santie[I] (121ii) unequivocally stated, “In other words a word sum. We call it word sums or problem sums”. Faye[I] (131-132ii) echoed this conclusion when she said, “Problem solving refers to... the old fashioned problem solving, isn’t it just the word sums?”

One can understand why so many teachers related word sums to problem solving, because in the CAPS document for mathematics for both the Foundation Phase and the Intermediate Phase (2011a,b) the examples given for mathematical problem solving are mostly word sums. However, not all word sums can be seen as mathematical problems. If the word sum opens up a space between the learner’s

immediate knowledge and how to instantly progress from the question to the answer, then it is a mathematical problem. These were the type of word *problems* observed in the classes, since most of the learners were unable to solve the problems without mediation from the teacher.

Other teachers explained that mathematical problem solving could be related to any content area of mathematics. Amy[F] (ii) described mathematical problem solving as any sum that learners must be able to solve and reason about and that it can be linked to any mathematical concept area, even data handling or shapes. Emma[I] (ii) shared this view, “Actually everything. Uhm... no, because problem solving to me is not about a word problem. It’s mathematics... every aspect that you approach is problem solving. You can’t separate it from one another, even if you want to” (140-142ii). This is in line with the NCTM’s (2000) view that “problem solving is an integral part of all mathematics learning” (p. 52). Emma[I] confirmed this statement during the focus group interview when she said:

*We tend to get stuck on the idea that word problems are problem sums. And it is not. Mathematics is a problem on its own, any sum that a child approaches is a problem, it doesn’t matter what he’s doing. (98-100fg)*

Sonja[F] probably came closest to Schoenfeld’s (1983) view that a mathematical problem is when one does not know how to solve a problem easily with known procedures. She explained that a sum is a problem when learners cannot immediately see the pattern needed to proceed to the solution (Sonja[F] ii). One of the aspects mentioned by the DBE (2011b), that higher-order understanding and processes are often involved in mathematical problem solving, was echoed by Retha[F] (58-59ii) when she said “...but it requires a little more... it’s higher-order thinking... he must sort of think outside the box”. Since this study was informed by an interpretivist paradigm, I did not share with the participants my own interpretation of mathematical problem solving. Since interpretivists are primarily concerned with understanding certain situations, they focus on the experience and interpretation of those involved in a research study (Henning et al., 2004)

- *Pedagogical knowledge*

The next type of knowledge, pedagogical knowledge, relates to a teacher’s classroom management and teaching repertoire, which is not subject-specific. In

relation to the research questions of this study, I explored this type of knowledge by specifically asking the participants during the individual interviews how they understood the concept of differentiated instruction. On the biographical information form (see Appendix I), I also asked them to indicate if they had received any formal training in differentiated instruction. Seven of the participants indicated that they had never received any formal training (see Tables 5.5 & 5.6). The responses from the Foundation Phase participants mostly related their understanding of differentiated instruction to the grouping arrangements they used in their classrooms. Sue[F] (1035ii) said, “Differentiated instruction is basically the three groups.” Sonja[F] (1057-1058ii) echoed this view, explaining, “I understand it as children being on different ability levels and you work with them in their ability groups. That's the differentiation that we mostly do.” Retha[F] (ii) agreed that you could not focus only on whole class teaching, since you needed to provide a learning opportunity for every learner and they would disappear in a large group. She explained that it was easier for learners to concentrate and pay attention in the smaller groups. In an unexpected remark, Sue[F] (1036-1037ii) said that she thought, “Differentiated teaching was more relevant to me a few years ago than it is now.” I asked her why she said that and she replied that in the past they were obliged to teach using the three ability groups, but nowadays, with the new CAPS curriculum, she could teach a new concept to the whole class. Lea[F] also referred to this recommendation in the new curriculum, but her feeling was quite the opposite:

*With CAPS they told us at our training we had last year that you have 20 minutes of whole class teaching when children must learn a new concept... then I sat there and listened to them and thought .. you can do that! Because how the hell can you... if your third group functions there below and your first group is far ahead... how do you teach a new concept? (1274-1278ii)*

This comment by Lea[F] implies that she realized the importance of working within the learner's zone of proximal development (see section 2.3.3)

The Intermediate Phase participants all agreed that differentiated instruction meant that teachers had to adapt their teaching to meet the varied needs of their learners (Mia[I], ii; Santie[I], ii; Faye[I], ii; Emma[I], ii; Carin[I], ii and Adri[I], ii). Faye[I] (ii) mentioned that learners think in different ways, and that teaching those who were visual thinkers, for example, would be different from the teaching needed for those who struggled with reading. Carin[I] referred to the different levels of ability displayed by

learners in the same class, specifically mentioning that the more gifted learners were at the top level and that “differentiated education wants us to use different methods for those different levels” (1053-1054ii). Emma[I] claimed that it was difficult to differentiate instruction when you used more traditional teaching methods, such as whole group teaching:

*[It] means that every child should be approached according to his own level which is impossible in a whole group... you cannot do it. Therefore, you will work in a way that will at least make everyone feel... I can do it. (1037-1039ii)*

This concern was echoed by Adri[I] when she explained that all learners were unique in terms of their backgrounds, abilities and talents, and that “you will not be able to help or encourage or support or educate everyone on their level” (1065-1066ii).

- *Pedagogical content knowledge*

Pedagogical content knowledge, in the context of this study, means the knowledge teachers have to teach mathematical problem solving to a diverse group of learners in their classrooms. During the individual interviews, I asked the participants what they thought a teacher could do to improve a learner’s ability to solve mathematical problems, and in the focus group interviews too I asked them what kind of knowledge they thought a teacher needed to help learners with mathematical problem solving. From the data analysis, three facets of a teacher’s pedagogical content knowledge surfaced regularly. The first related particularly to the Foundation Phase participants, since most of them mentioned that to help learners solve mathematical problems you needed to provide them with concrete objects or representational/semi-concrete models. “I think the value lies with the concrete. Work with the concrete until the child figures out what you want them to do” (Sonja[F], 324-325ii). Marli[F] confirmed this, “I think you must make it [mathematical problem solving] as practical as possible... make it as concrete as possible. We use counters or little cubes... we will even use pictures, because it is much easier for them” (Marli[F], 81-82ii). Retha[F] said that if a learner struggled to solve a mathematical problem, the teacher should “go back and work with concrete objects. If I can use concrete objects I will give him concrete objects (279-281ii). “And concrete... to work concretely and then semi-concrete and then to the formal part... it guides the child” (Retha[F], 1335ii). Lea[F] also referred to this gradual release of concrete objects during problem solving:

*Start with the concrete...uhm, I just go and sit down on the mat with them and then we start working concretely. So... you work with concrete objects and then go semi-concrete, and yes... then there is the abstract. But work with concrete objects until he understands the concept. (Lea[F], 345-348ii)*

It is thus not surprising that in all the lessons I observed of the Foundation Phase participants, they used either concrete objects or representational models. The use of concrete objects during mathematical problem solving strongly relates to Vygotsky's notion of tools and signs as mediational means (see section 2.3.1.1) and his claim that the difference between tools and signs depends on the context of the mediated activity. When I observed Retha's[F] lesson, she asked a learner how many pens each child would get if you shared six pens equally between two children. She handed the learner a holder with pens to help in solving the problem. The learner did not use the pens as externally orientated writing tools; instead, they became signs that were internally orientated and "aimed at mastering oneself" (Vygotsky, 1978, p. 55).

A second aspect of teachers' pedagogical content knowledge that frequently surfaced was that a teacher should know the learner's actual level of development (see section 2.3.3) and be aware of what the learner knows and is familiar with. The teacher can then gradually introduce new problems. Marli[F] explained that to help learners make sense of the problem you had "to take it back to their frame of reference" (294ii). Mia[I] also indicated that she would "start with the easy problems... then you can see... well everyone can do it now. Right... then we go on to the bit more difficult problems" (1077-1078ii). Retha[F] maintained that:

*I think you should know what is the number range children work in in the first place... and you have to stay in their number range, it is very important in problem solving. And don't go too high... first work from the small little numbers then to the bigger numbers... and it must be things that they can associate with. (8-11fg)*

This relates to Vygotsky's zone of proximal development in which optimal learning takes place. Teachers should therefore, gradually introduce the learners to the culturally constructed psychological tools such as numbers according to the learners' readiness (Schmittau, 2004; Vygotsky, 1978; 1981). Santie[I] clarified that:

*You need to see what they know. Before you start, you must first find out what he knows and what he doesn't know. I can't just walk into a class and start a mathematics lesson*

*and then have the children look at me and say we have never done this... you know. You have to start with the familiar. (3-6fg)*

Sue[F] said that it was the learner who guided you in knowing what to do, adding that knowing the learner's specific sociocultural context would also determine how you approached mathematical problem solving, "If you teach on a farm, you will then use completely different things to make a connotation for the children, compared to when you teach in the city, for example" (Sue[F], 23-24fg).

### **5.5.1.2 Knowledge of the learner**

The second category in the knowledge dimension logically leads to the teachers' knowledge of the learner. Knowing how learners think and learn is one of the aspects that make a mathematics teacher proficient (Schoenfeld & Kilpatrick, 2008; Lester, 2013). Vygotsky uses the Russian word *Perezhivanie* to describe a second aspect of such knowledge. It refers to the affective dynamics or emotional experiences of learners and how different learners will experience the same thing differently. Smagorinsky (2013) calls this a meta-experience: the way learners experience their experiences.

- *Knowing the learner as a learner/thinker*

The data analysis showed that the participants often displayed and made transparent their knowledge of the learner as learner/thinker. I will discuss how they gained this knowledge and then offer a synthesis of what they know about the learners as learners/thinkers that specifically relates to mathematical problem solving.

Marli[F] grasped the importance of this knowledge, "I think it is quite a challenge for a teacher to exactly understand what is happening in that child's head because I think if you understand what is happening in that child's head you can teach him anything" (387-389ii). Both from the interviews with the participants and my observations of their lessons, I identified several ways in which teachers gained knowledge of the learner as a learner/thinker. Firstly, they ask the learners directly. "[O]ften I ask a child... what do you think?" (Carin[I], 545-546ii). Marli[F] adds that "you have to actually ask questions to realize why the child thinks the way he thinks" (389-390ii), "this way you know how to approach the child to help him connect the dots, so that he can understand" (390-391ii).

Secondly, teachers gain knowledge through their observations of learners. Lea[F] said that she knew just by the way learners looked at her if they understood "...because they will look at you in a way and then you know, you've totally lost them" (1287-1288ii). Marli[F] also mentioned that through observation "you can see where the child gets stuck, it is to understand what you tell him, is it number sense, comprehension, is it the reading thing, is it the listening thing (646-647ii). Mia[I] explained that, besides looking at a learner's work, you could also determine if they understood by observing their body language, "You can see it in his attitude, but you can also see it in his answers" (335ii).

Thirdly, teachers obtain knowledge about their learners through assessment. This includes both formal and informal or ongoing assessments. Sue[F] explained that "...by marking his book you can see... well this guy gets the concept and he can run with it" (1130-1131ii). Carin[I] mentioned that, "If I mark the books... then I see... but nothing's going on here... the child doesn't have a clue what's going on here (719-720ii). Adri[I] indicated that in order to know what the learners can do she "marks their books every day, because I can't continue if I do not know where my children are with the previous day's work" (305-306ii). She further explained the value of formal assessments in this area, "Now after the first term assessments it is clearer to me who my learners are that struggle" (Adri[I], 735-736ii). In the Foundation Phase, baseline assessments are regarded as an important way to learn more about your learners, as "you can really see from your baseline assessment at the beginning of the year which children can already read numbers... which children can answer normal simple questions" (Retha[F], 883-884ii).

A fourth way, exclusively mentioned by the Foundation Phase participants, was through small group teaching. They found this to be instrumental in knowing their learners as learners/thinkers. Lea[F] boldly stated that, "We [Foundation Phase teachers] have small group teaching, so we work with our ability groups, so we know exactly which learners struggle with what and address it" (1493-1494ii). Retha[F] confirmed this, "A lot of times you see another side of a child that you would not really notice during whole group teaching" (1191-1192ii). Marli[F] added that, "I learn to know my child if I work in small groups" (1215ii).

Table 5.9 compares the teachers' understanding of learners as learners/thinkers in the Foundation Phase and Intermediate Phase respectively during the data collection.

Table 5.9.

*Teachers' knowledge of learners as learners/thinkers*

Teachers' knowledge of learners as learners/thinkers	Foundation Phase	Intermediate Phase
<b>Teachers know that learners differ in the way they learn/think</b>	<ul style="list-style-type: none"> <li>• “Different children learn in different ways” (Sue[F], 1046ii).</li> <li>• Even if three learners sit next to each other, the way in which they solved the problem can differ from one another (Retha[F], ii).</li> <li>• Sometimes learners will seem that they do not pay attention or they are busy playing with something, but then they do pay attention (Lea[F], fg &amp; Marli[F], fg).</li> </ul>	<ul style="list-style-type: none"> <li>• “Absolutely everyone is different” (Santie[I], 968ii).</li> <li>• Sometimes it is frustrating to figure out what a learner did to solve the problem, but we all learn in different ways (Carin[I], ii).</li> <li>• Learners differ from one another; therefore you will approach each learner in a different way when you help them to solve a problem (Emma[I], ii).</li> <li>• Some learners will not just do the basic things to solve a problem; they will take the problem and solve it in an exciting and creative way (Mia[I], ii).</li> </ul>
<b>Teachers know that learners who struggle with reading struggle with problem solving.</b>	<ul style="list-style-type: none"> <li>• Often when learners struggle with problem solving it is related to their reading and specifically comprehension. That is why the learners with poor reading skills cannot do problem solving (Amy[F], ii; Lea[F], ii; Retha[F], ii &amp; Sonja[F], ii).</li> </ul>	<ul style="list-style-type: none"> <li>• To solve a problem, learners need to understand what they read (Emma[I], ii).</li> <li>• The learners who do not understand what they read, cannot interpret what to do to solve the problem (Adri[I], ii,fg Carin[I], ii; Faye[I], ii &amp; Santie[I], ii).</li> </ul>
<b>Teachers know that many learners have difficulty to make their thinking visible.</b>	<ul style="list-style-type: none"> <li>• Learners, especially some of the smarter learners, will often easily find the solution to a problem, but then they cannot explain how they got the answer (Sonja[F], ii).</li> <li>• Learners find it very difficult to express what they did to find the solution (Retha[F], ii)</li> <li>• “...because... teacher, I just know it” (Sonja[F], 113ii).</li> </ul>	<ul style="list-style-type: none"> <li>• That is where the problem actually lies; how to explain your solution and write it down (Carin[I]; Emma[I], ii).</li> <li>• “It's very frustrating when I ask a Grade 6 child how you did it and they cannot tell me, then it's not my weak child, I talk about my smartest child in the class. Then she says... I just did it... and it's frustrating, because then they do not really understand the problem (Carin[I], 140fg).</li> </ul>
<b>Teachers know that learners learn from their peers.</b>	<ul style="list-style-type: none"> <li>• “It is okay if a learner looks at their peers' work, because that is how they learn from one another” (Marli[F], 1222ii).</li> <li>• “I mean the child that struggles will want to look at his friend's work... they don't think it's cheating; it's a natural thing to seek help” (Retha[F], 990-991ii).</li> <li>• Learners explain things to one another in their own language and at their own pace and sometimes the learners will then understand something better (Amy[F], ii; Retha[F], ii; Sonja[F], ii).</li> </ul>	<ul style="list-style-type: none"> <li>• “...because they often learn better from one another than from the boring teacher who always stand in front of the board” (Santie[I], 1529ii).</li> <li>• “...look I can explain it to a child to a certain point, but another child can do it much better than I ever could, because they speak to each other's level and they learn from each other” (Emma[I], 152-152ii).</li> </ul>

<p><b>Teachers know the specific areas in mathematics where learners often encounter difficulties.</b></p>	<ul style="list-style-type: none"> <li>• Learners struggle to do problem solving that involves money (Lea[F], ii &amp; Sue[F], ii).</li> <li>• Learners find it hard to do sums that involve more than one calculation or when they have to explain their thinking (Amy[F], ii).</li> <li>• “If you give him the sum to do or verbally say or read the sum to him, then he can do it, but give him a word sum... he doesn’t have a clue” (Sonja[F], 119-120fg).</li> </ul>	<ul style="list-style-type: none"> <li>• Learners struggle to estimate (Carin[I], ii).</li> <li>• “Fractions is a big problem in this school” (Emma[I], 1512ii).</li> <li>• Learners find word problems very difficult, mostly because they cannot identify the problem (Carin[I], ii). They can do an ordinary sum, but if you put the same sum in a word problem, they cannot do it (Faye[I], ii).</li> <li>• When a problem consists of more than one operation, learners seem to find it difficult (Carin[I], ii; Faye[I], ii &amp; Santie[I], ii).</li> <li>• Many learners do not know their tables and basic combinations (Adri[I], ii &amp; Emma[I], ii, fg).</li> <li>• Learners will often swop the digits in their numbers, copy the numbers incorrectly from the book or worksheet and are not in the habit of checking that they copied correctly (Carin[I], ii; Emma[I], ii &amp; Mia[I], ii).</li> </ul>
<p><b>Teachers know that some learners do not know that they do not know.</b></p>		<ul style="list-style-type: none"> <li>• Learners do not always know that they did not find the correct solution to a problem, especially the learners who struggle; however they think they did solve the problem (Adri[I], ii &amp; Carin[I], ii,fg)</li> </ul>
<p><b>Teachers know that learners need a good number concept to solve problems.</b></p>	<ul style="list-style-type: none"> <li>• Learners first need to have a good number concept, before they can attempt to solve problems (Marli[F], ii; Retha[F], ii; Sonja[F], ii &amp; Sue[F], ii).</li> </ul>	<ul style="list-style-type: none"> <li>• Learners need to understand the absolute basics of mathematics, combinations tables and basic calculations (Emma[I], ii).</li> </ul>
<p><b>Teachers know that learners benefit from small group teaching.</b></p>	<ul style="list-style-type: none"> <li>• It is easier for learners to concentrate, pay attention and share their thinking during small group teaching (Amy[F], ii, Lea[F], ii &amp; Retha[F], ii).</li> </ul>	

- *Perezhivanie*

The participants acknowledged the tremendous influence learners’ emotional experiences or their meta-experiences (Smagorinsky, 2013) could have on their ability to do mathematics. They also realized the importance of their role as teachers in creating a culture in the mathematics classroom where learners could feel emotionally safe to take risks and express themselves. Many researchers have found that non-cognitive influences, such as beliefs, attitudes, affect and motivation, can be linked to a learner’s problem solving performance (Carlson & Bloom, 2005; Jagals & Van der

Walt; 2013; Malmivuori, 2006; Schoenfeld, 2010; Wilson & Clarke, 2004; Zimmerman, 2008).

Some of the participants (Carin[I], ii,fg; Faye[I], ii; Lea[F], ii,fg; Retha[F], ii) highlighted learners' lack of self-confidence when confronted with a mathematical problem they had to solve. This seemed to be a concern in both phases and could affect all young school learners. Lea[F] (ii) explained that you had to support learners who lacked self-confidence step-by-step and guide them to understand, "because when they start to understand they get self-confidence and when the self-confidence is there, then there is courage" (577-578ii). This reinforces the importance of working within the learners' zone of proximal development (see section 2.3.3), since it will increase learners' self-confidence when they are appropriately challenged and at the same time supported. Retha[F] (ii) said that when she noticed learners with low self-confidence successfully solving a problem, she would ask them to explain their solutions. This would boost their self-confidence, since they realized that it was not that difficult. Another aspect of self-confidence that Faye[I] (ii) illuminated was that even the stronger learners who got all their answers right could seem unsure and would seek her approval. Carin[I] explained that some learners had the potential and knowledge to solve a problem, but "[a]t the end of the day it is... actually fifty percent is self-confidence and if a child decided... I can't do it and I will not do it... then he won't do it" (1369-1371ii).

Several participants noted that learners often experienced anxiety about mathematics. "[W]hen they hear the word mathematics then they all become stressed. So I must tell you... to make it fun for them... really enjoyable and completely take away that stress factor" (Santie[I], 651-652ii). "[M]any of the children become anxious and I don't want them to have that anxiety, because they become... some of the children just want to cry" (Retha[F], 611-612ii). Retha[F] (ii) said that if that happened she would ease the learner and calmly provide support. Faye[I] explained that if learners struggled to solve a problem, she would provide individual support at her table, otherwise "they become panicky" (241ii).

Several participants used the notion of *perezhivanie* to motivate the grouping structures in their classrooms. Even though Carin[I] realized the advantages of group work, she explained that she had not used it this year as she had previously had some incidents with groups that had hurt some of the learners' feelings.

*It's not nice to be in a group and then a child tells you but you are stupid... Unfortunately I often get such nasty things and I don't want to expose my children to it in mathematics. There is already this... let's call it a fear of mathematics... there is this... aah, mathematics is so hard. So I don't want to expose my children who are already struggling to that. (Carin[I], 1361-1364ii)*

Faye[I], who is generally not in favour of any group work, said that she would sometimes group learners together in pairs, but only to discuss the work verbally. She preferred them not to write when working together, since if a learner did the sum in the wrong way, another learner might think “look at this stupid child next to me” (1289ii). “I don't want to embarrass a child” (Faye[I], 234ii). Marli[F] (ii), who used mixed ability grouping, said learners knew which group they were in when grouped according to their abilities, and that she did not want to label them in that way. She felt that if they knew their labels, they would perform accordingly. Amy[F], who uses ability grouping, confirmed Marli's[F] assumption that learners knew which group they were in:

*[T]hey keep asking me who is group one and who is group two and who is group three... but they know... they definitely know. You can see it when one of them is moved up how chuffed he is with himself. (1267-1269ii)*

### **5.5.1.3 Knowledge of metacognition**

To explore the participants' knowledge of metacognition, I explicitly asked them during their individual interviews to tell me about their understanding of metacognition. I anticipated that many of them might not be familiar with the term, since several of my friends, family members and colleagues seemed puzzled when I told them the title of my thesis and would then usually ask what metacognition was. I was not too surprised, therefore, by answers such as:

- “Oh... gosh! You will need to help, I don't know. I do not know what it is” (Retha[F], 452ii).
- “Uh no, now I am clueless, now I don't know what that is” (Sue[F], 458ii).
- “I do not know what that means. Meta? As in many? I'm sorry...” (Sonja[F], 459ii)
- “No, you tell me... (laughing). Oh, gee...” (Lea[F], 470ii)

- “Ooh... why do you give me such a dirty word? I do not know... I do not know what to say. I’m not even going to waffle... I’m not like that” (Emma[I], 612-613ii).
- “Is there perhaps another word for it?... I don’t know, but that’s not familiar to me... to be honest” (Adri[I], 632-633ii).
- “Okay... I don't think I have ever heard the word before... I don’t know if I had to? (Faye[I], 606-607ii).

Even though Faye[I] admitted that she was not familiar with the concept, she tried to figure out the meaning, making her thinking visible during the interview when she said, “Uhm... cognition has to do with your cognitive thinking and meta means more than one at a time... so it’s to multitask in your brain” (606-607ii). I found her metaphor quite compelling.

I did not explain to any of the participants what metacognition was. Instead, I told them that if they were still interested, I would tell them after the focus group interviews. Some of the other participants, however, did to a certain extent have an idea of what metacognition means.

- “That's to think to think” (Amy[F], 460).
- “Meta is to think about the cognitive. Metacognition... and then there was something in language... about think about yourself and how you do it (Mia[I], 585-587).
- Metacognition is to think about how you think (Carin[I], 614ii).
- Meta is... it is about thinking... just about everything is about thinking... But higher thinking... it's really what it's about. A little beyond the ordinary... to really think and argue about it (Santie[I], 603-605ii).

Carin[I] recalled that when she was a student she had attended a course where she learned about metacognition. She said she still had the book, *Comprehension shouldn't be silent*, that she had used during the course, but admitted, “I must say I have not consciously tried to apply metacognition in mathematics. I now know how to do it in the languages, but I don't have the knowledge to do it in mathematics... honestly” (Carin[I], 912-914ii).

This question about metacognition made some of the teachers’ curious. The day after Santie’s[I] interview, when she returned her biographical information form, she

attached a printed page with a two-paragraph description of metacognition that she had retrieved from the internet, with a note saying, “It was good to read about this again”. Carin[I] shared that, a couple of days after her interview, Emma[I] asked her if she knew what metacognition was. During the Foundation Phase focus group interview, Sue[F] brought up the topic:

*Lea[F]: Yes, I think we have strategies that we do not even know we use.*

*Sue[F]: Yes, Susan-Mari, that word you asked me and I didn't have a clue what it was.*

*Susan-Mari: Oh, metacognition?*

*Chorus: Yes, yes, yes! [laughing]*

*Sue[F]: I think Lea[F] was the only one who knew. [laughing]*

*Lea[F]: No, I didn't, but it bothered me so much that she asked me something I didn't know, I had to Google it. I first ran to Amy[F]... do you know what it means?.. no! Phone! Google!*

*Chorus: [Laughing]*

*Lea[F]: It's once again knowledge that we have, but we didn't know that term was used for it. (85-95fg)*

It was clear that only a few of the participants really knew what metacognition was. This fact chimes with Papaleontiou-Louca's (2003) contention that teachers are already using metacognitive strategies in the classroom, but are not always consciously aware that they do, an argument that will be further explored in the next section.

The knowledge dimension discussed as the first theme can be regarded as the groundwork for the following theme. This will explore the strategies both Foundation and Intermediate Phase teachers employ to mediate metacognition during mathematical problem solving, taking into account the variety of learners in their classrooms.

### **5.5.2 Theme 2: The strategies dimension**

This section will explore *how* teachers mediate metacognition during mathematical problem solving. It will also explore strategies they employ that are “sensitive to the diverse needs of learners” (DHET, 2011, p.49).

### 5.5.2.1 *Mediation of metacognition*

Using the data collected from classroom observations and interviews, I was able to analyse how the participants mediated metacognition during mathematical problem solving. Both Flavell (1976) and Brown (1978) identify *knowledge of cognition* and *regulation of cognition* as the two main categories of metacognition. In my interview schedule and observation schedule, I therefore specifically noted these two categories as aspects to be explored. In particular, I took Brown's (1987) advice that in order to bring clarity to the construct of metacognition one must separately explore *knowledge of cognition* and *regulation of cognition*. The analysis of the data for this category naturally divided into two sub-categories: mediation of metacognitive knowledge and mediation of metacognitive regulation.

- ***Mediation of metacognitive knowledge***

Metacognitive knowledge is vital to the learning process since it can impact on how learners plan, regulate and direct their own learning (Goh & Hu, 2013). To enable learners to become self-directed, teachers should therefore mediate metacognitive knowledge in the classroom.

Questioning and probing were the strategies that most teachers in both phases used to mediate learners' *declarative metacognitive knowledge*. All the teachers said that after they had presented the problem they would ask the learners to tell them what they already knew and to describe the question that was asked in the problem. This was also a pertinent feature in all the observed lessons. A noteworthy observation from the questioning was that most teachers gave their learners enough thinking time to answer. This gave them an opportunity to activate or develop their metacognition (Larkin, 2009). If the learners still did not know, the teacher would then ask leading questions. This strategy is also recommended by Azevedo et al. (2007), who believe that it helps learners to reach higher levels of declarative metacognitive knowledge. Marli[F] said that after she posed a problem to the learners she would "ask questions to get their brains started that they can realize what the sum is about" (631ii). Santie[I] (ii) explained that she did not tell the learners straight away that they should just multiply the two numbers with one another; instead she would first ask them to tell her what they already knew. By asking learners if they understand the problem, Mia[I] (ii) noted that some of the learners were then able to realize that they did not understand and that

they needed assistance. This was also evident during my observation of Carin's[I] (ob) lesson, with the focus on long division. She asked the learners how many of them did not understand how to do long division. When some of them raised their hands, she told them to specify which part they did not understand. They were all able to tell her exactly what they did not understand. Adri[I] said that when learners did not know what the problem was, she would tell them, "You don't realize what is asked of you... let's look at it together" (926ii). Santie[I] preferred to ask learners if they agreed, for example, that six times seven was 43, because this forced them to realize that they did not know their tables.

In mediating *procedural metacognitive knowledge*, some of the Foundation Phase teachers (Sonja[F], ii; Sue[F], ii) highlighted the importance of presenting learners with mathematical problems that would enable them to use the knowledge and strategies they already possessed to solve the problem. Sonja[F] emphasized this crucial consideration when she said:

*So we need to expose children to the problems in such a way that they... the knowledge they have already gained... that they can identify it in the problem and that they have the confidence to solve the problem... within the space you provide to solve the problem... without the teacher being the one who tells them to do it in such and such a way. (549-552ii)*

This mirrors the conclusion of Wilson and Bai (2010) that to improve learners' procedural metacognitive knowledge teachers should provide them with appropriate assignments. This would require the learners to intentionally select metacognitive strategies which would enable them to complete the given assignment. Sonja[F], however, said that was usually easier for the more advanced learners to see the patterns and make associations, while some of the others needed guidance. Retha[F] (1317ii) did not consider this guidance as "spoon feeding" the learner, but rather as a form of support enabling the learner to solve the problem. This again reinforces the importance of working within the zone of proximal development.

During some of the lessons, I observed how teachers mediated *conditional metacognitive knowledge*. In the following dialogue, between Faye[I] and one of her learners, she explained to the learner when to apply a certain strategy:

*Learner [L]: Ma'am, is it wrong if I estimated the answer first?*

*Teacher [T]: It is never wrong to estimate the answer. In a test situation, if you want to estimate your answer and you are a fast worker, it is fine. It is a good measurement to use to see if your answer is close to your estimated answer, but you write slowly when you write tests, so you shouldn't do that in a test. Afterwards when you check over your paper what is better to do? An estimated answer or what?*

*L: An inverse operation.*

*T: An inverse operation is then better. So you do that when you have time. (Faye[I], 30-37ob)*

According to Schraw et al. (2006), conditional metacognitive knowledge refers to the *why* and *when* to use a particular strategy that is most appropriate for that situation. In the above dialogue, Faye[I] made it clear to the learner why and when she could use estimation. I observed a similar dialogue between Carin[I] and one of her learners, where she explained the use of a clue board during long division:

*L: Do we have to do a clue board?*

*T: If you can do it out of your head... no, but if the numbers get too big, can you do it out of your head?*

*L: No.*

*T: Then you use a clue board... alright?*

*L: It was really easy... I didn't need to use the clue board.*

*T: I hope your answers are correct. Grade 6, the clue board is a tool. It is effort, but it is a tool to help you. (Carin[I], 83-90ob)*

This mediation of conditional knowledge was also observed in the Foundation Phase (Lea[F], ob; Retha[F], ob; Sue[F], ob). Sue[F] (ob) asked the learners if they would be able to divide a marble into fractions, as they did with the pizza, if there was one left over after you had shared it. They concluded that certain objects cannot be divided into fractions. These examples show that, through the use of language, knowledge can be shared on an interpsychological level, and that this can lead to internalization, with learners applying this knowledge in future on an intrapsychological level (Vygotsky, 1978).

- *Mediation of metacognitive regulation*

Metacognitive regulation is divided into three components: planning, monitoring and evaluation. These enable learners to gain executive control of their behaviour and should take place before, during and after learning activities (Hargrove, 2013). During the individual interviews, I specifically asked the participants to describe how they helped learners to plan, monitor and evaluate their mathematical problem solving. From these answers and by observing their lessons I found several strategies teachers employed to mediate metacognitive regulation.

To help learners to *plan* their problem solving process, the participants from both phases emphasized the significance of four strategies: reading the problem, making sense of the information given, breaking up the problem into its smaller parts, looking for familiar key words that could help learners decide which calculation would be most appropriate, visualizing the problem, and drawing the problem. When monitoring the process, all the participants once again indicated that they prompted the learners to read the question again to ensure that they were still on the right track. “I will often... if I see a child is heading in the wrong direction, I will tell the child okay... let teacher read the problem to you again” (Retha[F], 785-786ii). “I always tell them... go back and read what they asked, because they often get off track” (Carin[I], 836-836ii). This is an important strategy, also identified by Yimer and Ellerton (2010) since they found that re-reading the problem influenced the metacognitive decisions and/or actions a problem solver would take. Teachers in both phases emphasized the importance of showing learners how to monitor their calculations by using inverse operations (Adri[I], ii; Faye[I], ii; Santie[I], ii & Sonja[F], ii).

To empower learners to *evaluate* their work, the participants offered them opportunities in class to present their solutions. They either verbally explained what they had done or showed their written solution. The solution would then be discussed and evaluated by the class and the teacher. I noticed during all the observations that learners marked their own work after the correct answer had been displayed. Mia[I] explained that, “I also let them mark their own work, because I want them to see where they went wrong” (869-870ii).

Vygotsky’s (1978) notion of the transition from other-regulation to self-regulation is especially relevant during the mediation of metacognitive regulation. The teacher gradually increases the learners’ responsibility to the learners as they become

more capable of independently performing these metacognitive regulation tasks after internalisation (Baker, 2010). Marli[F] explained that Grade 1 learners found it difficult to “check” their answers (669ii). However, she gradually mediated this concept to them during the year, noticing that by the end of the year they were able to “go back and they can just see... oops, I've done that wrong” (670-671ii). The learners had thus internalized this metacognitive strategy and in the future would be able to self-regulate.

- ***Strategies to mediate metacognition during mathematical problem solving***

In the analysis of the data, I identified strategies which were purposeful, process-driven, intentional and carefully selected to reach a specific goal (Okoza & Aluede, 2013). Many of the strategies the participants employed to mediate metacognition were evident from the data. Some of these were already discussed above in relation to the mediation of metacognitive knowledge and regulation. I found it challenging to determine exactly when teachers were mediating cognition and when they were mediating metacognition. I reasoned that, even when they were mediating cognition, their learners might be able to reflect on the mediation and in the future use it to regulate their own cognitive behaviours. An initially interpersonal cognitive mediated act can evolve in the learner into intrapersonal metacognitive regulation. Cognitive processes thus need to be mediated to increase learners’ metacognitive knowledge, which can then be utilized in particular situations (Efklides, 2008; Zohar, 2006). The following example, from my observation of Sue’s[F] lesson, demonstrates how mediation of cognition might help learners to metacognitively regulate their behaviour in the same way in similar future situations.

*[The teacher removes the first word sum from the board and pastes a new sum on the board. She tells the learners to read the sum with her.]*

*Chorus: There are 24 boys and 13 girls. How many learners are there in the class?*

*[The teacher asks the girls to read the sum together again.]*

*T: What are the two numbers that are in your question?*

*[Teacher asks specific learner.]*

*L: 24*

*T: Two numbers*

*L: 24 and 13.*

*T: 24 and 13. Now if you look at the story there [points to the word sum on the board] ...24 WHAT were there?*

*[The learners are not able to answer the question immediately.]*

*T: Okay, look the answer is on there [points to the word sum on the board].*

*L: 24 bananas [previous sum was about bananas].*

*T: Uh-uh. Read your problem again.*

*L: Boys.*

*T: There were 24 boys... 24 Boys. Right and what was the 13? The 13 was what?*

*L: Girls.*

*T: What I know now children is that there are boys AND girls. Now teacher wants to know how many learners are there. What can I immediately tell?*

*L: Plus!*

*T: It is a plus sum... we know it is a plus sum. (Sue[F], 108-128ob)*

Interpersonal communication was a prominent feature in all the observed lessons. The focus of all these lessons was on problem solving, reminding us of Vygotsky's (1978) statement that it is through language that learners are given the tools to plan a solution, not jumping haphazardly into difficult tasks but regulating their own behaviour. The prominence of interpersonal communication during the lessons further echoes Damianova and Sullivan's (2011) statement that speech can be seen as the supreme instrument during mediation which makes internalization possible.

To promote metacognition, thinking should be made visible and shared among teachers and learners (Wilson & Bai, 2010). Both the teacher's and the learner's thinking should be made visible. Participants from both phases revealed how thinking was made visible in their classrooms during mathematical problem solving. Many of the teachers in the Foundation Phase encouraged their learners to *make their thinking visible*. Sue[F] said that "often the child knows the answer right away, but I tell them they have to show me how they thought" (700-701ii). Sonja[F] went so far to say "to show how you think, THAT is the problem solving, not necessarily the answer" (112-114ii). The focus is thus on the process, not on the product. Amy[F] explained how learners in her Grade 3 class are able to notice when their answers do not make sense

and she attributes this ability directly to the fact that learners are expected to make their thinking visible.

*Then... they can often see when they get the answer... okay but it doesn't make sense. Then we go back to the steps on why it makes no sense. Where is the mistake... so... I will always... because we are so focused that we want to see his thought process... we want to see it on the page... on the task card it also states... 'show your thinking'. (753-757ii)*

Retha[F] promoted the effectiveness of small group learning, saying that it created a space where learners felt safe and confident enough to share their thoughts on how they solved a problem. During the Foundation Phase observations, I noticed that through small group teaching the teachers were able to pay attention to all the learners' verbal or written thinking and remark on it. The various solutions were discussed and evaluated within the small groups. This is a strategy known as *debriefing* (Wilson & Bai, 2010). The learners were encouraged and seemed eager to share their thinking and evaluate one another's work.

In the Intermediate Phase, learners were expected to show all the steps in their books when they had solved a problem (Adri[I], ii; Carin[I], ii & Mia[I], ii), Emma[I] noted that some learners immediately got the answer, but had difficulty in making their thinking visible. She would then guide them, "Tell me what is in your head. Explain to me what you see to get to the answer?" (898-899ii). Carin[I] confirmed this concern when she explained that "something they are struggling with is to show their calculations. They rush off their mathematics. They just want to finish" (441-442ii). During some of the observations in the Intermediate Phase, I saw teachers ask specific learners to show on the board in the front of the class how they had solved the problem. Most of the learners would do the sum on the board and then go back to their desks. The teacher then asked the other learners if they agreed with the answer and they would then either correct the error if it was wrong or move on to the next sum if it was right. In Carin's[I] class I observed how she explicitly told the learners to make their thinking visible while doing the sum on the board. One of the learners seemed unsure how to explain her thinking, but Carin[I] prompted her while she explained the calculations:

*T: Okay, you are not just going to do the sum. You are going to explain to the class your steps. Just what I did now. You are going to explain the steps.*

[Learner starts with the sum on the board.]

T: I am not hearing you talk. What are you doing? I want to hear you explain what you are doing (Carin[I], 102-106ob).

The focus here was on what the learner was *doing* and not what she was *thinking*. Schraw et al. (2006) maintain that it is difficult for us to explain our thinking, since we lack an accessible language or appropriate vocabulary of metacognitive processes, limiting the discourse in the classroom about metacognition.

In the mediation process, the teacher also needs to make her thinking visible (Wilson & Bai, 2010). This is known as *modelling* (Hargrove, 2013; Martinez, 2006; Mayer, 2001; Shannon, 2008; Wilson & Bai, 2010; Zakin, 2007). Mayer (2001) holds that:

The most successful instructional technique for teaching students how to control their mathematical problem-solving strategies is cognitive modeling of problem solving in context, that is, having a competent problem solver describe her thinking process as she solves a real problem in an academic setting. (p. 56)

All the teachers, to some extent, modelled how to solve mathematical problems. When the teacher modelled the problem solving the learners were actively involved. However, I noticed that none of the teachers modelled how to solve a problem from beginning to the end, allowing learners to imitate the whole process. The Foundation Phase learners simultaneously solved the problem step-by-step with the teacher in their books on the mat. A similar modelling strategy was only observed in Adri's[I] class in the Intermediate Phase, where learners were involved in solving a novel problem while she modelled it on the board. In the other Intermediate Phase classes, learners either had the problems for homework or first had to solve them in class; the teacher would then model the process while asking them questions. Thus the Intermediate Phase learners had to reflect on their earlier work and remember how they thought about it while they were solving the problem. Larkin (2010) would argue that this reflection is probably only an interpretation of what the learners truly thought at the time. The strategy as used by the Foundation Phase teachers and Adri[I] would be more conducive to the development of metacognition, since the learners would become aware of their thinking in real time (Larkin, 2010).

It is through teacher modelling that learners can be taught heuristic strategies to solve problems such as (1) read and re-read a problem, (2) break a problem into smaller parts, (3) draw a picture, (4) distinguish relevant from irrelevant information, (5) visualize the problem, (6) look for a pattern, (7) look for keywords, (8) follow heuristic steps, (9) estimate and check/inverse operations, and (10) use available concrete objects or mathematical resources. These strategies were modelled more than once in each phase by different participants, except for the latter strategy which was exclusively modelled by Foundation Phase participants. It could be argued that learners in the Intermediate Phase should already have internalized the mathematical tools and basic systems for counting to which they were exposed during their years in the Foundation Phase. From the comments of some of the Intermediate Phase participants, however, it appeared that not all the learners had yet internalised these tools. Emma[I] for example said:

*[E]ven the ones I think... that I think can do mathematics and understand what I'm saying... I also catch them that they will count on their fingers and work with the fingers. For me... that's not on. You need to know that stuff. (520-523ii)*

This was echoed by Adri[I] who said that “he can only count from one to twenty, then he uses his fingers” (576-577ii). Faye[I] noticed the same tendency, “I prefer them not to count on their fingers, but some of them use... some of them look at their rulers or they count... I've seen them counting their pencils” (376-377ii). Clearly, for some learners in the Intermediate Phase these socially constructed artefacts and various systems for counting had not yet been turned inwards and transformed into an intrapersonal activity. For Vygotsky (1987), the process that finally leads to internalization consists of a long chain of developmental events which will not happen for all learners in the same grade at the same time. This brings us to the next section of the findings, where the strategies teachers employ to differentiate their teaching during the mediational process will be explored.

### ***5.5.2.2 Differentiated instruction in the mediational process***

To determine if the participants encountered diversity among their learners, I asked them during their individual interviews to describe the range of learners they had in their mathematics class in terms of their diverse abilities and needs. All the participants confirmed the large variety of learners and learning needs in their classes.

Most only referred to the learners' current mathematical performance, but Faye[I] and Santie[I] also mentioned learners who had other barriers to learning that influenced the learning process. "I also have children in my class who have Tourette's and ADHD and struggles with hearing... so all that have an effect on how I should teach" (Faye[I], 992-993ii).

From the participants' responses, I concluded that they all arranged their learners' current mathematical abilities somewhere along a continuum. Those learners who performed well in mathematics, easily understood the concepts and welcomed challenges, were on one end of the continuum, while those who performed at a very low level and needed constant intervention were on the other end of the continuum. All the participants indicated that this wide range of learners, especially those in the latter end of the continuum, was one of their biggest challenges when teaching mathematics. Some of the Foundation Phase participants (Retha[F], ii; Sonja[F], ii; Sue[F], ii) said they only had a small group of the learners at the lower end of the continuum. On the other hand, the Intermediate Phase participants expressed their concern about the large group of their learners who were at the lower end of the continuum. Santie[I] (ii) said that this lower group was "just getting bigger and bigger", while Emma[I] (ii) said that her lower group was "quite big". Carin[I] was also concerned about the lower group in her class and said that, "There is a group that I honestly don't know how they got to Grade 6" (997-998ii). In the next section, I will focus on how the participants differentiated their teaching to meet the needs of these diverse learners.

- ***Differentiation of content, process and/or product***

The Foundation Phase participants unanimously agreed that they all varied the number range to match their learners' diverse needs. This was also observed during their lessons and confirmed again during the focus group interview. As described in section 5.2.1, the Foundation Phase teachers also used daily small group teaching to teach mathematics. The different ability groups did different work, as Lea[F] explained: *So your tasks are basically differentiated. So not all the children do the same tasks every day, the first group is much further than the other groups. So everyone's tasks they do at the desks are appropriate to the level where they are now, so the mat work [small group teaching] strengthens the desk work. (1174-1176ii)*

This was in fact also the case when I observed the Foundation Phase participants' lessons: the content was differentiated according to the learners' current abilities. When content is differentiated in this way, all the learners will be appropriately challenged, finding the content neither too easy nor too difficult thus working in their zones of proximal development (Tomlinson & Kalbfleisch, 1998).

The Foundation Phase teachers indicated that the process they used to help learners make sense of the work differed from ability group to ability group. As Retha[F] explained, "With the third group... your pace is slower with them and so on..." (908-909ii). Lea[F] said "with the weak learner you do more concrete work than your fast learner... I am there to offer them a challenge" (568ii). Lea[F] (ii) further explained that she would often differentiate the amount of work; she would sometimes give the learners who were really struggling less work, since otherwise they would become despondent. This was also evident during my observation of Lea's[F] lesson. When one of the learners really battled to solve a certain problem, Lea[F] gave him individual help; he then also received peer support when she had to start with a new group. When the boy and another girl who had worked together on the problem showed Lea[F] that they had got different answers she said:

*T: Then why do you have two different answers, when you should have worked together?*

*L: Teacher, we did, but... I didn't think.*

*T: Oh man, I think you have worked enough for today... you can sit at your desk and relax.*

*However all the other learners had to finish their tasks (Lea[F], 275-279ob.*

In the Intermediate Phase, teachers do not use small group teaching. From the data analysis of the interviews, it was clear that some of the teachers differentiated their teaching to meet the diverse learning needs in their classrooms. Mia[I] (ii) said she would sometimes give extra, more challenging sums to learners if time permitted and they had already done their work. She however indicated that this did not happen frequently, not even once every week. Carin[I] (ii) said that the wide range of learners could sometimes be a dilemma for her when she was teaching mathematics:

*I have children who work extremely fast and extremely slow uhm... and then I don't know... should I go on and leave the slow learners behind?... and I prefer not to do it,*

*because... uhm those particular learners' confidence is already not where it should be and... uhm... but then the fast learners have to wait... so when that happens, they [fast learners] must do the work in their Rainbow books. (Carin[I], 1557-1560ii)*

Emma[I] said that she felt sorry for one of the learners in her class, because he could not do the mathematics, “he just sits there”. She added that she was going to ask the learning support teacher to provide some tasks that he would be able to do. Mia[I] explained how she did mathematical problem solving in her class:

*I'll start with the easy problems... then you can see... well everyone can do it now. Right... then we go on to the bit more difficult problems. The whole class does the same, as it is... there is not a mat where you take a couple of learners together... and there is no time for it. The leap from grade three to grade four is too big and they really struggled at the beginning of the year to adapt. So I take them as a group and they must understand... everyone has to do all the work. Plus... uhm... there is literally no room for a mat or something, where I can take a group. (Mia[I], 1077-1084ii)*

Adri[I] (ii), Santie[I] (ii) and Carin[I] (ii) indicated that they reduced the amount of work for learners who were struggling to keep up. Santie[I] explained that she would often give individual support to learners who struggled; to her, it was more important that the learner could at least do and understand some of the work.

*Even if I... say I planned eight or ten sums for that day and I only do two with that learner who struggles... it's fine... that's okay. I don't pressure a child to do all eight. (Santie[I], 657-659ii)*

This strategy that Santie[I] used to reduce the work and simultaneously to support the learner mirrors Tomlinson's (2001) recommendation that differentiated instruction should rather be seen as more qualitative than quantitative, because a struggling learner will still need support to solve a problem, even if the number of problems is reduced.

- ***Differentiate to match learners' readiness, interests and/or learning profile***

The Foundation Phase participants said they used a baseline assessment at the beginning of the year as a guide to determine how learners would be grouped in their classes. The groupings would change throughout the year as the learners developed. The teachers used their formal and ongoing informal assessments as an indication of the learners' current needs. Sonja[F] realized that “now with CAPS... I have to say... you

change your children more often between the groups” (1143ii). Sue[F] (ii) confirmed that since CAPS was implemented she had been more flexible with the grouping arrangements in her class, “To me, there isn’t a specific group one, two and three anymore. This is quite a new thing... but I realized that it is much easier for me and I am progressing faster and the children don't become bored” (Sue[F], 33-935ii). This relates to what Tieso (2002) and Tomlinson (2006) say about flexible grouping being more fluid and effective than static ability grouping, since it allows for frequent assessment of learners’ growth and enables reassignment to a different group as indicated by the assessment. Amy[F] (ii), Retha[F] (ii), Sonja[F] (ii) and Sue[F] (ii) agreed that if they saw a group of learners all struggling with the same thing, irrespective of the ability group they usually belonged to, they would temporarily group them together and work on that specific concept.

Many of the Foundation Phase participants (Lea[F], ii; Marli[F], ii & Retha[F], ii) described how they provided the more advanced learners in the class with more challenging tasks, “You give them problems and challenges, which is absolutely wonderful” (Lea[F], 960ii). On the other hand, all the participants said they supported learners who really struggled with a concept either individually or in a group of two or three learners. Sonja[F] said “those three that don't even fit in the third group. Sometimes they are in the third group... but sometimes I group them together and work with them individually” (1154-1156ii). I observed the same occurrence in Retha’s[F] class, where she grouped together two learners who were at a much lower level than the other groups.

When Retha[F] teaches mathematics, she groups the learners according to their gender, “Boys like mathematics a lot. Boys are often better in mathematics than girls... I don't say it is like that, but that's my experience... boys love math, girls prefer reading” (Retha[F], 897-899ii). This statement by Retha runs counter to the actual findings of the SACMEQ III report, which found that in South Africa, Grade 6 girls outperformed the boys in both reading and mathematics in 2000 and 2007 (Moloi & Chetty, 2010).

During the Foundation Phase focus group interview, Retha mentioned that learners’ own interests should be considered, for example when you give them word problems:

*[I]t must be things that they can associate with. So when you give them a problem to solve, it must be something they like... like sweets... or things that interest them, it should not be things that they don't know about. (Retha[F], 11-13fg)*

The Intermediate Phase participants mostly used the learners' workbooks to track their progress. Adri[I] (ii); Carin[I] (ii); Faye[I] (ii) and Mia[I] (ii) said they regularly marked their learners' books. When they saw there was something that several learners did not understand, they would explain it again the next day. "If there are many children who had the work wrong, then I try to explain it in different ways, because all the children don't think in the same way. (Faye[I], 230-331ii). Carin[I] said she found it difficult to really support those learners in her class who were more advanced, "I must say that is something I struggle with. Uhm... often I will think ... my poor hundred percent child. Today again a child told me "ma'am... but it is so easy" (1160-1161ii). Carin[I] said that it would be ideal to have an enrichment book for each subject, but at the moment she did not have the time to make such a book. She added that the learners were under a lot of pressure to get through the work, and she would like to do certain things differently to match learners' preferred learning style:

*I feel terribly sorry for the kinaesthetic learners in our phase... uhm... I would really want to build a 3D shape, I would really like... uhm work with counters or representative things or... but as I said, the children are under a lot of pressure (1552-1554ii).*

Even though the Intermediate Phase teachers did not formally group their learners as was done in the Foundation Phase, all four grouping structures (T=Total groups, A=Alone, P=Partners and S=Small groups), as proposed by Gregory and Chapman (2013), were evident in both phases (see section 3.4.1). Most participants in both phases were in favour of cooperative learning groups. Emma[I] and Faye[I] said they preferred not to do group work. Emma[I] unequivocally stated, "I do not believe in group work. Not at all. I don't use group work in my class" (1306ii). She claimed that, besides all the chaos in the class, only one or two learners did all the work and nobody learnt anything. Faye[I], who had had first-hand experience of group work while still in school, explained why she was not particularly keen on group work:

*Okay... in general, I am not a fan of group work... uhm, I have a dislike in group work, because I was a Curriculum 2005 guinea pig... we ONLY did group work ... everything*

*was group work... from art to language to things that was actually supposed to be your own work... it was all done in groups. It was a nightmare... because in group work the weak child doesn't feature... only the high flyers feature. So they overpower the weaker children and the weaker ones... uhm... pretend to keep up... they pretend to understand everything, because they do not want to look bad. So I am generally not crazy about group work in mathematics. (Faye[I], 1278-1285ii)*

It is important to note that, from a sociocultural point of view, when learners are working in a group with their peers, the presence and active role of the teacher or final form (see section 2.4.3) are non-negotiable. If the final form is not actively involved in mediating the process, “the development of the child turns out very limited, and what results is a more or less completely underdeveloped state of the child’s proper forms of activity and traits (Vygotsky, 1994. p. 350).

It is noteworthy, however, that none of the participants indicated whether they had ever asked their learners to specify their own learning preferences or what types of differentiation they wanted, and then adjusted the curriculum accordingly (Kanevsky, 2011). It can therefore be assumed that deferential differentiation was not practised in the participants’ classrooms when solving mathematical problems.

The challenges identified by the Intermediate Phase participants were similar to those found by Stetson et al. (2007) (see section 3.4.2). Mia[I] (ii) said that she would have liked to use small group teaching in her class, but that the classroom was too small to fit a mat where she could carry out such activities. Carin[I] said that she would not have minded working out differentiated tasks, but that she had so many subjects to teach, as well as administrative tasks, and had to attend extramural school activities as well. Almost all the participants complained that they did not have enough time for all the things they would have liked to do and that it bothered them that they were not able to attend to the learners’ different needs.

### **5.5.3 Theme 3: The context dimension**

From a sociocultural perspective, mediation does not take place in isolation (see section 2.2 and 2.3). It is embedded in a complex and interrelated social and cultural context which influences the quality of the mediated process. This theme will illuminate the contextual factors which influenced the way in which the participants of this case study mediated metacognition during mathematical problem solving. I will

present the extrinsic influences on teachers' mediation and then explore the intrinsic influences.

### ***5.5.3.1 Extrinsic influences on teachers' mediation***

Several external factors which influence the way teachers mediate metacognition during mathematical problem solving were identified from the data analysis.

- ***Learners***

The learners in the class play a defining role in the mediation process. The learners' current level of development determines how teachers will adapt their teaching strategies and styles. The Grade 1 teachers, for instance, have to teach mathematics in a different way in the beginning of the year, when learners are not yet able to read, compared to the end of the year (Marli[F], ii & Retha[F], ii). "It's the child that leads you" (Sue[F], 1050ii). A teacher would therefore adapt the mediation process according to the learners' zone of proximal development (see section 2.3.3). Retha[F] explained that "often, especially with mathematics, I planned something, but then I end up in an entirely different place, because the children were not yet where I needed them to be" (184-185ii). Mia[I] also said that "you change your style according to [the learners] you have" (1027ii). One of the biggest concerns, emphasized by all the participants in both phases, was the learners' poor reading skills and specifically their reading comprehension, since that had a direct influence on their ability to solve mathematical problems.

*[H]ow often don't I tell parents at parent evenings... look at your child's reading mark and look at your child's mathematics mark. This goes hand in hand... because if he can't read, he will not understand and he can't... then he doesn't know what to do. (Amy[F], 430-433ii)*

This was seen as a major barrier in the mediation process, "Somewhere you get this wall that you crash into and it is... I see it as reading" (Adri[I], 61-62fg). Santie[I] (fg) and Sonja[F] (ii) said that when learners were unable to solve word problems it mainly had to do with their reading and comprehension, because if you gave them the sum without the words, they were usually able to solve the problem. They were especially concerned about this problem with reading since they are not able to read the question

papers to the learners when they are writing school, provincial or national assessments. This is only allowed in Grades 1 and 2. This concern can have a further detrimental influence on learners' development of metacognition, since re-reading the problem influences the metacognitive decisions and/or actions a problem solver takes (Yimer & Ellerton, 2010).

The participants also indicated that learners' behaviour sometimes influenced their mediation during problem solving. Many indicated that learners who battled to concentrate found mathematical problem solving especially hard (Adri[I], fg; Amy[F], ii; Carin[I], ii; Emma[I], ii; Marli[F], ii; Retha[F], ii, Santie[I], ii,fg; Sonja[F], ii). However, Lea[F] (fg) and Marli[F] (fg) said that sometimes it seemed as if they were not paying attention, when in fact they were engaged in the learning process. I observed this in Amy's[F] class, when one of the boys juggled three rubbers the entire time during his group learning session, but still managed to solve all the problems successfully. During my observations, I noticed some other learners who also had trouble concentrating. However, none of the participants made a big fuss about those learners' behaviour and just calmly told them to refocus. Faye[I] (ob), for instance, quietly and patiently talked to one of the boys who was trying to distract some of the other learners. She told him to put his coloured pencils away, and then helped him to rearrange his desk, with only his textbook and workbook in front of him, opened at the sum that she was explaining on the board. According Lindblom and Ziemke (2003), this control of learners' focus of attention by the teacher is an important aspect of mediation within the zone of proximal development.

Some of the participants pointed out how learners' attitudes and beliefs about mathematics could influence their learning. Emma[I] said that "now I get those with a negative attitude who don't want to do it" (399-400ii). She added that she would rather help those who struggled with a problem but had the will to solve it, than waste her time on those who struggled with it but did not have the will to solve it. Carin[I] said that the learners in her class had no motivation to solve problems; she attributed this to their belief that mathematics, and in particular word problems, were difficult. I also observed this in Carin's[I] class. She told the learners that if they had time, they would continue with word sums after everyone had finished the second exercise.

*L: Oh no!*

*T: Why do you say "oh no"?*

*L: I hate word sums. (Carin[I], 187-189ob)*

Some of the teachers (Carin[I], ii; Marli[F], ii; Sonja[F] fg) also mentioned the emotional difficulties some of their learners had to deal with and how these directly impacted on their performance:

*And then when I look at this boy who is really struggling... In the first term it looked like... he's not going to make it, he got threes for about everything, because he was emotionally in such a bad spot and this term his situation at home has stabilized a little more... and it shows in his marks... where it was a three, it's now a five and a six. (Sonja[F], 145-148fg)*

Abdul Rahim et al. (2009) confirm that distinct human features such as emotions affect the way the teacher and the learner engage in the mediation process.

- ***Professional collaboration***

The participants indicated that parents could have a critical influence on how their children performed in the mathematics class, which in turn influenced the mediation process. Marli[F] (ii) noticed that learners whose parents were involved performed better. Numerous research findings support this assumption, indicating that parental involvement has a positive effect on learners' performance (Epstein, 2005; Montgomery, 2005; Xu & Gulosino, 2006). Adri[I] (ii), Mia[I] (ii), Retha[F] (ii), Santie[I] (ii) and Sue[F] (ii) often contacted parents specifically to ask for support in helping their children with counting, tables, basic calculations and reinforcing the work done in class. They found that this type of support helped learners to work more effectively and accurately when solving mathematical problems in class.

On the other hand, some of the participants felt that parents could have a negative influence on their children's mathematical performance. Marli[F] (ii) believed that some parents were not patient enough and did not allow the child enough time to answer when they asked questions or solve real life problems that could directly impact on mathematical problem solving in class. According to Amy[F] (ii) and Carin[I] (ii), some of the parents were unfamiliar with the methods the learners used in school and thus did not know how to support their children. Emma[I] (ii) preferred not to give her learners any mathematics homework as she believed that parents would only confuse their children at home, and she would have to rectify the confusion in the classroom.

The last major concern, illuminated by several of the participants (Adri[I], fg; Carin[I], ii; Marli[F], fg & Santie[I], ii,fg), was the influence parents could have on their children's beliefs and attitudes to mathematics. Santie[I] said that if some of the learners only heard the word *mathematics* they would already be stressed out, saying, "Oh, my mom said she couldn't do math... so she can't help" (649ii). Marli[F] commented that, "You can see when the parent is negative towards the child or puts a lot of pressure on them... they actually sort of crack... rather than to build them up and encourage them" (164-165ii). Adri[I] (fg) described how one of the parents had told her daughter that neither she nor her husband could do mathematics at school, so they did not expect their daughter to do well in it, either. Adri[I] said that the girl was now just sitting in class and had no motivation to even try.

A further aspect of professional collaboration is the relationship between colleagues in the same grade and phase. The Foundation Phase participants said how much they valued these relationships with their colleagues and that they felt privileged to be more than just one teacher in a grade. Several of them said that they would consult their colleagues if they were unsure about something or ask their advice if they noticed that the way they explained something to their learners was not showing the desired effect (Amy[F], ii; Lea[F] ii,fg; Sue[F], fg). They further explained the significance of grade and phase meetings, "Look... I think another thing that is very valuable is to have grade meetings" (Sue[F], 258fg). Retha[F] confirmed this, "I think our Foundation Phase cooperation and how we plan together is much better than in the higher grades. We literally sit and talk everything out" (259-260fg). Sue[F] explained how all the Foundation Phase teachers would gather at the beginning of the year, "You know, if we have picked up something, for example, we see a shortcoming... then we talk to the other grades about it" (Sue[F], 266fg). Lea[F] said that this collaboration between teachers was not something that just happened once a week; they worked together daily and she could not imagine teaching without communicating with her colleagues. Sue[F] concluded that "it is wonderful to have that togetherness" (278fg).

Among the Intermediate Phase participants, only Carin[I] (ii,fg) stated that she would informally talk to one of her more experienced colleagues when she was unsure about something in the mathematics classroom. Santie[I] (ii) said that the system they used in the Intermediate Phase, where one mathematics teacher planned the work for the whole grade, frustrated her. She explained that the classes differed and that she

really battled to keep up with the work. Emma[I] (ii) was concerned about the collaboration between the teachers in the Intermediate Phase and the continuity between the grades of the methods used in mathematics. She felt they would need to work more closely together because too many different methods were used by the different teachers and this confused the learners. She suggested that all the Intermediate Phase teachers meet once a month to decide together how they would approach the work in a way which would benefit the learners.

Another form of professional collaboration was that between the participants and their class assistants (Amy[F], ii; Marli[F], ii & Sue[F], ii). All agreed on the importance of this support when teaching mathematics. “It helps me a lot to have a class assistant... I use her specifically for mathematics. I'll let her work with my weaker group... they can then get more attention than the others” (Amy[F], 1159-1161ii).

The details on the role of the learning support teacher only emerged from the Intermediate Phase data, where the participants explained how she specifically helped those learners who found mathematics particularly difficult.

- *Context of class/school*

As explained in section 5.2, the teachers in the English classes had proportionally more learners than the teachers in the Afrikaans classes (see Tables 5.5 & 5.6). This reflected the influence of the English class teachers' approach to mathematics. Faye[I] (ii,fg) explained that the more learners you had in your class, the more difficult it was to teach mathematical problem solving, because you were not able to attend to all your learners. Carin[I] agreed with this statement, “I personally struggle to attend to every child” (1059ii). However, this was not exclusively a concern for the teachers of the English classes, since Adri[I], (ii), Emma[I], (ii) and Santie[I] (ii) experienced the same problem. One barrier, however, was exclusively experienced by the English class teachers in the Intermediate Phase. Most of the learners in their classes had been in the same class since Grade R, meaning that they knew one another and that “there are terrible behaviour problems, they know each other too well, they know each other's buttons” (Carin[I], 193fg). Carin[I] (ii) said that this prevented her from working in groups, even though she thought the learners could benefit from group work during mathematical problem solving. Mia[I] echoed this, saying that she would have liked to use group work during mathematical problem solving, “but it's pretty difficult... it's just such a big class... so it's just so much noise, but uhm... no I would

very much like to do group work” (1229-1230ii). However, during my observation of Mia’s[I] lesson, a large part consisted of group work, and even though she said it was the first time she had used group work that year, the learners seemed to enjoy it, were well behaved and were actively involved in the lesson.

Many of the participants (Faye[I], fg; Lea[F], fg; Mia[I], ii) commented on physical aspects of their classrooms which hindered them from working in the way they would have liked. Lea[F], for example, said that “our class size... there is not always enough room for what you want to do. Because you do not have space, you feel so caged in and you feel irritable and disorganised... because we have so many things” (226-227fg).

- ***Department of Basic Education***

The DBE is the organizing body of basic education in South Africa and thus has a significant influence on what happens in classrooms. Teachers are obliged to implement the content of the DBE’s policy documents and curricula in their teaching. Cross (2010, p.441) notes that “[p]olicies represent a key sociocultural ‘tool’ that mediate the genesis of teacher activity”. The data analysis highlighted four aspects related to the DBE which influenced how the participants taught mathematical problem solving in their classrooms: (1) the CAPS curriculum, (2) the departmental assessments, (3) the Rainbow workbooks supplied by the DBE, and (4) the professional development training arranged by the DBE.

One facet of the new *CAPS curriculum* (see section 3.2.1) was a matter of concern for the participants in both phases: it does not provide enough time to consolidate a topic or concept. The Foundation Phase participants reported that they were not as “slow and thorough” in teaching a particular number range as they used to be, and they had already noticed the effect of this on their learners (Sonja[F], 1445ii). Sonja[F] (ii) had observed more learners showing reversals of digits in numbers than in the past. For instance, they now confused numbers such as “12 and 21... in the past, we would first have ensured the numbers between ten and twenty are consolidated so... they have not met 21, they knew everything about 12 before we went to 21” (Sonja[F], 1457-1458ii). Problem solving is directly linked to the number range learners work in. If their number concept is not yet fully developed in a particular number range, they may be unable to solve mathematical problems within that range. In the Intermediate Phase, participants (Carin[I], ii; Emma[I], ii & Santie[I]) were also concerned about

how little time they had to teach a concept. Santie[I] explained that “it is not consolidated and that’s CAPS. I would say... first complete and consolidate one concept before you move to another concept” (1229ii).

Participants in both phases felt that their learners were not used to the type of questions or the way the questions were asked in the *departmental assessments*, so they now had to adapt their teaching accordingly (Amy[F], ii; Carin[I], ii; Faye[I], ii; Retha[F], fg & Santie[I], ii). Amy[F] (ii) and Santie[I] (ii) said they had to rush through the whole year’s mathematics to ensure that their learners would be able to solve all the problems in the Annual National Assessment in September. This method, commonly known as the “sprint and cover” mode, only encourages shallow learning and thus inhibits learners from developing higher-order thinking skills such as metacognition (Gallagher, 2010, p. 29).

Carin[I] (ii) and Marli[F] (ii) also pointed out that the ANA’s standard differed from the school’s standard, “Our standard for mathematics is somewhat higher than the ANA's” (Carin[I], 1542-1534ii). Amy[F] (ii) said that they spent much of their time teaching learners how to solve different types of mathematical problems, but only a small portion of the assessment consisted of problem solving. She added that the assessments placed greater emphasis on practical and mental mathematics, which most of the learners could do, “so that is actually now the focus of CAPS... so I can basically say they want a society that doesn’t think so hard”. This is in sharp contrast with Vygotsky’s ideal of a society that is cognitively and socially enlightened (Thorne, 2005).

The participants in both phases said that they often incorporated the *Rainbow workbooks* (see section 5.2.1 & 5.2.2) when they taught mathematical problem solving. “And in those departmental books [Rainbow workbooks] there are specific sections with problem solving sums. We will make a note of those pages and when we do our planning we will discuss which problems we are going to do” (Retha[F], 175-176ii). Sue[F] (1384fg) said they had not been too keen on the Rainbow workbooks at first, but now realized the “method in the madness”, since the type of questions in the ANA are similar to those in the Rainbow workbooks. Some of the other teachers also mentioned this reason as their main consideration for incorporating these workbooks into their mathematical problem solving (Carin[I], ii; Marli[F], fg; Retha[F], fg and Sonja[F], fg).

It could, however, be questioned whether teachers would use the Rainbow books, were the assessments not based on them.

Carin[I] (ii), Retha[F] (ii) and Santie[I] (ii) indicated that they found the *professional development* training sessions organized by the DBE to be valuable. They all agreed that they were excited to learn new things that they could apply in their mathematics class. “I really look forward to this new math thing... just to... to learn some new ways” Retha[F] (1198-1199ii). “I know it's during the holidays and it's horrible... I'm very excited though, because I hope I can learn something” (Carin[I], 459-460ii). Santie[I] said that she still had a lot to learn, noting how “many people, on principle, don't want to go to those work sessions” (1448ii). She compared the work sessions with going to church, “For weeks the Reverend tells you nothing... and then one day he will say one sentence that speaks to you” (1450-1451ii).

### **5.5.3.2 *Intrinsic influences on teachers' mediation***

Larkin (2010) believes that teachers hold the power to create a classroom environment that fosters metacognition. She adds that how teachers create such a space depends on their intrinsic beliefs, knowledge and opinions. I did not plan to explore the influence of intrinsic factors, apart from knowledge, on teachers' mediation. However, the actualisation of this category can be attributed to the emergent character of qualitative research (Suter, 2012).

- ***Teacher reflection***

Teachers naturally self-reflect when teaching, as they frequently question their own thinking and actions as they do so (Joseph, 2010). These reflections sometimes turn into actions, impacting on how mediation takes place in the classroom. During the interviews, several instances of the participants' self-reflection were evident.

Some of the participants explained how they critically reflected on their practice and reconsidered their strategies and goals during mathematical problem solving. Lea[F] (ii) said she often thought how she could adapt her teaching to make it more accessible for her learners, “And then you go and think that afternoon... how am I going to explain it to the children in an easier way?” (1289-1290ii). Retha[F] (fg) said that through self-reflection she had realized the importance of planning, “There have been some days when I was unprepared and then I think to myself... if I just planned this thing a little better, it would've been easier for me” (181-182fg). This echoes the

belief that a true craftsman can be distinguished from others by the quality and quantity of planning and reflection that are done both before and after teaching, as this has a valuable impact on classroom teaching (Lester, 2013). Sonja[F] (ii) had come to realize that the goal of mathematical problem solving was to enable learners to solve problems in real life. They should be able to extract the concepts taught in class and use them to solve a problem. She added that when she noticed the learners grasping this idea, “That to me, is such a wow!” (1440-1441ii). Adri[I] recalled the value self-reflection had had on her practice during her first year of teaching:

*I came to realize... the longer... as the days go by and I look... I would almost say reflect on my own teaching... During the first term I've learned a lot and I now want to build on it. Okay... no... rather do it that way or this way. (746-748ii)*

During the interviews, I had first-hand experience of how some of the teachers reflected on the topic we were discussing. Nevertheless, I would be reluctant to comment on whether these reflections had an impact on their teaching. Sue[F], for instance, said that she did not often use peer support, “Perhaps it's a shortcoming. Maybe I have to make more of it” (1235-1236ii). When I asked Santie[I] if her learners ever had the opportunity to do mathematical problem solving in groups, she said:

*It's a good thing that you mention this... We have a meeting this afternoon and I'm going to tell them some of these things we've discussed, because it's really nice, you know... We can still do the things in the CAPS, but we should be able to do it. You can easily integrate it... it's just a bit of more thinking. (1265-1279ii)*

During my observation of Santie's[I] lesson, she integrated group work into her lesson, so this self-reflection might indeed have influenced her practice during mathematical problem solving.

- ***Teacher autonomy***

Several of the teachers described how they made their own decisions about their teaching practice. Some of the Foundation Phase participants (Marli[F], ii; Sonja[F],ii & Sue[F],ii) said that, even though they planned their mathematical problem solving together as a grade with the prescriptions of the curriculum in mind, they had the autonomy to decide how much problem solving they would do each week with their class and when and how it would take place. In the Intermediate Phase, Faye[I] (ii) and

Mia[I] (ii) adapted the mental mathematics the learners had to do every day as prescribed by the curriculum to meet the needs of their learners.

Lea[F] said she could not see how one could teach a new concept using whole class teaching, as they were instructed to do during their CAPS training. She still used small group teaching to introduce a new concept, knowing that the learners would not all be ready simultaneously to grasp it. This conclusion can be related to the notion of the zone of proximal development.

In some cases, learners might not have benefited from a teacher's autonomy. Carin[I] said that, even though she knew CAPS prescribed that learners should estimate their answers, she did not expect that from her learners, since they did not have the number sense to do it. To be able to estimate an answer is, however, an important metacognitive regulatory strategy which should be encouraged during problem solving.

Emma[I] (ii,fg) recalled that she soon realized that the new curriculum did not provide enough time to consolidate concepts, as it jumped randomly from one concept to another. As a result, many learners in the class did not have the chance to internalize a concept before a new concept was introduced (Emma[I], fg). The concept thus stayed only in the intermental plane (see section 2.3.2 & Figure 2.2), leaving the learner unable to independently solve a problem related to that concept during assessments. "And then I decided, but... I should not really say this, but I decided that from now on I'll do it my own way, because I have to help that child" (Emma[I], 252-253fg). During the focus group interview, Carin[I] and Faye[I] said they felt that there were not enough formal assessments in mathematics, to which Emma[I] replied, "But you can make your own assessments and adapt it according to your children's needs. CAPS is not a Bible that you need to follow, it's really a... you can use your own initiative. Yes... it's just a guideline" (321-323fg).

- *Teacher's beliefs and attitudes*

Some of the participants explained how their own beliefs and attitudes influenced the way they taught mathematical problem solving. Marli[F] (ii) believed that the way she taught helped her to know exactly the needs and current abilities of each learner. She maintained that she would never again teach in a different way, "I will cry if I am not allowed to do that any more" (1219ii). Santie[I] (ii) said that she believed learners could benefit from group work, since they learned how to work

together as a group and also learned how to reason. On the other hand, Emma[I] (ii) and Faye[I] (ii) expressed their dislike of group work, as they did not believe that it was beneficial to all learners, “Don't ask me to do group work. I hate it” (Emma[I], 1328ii). This difference of beliefs relates to the ontological underpinning of this study that assumes that there are multiple realities (see section 4.2.2).

Larkin (2010) explains that beliefs and opinions originate from our experiences. Thus the experiences teachers had as school learners can influence their beliefs and practice of teaching, which in turn influence the experiences of their learners. Two such instances emerged from the interviews. Firstly, Amy[F] said that she was still unsure about mathematics, because “they [the teachers] made it [mathematics] a nightmare to me... If you got it wrong, they would shout at you... so you have to be aware of those things. Don't make the child negative. You have to make it fun and interesting” (342-344ii). Secondly, Faye[I] described why she did not do any group work in her class, “I stay away from group work, because I had bad experiences of group work in my school career. So I came to the conclusion that group work doesn't work” (1294-1295ii).

Some of the participants in both phases commented on the attitude a teacher should have when teaching mathematics. Mia[I] (ii) and Santie[I] (ii) said that you could not have an attitude where you decided you had done enough, and that if the learners still did not understand, it was not your problem. From the data analysis, several qualities that a teacher should have when teaching mathematical problem solving were identified by the participants. A synthesis of the qualities identified (excluding knowledge, see section 5.4.4.1) indicate that in order to successfully teach mathematical problem solving a teacher should be patient, optimistic, enthusiastic, self-confident, persistent, compassionate, encouraging, responsible and open-minded. Santie[I] (ii) believed that if you had the right attitude, you could achieve great things. Carin[I] (ii,fg) said that, even though the curriculum required teachers to incorporate word problems into their teaching, she became really frustrated with the learners when they did such problems, and therefore avoided them as far as possible. However, she added that, since she had not taken mathematics as a subject in her third and fourth years at university, she had self-studied methods on how to explain mathematics to her learners. Some of the other teachers also commented on the importance of being a lifelong learner and were very positive about learning new strategies. Lea[F] and

Retha[F] commented on how much they had enjoyed and learned from the iKwezi<sup>2</sup> and READ<sup>3</sup> initiatives, “I now think differently about things and it's nice, because I mean you see it's working with the children” (Retha[F], 1198ii). Lea[F] recalled that “you learn so many new ideas... and it's instantly... wow! That's a good idea and immediately you go back to school with a positive mind set” (1740175fg). The attitude that I found summed up my general impression of the participants of this case study was beautifully articulated during a reflective moment in Santie's[I] individual interview:

*I have to say I enjoy it [teaching] and it is still a challenge to me... honestly... I still want to learn. What quality of life do you have anyway if you spend two-thirds of your day at a job and it is not even challenging? Do not stagnate... expand your knowledge... read... read what they say about education in the newspaper... read what other schools do... read what the minister says... listen to what others say and do something about it. Enrich yourself... use new methods. (1428-1434)*

## 5.6 SUMMARY

In this chapter, I provided a thick and detailed account of the context and cases of this inquiry. A transparent and comprehensive description of the data collection process was reported. The presentation of the data analysis process was divided into the first four of the phases suggested by Yin (2011).

The three themes were then presented, supported by direct quotes from the participants' own words and related to the relevant literature.

In the next chapter, the last of Yin's (2011) five phases will be discussed, in which I will draw conclusions from the entire study and answer each of the research questions individually. This chapter will also examine the implications for practice and future research, the strengths and limitations of the study.

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<sup>2</sup>A primary school language and mathematics improvement project initiated by the University of Cape Town.

<sup>3</sup>The literacy provider in the literacy and numeracy training intervention undertaken by the Western Cape Education Department.

# CHAPTER 6

## ADDRESSING THE RESEARCH QUESTIONS, RECOMMENDATIONS, STRENGTHS, AND LIMITATIONS

### 6.1 INTRODUCTION

This qualitative collective case study was designed to explore and compare how Foundation and Intermediate Phase mathematics teachers mediate metacognition during mathematical problem solving. It sought to offer a deeper understanding of the process of mediation, the complex interplay between cognition and metacognition, and how teachers differentiate the mediation process to accommodate diversity among their learners. It also aimed to contribute to the limited body of knowledge on the role of the teacher during mathematical problem solving (Ader, 2013; Kennedy, 2009; Lester, 2013).

Recent assessments, both national and international, single out problem solving as an important but problematic factor in the current mathematical capacities of learners in South Africa (DBE, 2013; Moloi & Chetty, 2010; Mullis et al., 2012). It is evident that the problem escalates as learners progress to the Intermediate Phase of their school careers (DBE, 2013). Moloi and Chetty (2010) urge teachers to expose learners to more extensive applications, including higher-order questions involving both concrete and abstract problem solving skills. To actualize this, the teacher would be the primary catalyst.

Extensive research indicates a significant link between metacognition and successful mathematical problem solving (Desoete et al., 2003; Efklides & Vlachopoulos, 2012; Erbas & Okur, 2012; Holton & Clarke, 2006; Iiskala et al., 2011; Jacobse & Harskamp, 2012; Kennedy, 2009; Kim et al., 2013; Kuzle, 2013; Mevarech & Amrany, 2008; Mokos & Kafoussi, 2013; Wilson & Clarke, 2004). However, given the sociocultural perspective which formed the theoretical framework of this study, I saw metacognition as a higher-order function developing through interaction within social and cultural contexts (Lantolf & Thorne, 2007). Vygotsky's (1978) general genetic law of cultural development asserts that, before learners can progress to a stage

where they can self-regulate, they first need to experience it in the social realm in the form of other-regulation known as mediation. In this study, the mathematics teacher was identified as the human mediator who was regarded as the *more knowledgeable other* or *final form*.

Metacognition can be enhanced with appropriate mediation, especially in learners who face specific barriers to learning (Anderson, 2002; Lai, 2011). When teachers encourage learners and help them to think metacognitively during mathematical problem solving, it will move from the intermental to the intramental plane (see section 2.3.2 & Figure 2.2) and enable them to self-regulate their thinking and as a result enhance their mathematical problem solving capabilities.

This study aimed at contributing to the limited corpus of knowledge about Foundation Phase and Intermediate Phase teachers' respective roles when mediating metacognition during mathematical problem solving in diverse classrooms. To address this, I focused on three main research questions:

1. How do Foundation and Intermediate Phase teachers mediate metacognition during mathematical problem solving?
2. How do Foundation and Intermediate Phase teachers differentiate the mediation process during mathematical problem solving in such a way as to support all the learners, given their diverse abilities and needs?
3. How do teachers in the Foundation and Intermediate Phases differ in the way they mediate metacognition during mathematical problem solving?

To address these questions, I identified two cases involving mathematics teachers, the first in the Foundation Phase and the second in the Intermediate Phase of an urban primary school in the Western Cape Province. Each of the two cases included a sample of six mathematics teachers. I conducted semi-structured individual interviews, non-participant classroom observations, and semi-structured focus group interviews. From these, I gathered and triangulated rich and thick data. I analysed the empirical data, then juxtaposed it with the theoretical data that I had obtained by reviewing the literature relevant to this inquiry. The findings from the analysed data were presented as three themes in Chapter 5.

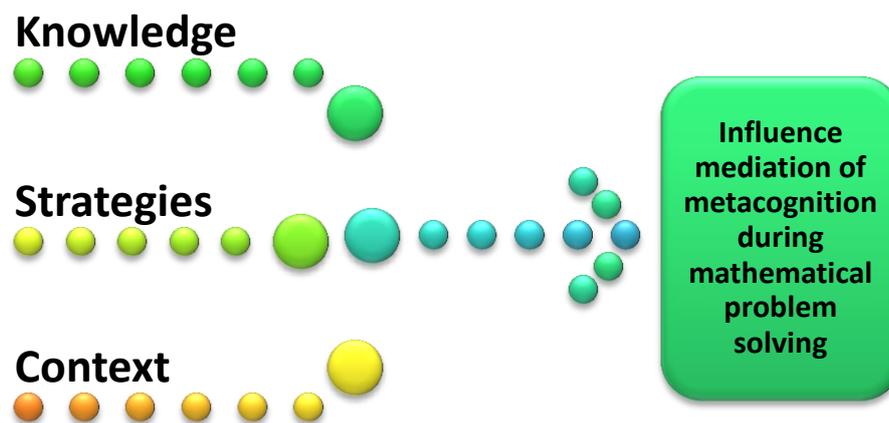
In the next section, the last of Yin's (2011) five phases will be discussed. I will report on the significant findings of the study as they relate to each research question.

This will be followed by the recommendations for practice and future research, as well as a summary of the strengths and limitations of the study.

## 6.2 ADDRESSING THE RESEARCH QUESTIONS

### 6.2.1 Research question one: How do Foundation and Intermediate Phase teachers mediate metacognition during mathematical problem solving?

Knowledge, strategies and context were identified as three dimensions that are omnipresent when teachers mediate metacognition during mathematical problem solving in diverse classrooms. As shown in Figure 6.1, these three dimensions directly influence *how* teachers mediate metacognition during mathematical problem solving.



**Figure 6.1. Three dimensions influencing teachers' mediation of metacognition during mathematical problem solving.**

All the participants had episodes where they mediated metacognition during mathematical problem solving. Only a few, however, displayed an understanding of the concept of metacognition. This confirms Papaleontiou-Louca's (2003) remark that teachers may already be using metacognitive strategies in the classroom, even though they are not always consciously aware that they are doing so.

The development of metacognition is understood as being embedded in a social context (Albert, 2000; Iiskala et al., 2011; Larkin, 2009). This strongly relates to Vygotsky's (1978) general genetic law of cultural development (see section 2.3.2),

which holds that the mediation of higher-order functions, such as metacognition, through social interaction precedes a learner's independent effort. Thus the first step towards ensuring the development of metacognition is for the teacher to create a classroom culture where social interaction and discourse are facilitated and encouraged.

The participants in this study all created such an atmosphere in their classrooms, actively involving their learners in many different ways during the observed lessons. Both the Foundation and Intermediate Phase participants used a number of general strategies to mediate metacognition during mathematical problem solving. These were characterized by highly interpersonal communication. This chimes with the claim of Damianova and Sullivan (2011) that speech is the supreme instrument during mediation and actualizes internalization. These strategies are laid out in Table 6.1.

**Table 6.1.**

*Strategies to mediate metacognition*

<b>Strategy</b>	<b>How it is mediated</b>
<b>Modelling</b>	<ul style="list-style-type: none"> <li>• Makes thinking visible by describing the thinking process while solving a problem.</li> <li>• Models the heuristic steps to solve a certain type of problem.</li> <li>• Models how to plan, monitor and evaluate the process.</li> <li>• Actively involves learners during the modelling process through questioning, ensuring they keep track.</li> <li>• Allows learners to make their thinking visible by modelling how they solved a problem.</li> <li>• Asks learners to imitate the process.</li> </ul>
<b>Debriefing</b>	<ul style="list-style-type: none"> <li>• Allows learners to discuss and evaluate the various solutions of different learners.</li> <li>• Allows learners to explain why a certain solution is or is not appropriate and which one is most appropriate.</li> <li>• Allows learners to reflect on their own solutions and evaluate their effectiveness.</li> </ul>

The general strategies of modelling and debriefing to mediate metacognition are consistent with the findings of Wilson and Bai (2010). They can be seen as the foundation for the more specific strategies the participants in this study employed to mediate metacognitive knowledge and metacognitive regulation. Metacognitive knowledge refers to one's awareness of the specific cognitive processes used in a particular situation and are thus continuously supplemented, updated and reorganized as

internalization takes place (Efklides, 2008; Zohar, 2006). Learners' metacognitive knowledge enable them to draw on their accumulated knowledge when solving problems (De Jager et al., 2005). Metacognitive knowledge includes declarative, procedural and conditional forms of knowledge (see section 2.4.1). The strategies the participants employed to mediate metacognitive knowledge are presented in Table 6.2.

**Table 6.2.**

*Mediation of metacognitive knowledge*

Component of metacognitive knowledge	Strategies
<b>Declarative metacognitive knowledge</b>	<ul style="list-style-type: none"> <li>• Questions and probes learners about their understanding of the problem.</li> <li>• Ensures learners can identify the problem that needs to be solved.</li> <li>• Allows learners enough thinking time to answer these questions.</li> <li>• Asks leading questions instead of telling them what they know or should do.</li> </ul>
<b>Procedural metacognitive knowledge</b>	<ul style="list-style-type: none"> <li>• Presents appropriate mathematical problems, guided by the learners' ZPD, which enable them to use the knowledge and strategies they already possess to solve the problem.</li> <li>• Provides support to lead learners to see the patterns or relating their prior knowledge to the current problem.</li> </ul>
<b>Conditional metacognitive knowledge</b>	<ul style="list-style-type: none"> <li>• Discusses with learners in real time why and when certain strategies are more applicable during certain situations than others.</li> </ul>

Metacognitive regulation refers to the interactive dimension of metacognition and takes place in the action phase of the learning experience (Garrison & Akyol, 2013). Teachers mediate metacognitive regulation while learners are busy solving a mathematical problem. They regulate and control the problem solving process in order to help the learners to successfully solve the problem. Planning, monitoring and evaluation, which are the elements of metacognitive regulation, act as the executive processes which enable learners to supervise their own learning (Iiskala et al., 2011). The strategies employed by the teachers in this study to mediate metacognitive regulation are identified in Table 6.3.

**Table 6.3.***Mediation of metacognitive regulation*

<b>Component of metacognitive regulation</b>	<b>Strategies</b>
<b>Planning</b>	<ul style="list-style-type: none"> <li>• Reads the problem aloud.</li> <li>• Asks questions to help learners make sense of what information is given.</li> <li>• Breaks up the problem into its smaller parts.</li> <li>• Looks for familiar key words that can help learners plan what calculation(s) will be most appropriate.</li> <li>• Guides learners in visualizing the problem.</li> <li>• Allows learners to draw the problem.</li> </ul>
<b>Monitoring</b>	<ul style="list-style-type: none"> <li>• Prompts learners to regularly re-read the question while solving the problem to ensure they are still on the right track.</li> <li>• Prompts learners to monitor their calculations by using inverse operations or counting.</li> </ul>
<b>Evaluating</b>	<ul style="list-style-type: none"> <li>• Provides opportunities in class in which various learners verbally or visually present their various solutions to the same problem.</li> <li>• Discusses and evaluates the different solutions in the group.</li> <li>• Allows learners to mark their own solutions, enabling them to recognize where their solution differs from those of the others and which solution would be the most appropriate.</li> </ul>

Even though this research question focused only on the mediation of metacognition during mathematical problem solving, other influences could not be disregarded. Many of the cognitive and non-cognitive factors that both teachers and learners bring to the mediation process, such as knowledge, abilities, beliefs, attitudes, affect and motivation, can influence the outcome and quality of the mediation. Moreover, contextual factors, such as the classroom and school setting, the teacher's professional collaboration with colleagues and parents, as well as the influence of the curriculum, assessments, textbooks/workbooks and professional development training, can all have an impact on how a teacher mediates metacognition during mathematical problem solving.

**6.2.2 Research question two: How do Foundation and Intermediate Phase teachers differentiate the mediation process during mathematical problem solving in such a way as to support all the learners, given their diverse abilities and needs?**

The increasing diversity found today in schools around the globe was evident too in the classrooms where this case study took place. All the teachers commented on the wide range of learners and learning needs in their classrooms and the challenges that this presented. This suggests that the traditional teaching methods used when classrooms were more homogeneous cannot be used in today's classrooms with the same level of success. This raised the question: how can today's teachers differentiate the mediation process during mathematical problem solving in such a way as to support all the learners, taking into account their diverse abilities and needs? All the participants were aware of the diverse needs of the learners in their mathematics classes, recognized that they learnt differently and that they should therefore respond differently to these needs.

However, from the teachers' responses and from observations, learners whose needs differed from those of the average learner, particularly in the Intermediate Phase, were the ones whose needs were least addressed. Rock et al. (2008) identify this strategy, where teachers mostly *teach to the middle*, as a serious shortcoming, since it hinders both gifted learners and those who experience learning difficulties from reaching their full potential (Lipsky, 2005; Olszewski-Kubilius, 2006).

In the Foundation Phase, the participants used several strategies to differentiate their teaching, responding to all the learners at their own levels when the focus was on mathematical problem solving, challenging them within their zones of proximal development. They mediated the problem solving process in such a way that most of the learners were then able to successfully solve similar problems independently. Thus what was initially a non-routine problem evolved into a routine problem or exercise (Schoenfeld, 1992), in which the learners were themselves able to plan, monitor and evaluate the process and internalize the concept.

A synthesis of the various strategies employed respectively by the Foundation and Intermediate Phase participants is given in Table 6.4. It should be noted, though, that this does not mean that *all* these strategies were practiced by *all* participants in both phases.

**Table 6.4.***Differentiated instruction during mathematical problem solving*

<b>Foundation Phase teachers</b>	<b>Intermediate Phase teachers</b>
<ul style="list-style-type: none"> <li>• Use small group teaching as part of the daily routine. Mostly ability grouping.</li> <li>• Tasks and small group teaching are differentiated to match learners' various abilities; thus not all learners solve the same problems on the same day.</li> <li>• Determine prior knowledge of small group and gradually link new knowledge to it.</li> <li>• Reduce the number of problems specific learners have to solve after individual support.</li> <li>• Provide more challenging or abstract problems for more advanced learners.</li> <li>• Work more concretely with learners who have not yet internalized certain concepts.</li> <li>• Allow all learners access to mathematical aids in the classroom when solving problems.</li> <li>• Use formal and ongoing informal assessments to determine learners' current needs.</li> <li>• Use flexible grouping to teach certain concepts that specific learners have not yet internalized, as indicated by assessment.</li> <li>• Use different grouping structures when solving mathematical problems such as in total groups, alone, as partners or in small groups.</li> <li>• Provide individual or peer support to learners who struggle.</li> <li>• Link word problems to learners' interests and life world.</li> <li>• Vary the number range to match the learners' diverse needs.</li> <li>• Adapt, approach and pace according to the small group's pace.</li> <li>• Use baseline assessment to group learners in class.</li> </ul>	<ul style="list-style-type: none"> <li>• Mostly use whole group teaching.</li> <li>• All learners work from the same textbook and solve the same problems on the same day.</li> <li>• Determine prior knowledge of the whole group and gradually link new knowledge to it.</li> <li>• Reduce the number of problems specific learners have to solve after individual support.</li> <li>• Occasionally provide extra, more challenging work.</li> <li>• Rely on learning support teacher to provide adequate content for learners who struggle to keep up with the core curriculum.</li> <li>• No concrete mathematical aids are readily available for learners to use when solving mathematical problems. Encourage learners to draw or visualize the problem.</li> <li>• Use formal and ongoing informal assessments to determine learners' current needs.</li> <li>• If certain concepts are not yet internalized, the teacher will teach the concept again to the whole group, but will use a different approach.</li> <li>• Use different grouping structures when solving mathematical problems such as in total groups, alone, as partners or in small groups.</li> <li>• Provide individual or peer support to learners who struggle.</li> <li>• Use word problems in textbooks or from old question papers.</li> </ul>

An essential feature of differentiated instruction, one which relates to sociocultural theory, is interpersonal communication. In both phases, learners were encouraged to share their thinking on how they solved certain problems with each other, stimulating opportunities for conceptual development (Murray & Jorgensen, 2007). Those who independently were only able to progress to part of the solution could follow their peers or the teacher's modelling to reach to a higher level of understanding of the problem. Another important feature, related to the reciprocity between learner and teacher in the differentiated classroom, is what Kanevsky (2011) calls deferential differentiation. In this, adjustments to the curriculum are made after learners' have explicitly stated what types of differentiation they want. However, this was not mentioned or practiced by any of the participants during the data collection.

Comparing how teachers in the Foundation and Intermediate Phase differentiated the mediation process, I concluded that the Foundation Phase participants consciously practised differentiation on a daily basis, making provision for it when they planned their lessons and prepared their learning materials. They did not identify any obstacles other than the fast pace across number ranges demanded by the curriculum. They indicated, however, that they adjusted the number ranges to match the learners' zones of proximal development when presenting them with mathematical problems. From this it can be concluded that they considered learners' readiness, and to a certain degree their interests, but not their learning profiles when teaching was differentiated.

On the other hand, the Intermediate Phase teachers indicated that they would have liked to differentiate their teaching more. Some of them acknowledged that they were neglecting learners with certain learning styles, claiming that they were restrained by several barriers. The physical space in the classroom, the large number of learners in a class, time constraints and the pace demanded by the curriculum were among the obstacles preventing them from consistently teaching in a differentiated manner.

### **6.2.3 Research question three: How do teachers in the Foundation and Intermediate Phases differ in the ways they mediate metacognition during mathematical problem solving?**

The findings in section 6.2.1 showed that Foundation and Intermediate Phase teachers mediated metacognition during mathematical problem solving in similar ways. However, it can be concluded that the quality of the mediation process was influenced by the three dimensions, as indicated in Figure 6.1. To gain clarity on the different factors that impacted on the quality of teachers’ mediation, I looked at the influences of the three dimensions within each phase. Table 6.5 gives an overview of the factors which caused differences in the quality of the teachers’ mediation in both the Foundation and Intermediate Phases.

**Table 6.5.**

*Influences causing differences between Foundation and Intermediate Phase teachers’ mediation of metacognition during mathematical problem solving*

<b>Influence</b>	<b>Foundation Phase teachers</b>	<b>Intermediate Phase teachers</b>
<b>Knowledge dimension</b>	<ul style="list-style-type: none"> <li>• Understanding differentiated instruction as the grouping arrangements they utilize in their classrooms in order to support learners according to their current abilities.</li> <li>• Knowing that you need to provide learners with concrete objects or representational/semi-concrete models when solving mathematical problems.</li> <li>• Knowing that learners benefit from small group teaching and peer support when solving mathematical problems.</li> </ul>	<ul style="list-style-type: none"> <li>• Understanding differentiated instruction as how teachers have to adapt their teaching to meet the varied needs of the learners.</li> <li>• Knowing that learners need to visualize or draw a problem if they do not understand how to solve it.</li> <li>• Some teachers know that learners can benefit from group work, and all the teachers were in favour of peer support when solving mathematical problems</li> </ul>
<b>Strategies dimension</b>	<ul style="list-style-type: none"> <li>• Lead learners through questioning to identify what they understand about the problem.</li> <li>• Tailor the problems to be solved for each group to enable the learners to utilize the knowledge and strategies they already possess to solve the problem.</li> <li>• All learners make their thinking visible within the small group so the teacher can immediately respond to each learner’s thinking.</li> <li>• Debriefing of the problem solving process takes place within the small</li> </ul>	<ul style="list-style-type: none"> <li>• Explicitly ask learners to identify which part of the problem they do not understand.</li> <li>• Use problems from textbooks or old question papers for the whole group.</li> <li>• Teachers ask some learners to make their thinking visible to the whole group and respond to those learners’ thinking.</li> <li>• Debriefing of the problem solving process takes place within the</li> </ul>

Influence	Foundation Phase teachers	Intermediate Phase teachers
	<ul style="list-style-type: none"> <li>group.</li> <li>Model how to use concrete objects or mathematical resources to solve mathematical problems.</li> </ul>	<ul style="list-style-type: none"> <li>whole group.</li> <li>Do not provide learners with concrete objects or mathematical resources to solve mathematical problems.</li> </ul>
<b>Context dimension</b>	<ul style="list-style-type: none"> <li>Teachers are allowed to read mathematical problems to learners in Grades 1 and 2 during assessment.</li> <li>The teachers of each grade meet at least once a week to plan, among other things, the mathematical problems the learners will do during the week.</li> <li>Teachers in the phase meet to discuss how they will gradually progress between the grades with regard to the methods learners use to solve mathematical problems, to ensure coherent teaching / learning.</li> <li>Large English classes have a classroom assistant to provide support during mathematical problem solving.</li> <li>Spend seven hours of teaching time per week on mathematics, with problem solving done on a daily basis.</li> </ul>	<ul style="list-style-type: none"> <li>Teachers are not allowed to read mathematical problems to learners in the Intermediate Phase during assessment, which is identified as a major barrier when solving problems.</li> <li>In each grade one teacher plans the mathematics, including problem solving. The other mathematics teachers in the grade are provided with the written weekly plan.</li> <li>Teachers in different grades and even in different classes in the same grade do not necessarily provide learners with the same procedures to solve mathematical problems.</li> <li>None of the classes in the Intermediate Phase have classroom assistants.</li> <li>Spend six hours of teaching time per week on mathematics, but teachers gave varied indications of how often they spent time on mathematical problem solving.</li> </ul>

From the research findings, it can be concluded that teachers from both phases mediated metacognition during mathematical problem solving using the same strategies (see section 6.2.1). However, as indicated in section 6.2.2, there were a number of differences between how teachers in the Foundation Phase differentiate their teaching compared to their Intermediate Phase colleagues. These differences between Foundation and Intermediate Phase teachers' knowledge, strategies and contexts, as indicated in Table 6.5, could influence the quality of mediation of metacognition during mathematical problem solving. Metacognition is improved when learners participate in collaborative group work (Kramarski & Mevarech, 2003; Larkin, 2010), and where the teacher is actively involved as the more knowledgeable other or final form (Vygotsky, 1994). It could be argued that a better quality of mediation of metacognition can be

expected when problem solving is done through collaborative group work with the active involvement of the teacher, as practiced daily by the Foundation Phase teachers.

### **6.3 RECOMMENDATIONS AND IMPLICATIONS**

This inquiry offered insight into several under-researched areas of the role of the teacher as mediator of metacognition during mathematical problem solving in diverse classrooms. The positive attitude of the teachers on the value of professional development had a significant influence on the proposed recommendations.

#### **6.3.1 Recommendations and implications to improve the mediation of metacognition**

This study set out to offer insight into how teachers mediate metacognition during mathematical problem solving. According to Griffith and Ruan (2005), in order to engage in metacognitive teaching strategies, teachers should not only be familiar with the learners' background knowledge, but should also be knowledgeable about the practice and implementation of such strategies. This study, however, explored teachers who were not explicitly trained in the use of metacognitive strategies during mathematical problem solving. Indeed, most were not even familiar with the term metacognition. Nonetheless, mediation of metacognition was evident in the way they focused on mathematical problem solving. This echoes Papaleontiou-Louca's (2003) assertion that teachers are not always consciously aware that they are using metacognitive strategies in the classroom. In this study, the teachers did not explicitly aim for metacognition or use the terminology related to metacognitive strategies, since they had no conscious knowledge about it. As a result, they overlooked countless other opportunities during the lessons where metacognition could have been mediated.

It is therefore recommended that *all* teachers, both in-service and student teachers, should be educated in the application and explicit mediation of metacognitive strategies. They would then be able to demonstrate to their learners the benefits of employing metacognition (Veenman et al., 2006). It is evident that teachers find it difficult to apply metacognitive intervention programmes effectively, since this means changing from their established, conventional ways of teaching (Larkin, 2010). Larkin (2010) suggests that they should be skilled to recognize situations which could offer opportunities for the development and practice of metacognition in their day-to-day

teaching. This would allow them to share their classroom practices, possibly leading to opportunities for reflection and evaluation (Van der Walt & Maree, 2007). Disturbingly, this recommendation was already made seven years ago by the South African scholars, Van der Walt and Maree (2007), but teachers are still in the dark in their understanding of this concept. In the meantime, a whole generation of learners have not been equipped to become the type of learners as described in the National Curriculum Statement Grades R-12 (DBE, 2011a, p. 5).

### **6.3.2 Recommendations and implications to improve mediation of mathematical problem solving**

Many of the teachers in this study related mathematical problem solving to word problems. However, not all word problems can be classified as mathematical problems. When learners know exactly how to proceed from the question to the answer, the result is not a novel, non-routine mathematical problem, but a mathematical exercise or routine problem (Hoosain, 2003; Orton & Frobisher, 2005; Schoenfeld, 1992). It is recommended that teachers be familiarized with the difference between a novel mathematical problem and a mathematical exercise. Even though both play a significant role in mathematics education, a mere exercise does not call for the higher-order thinking skills needed for a non-routine problem.

Learners' poor reading skills were identified as a further major barrier to their solving mathematical problems. Reading skills and mathematical vocabulary in both the Foundation and Intermediate Phase need urgently to be addressed. The learners should be exposed to many different types of mathematical problems in order to familiarize them with the vocabulary used and the procedural and conditional knowledge related to it.

### **6.3.3 Recommendations and implications to improve differentiated instruction**

While inclusive education and differentiated instruction are nowadays familiar concepts, many teachers, especially Intermediate Phase teachers, still have problems with applying differentiated instruction. Often this is because they have had no first-hand personal experience of such teaching in action (Tomlinson, 2005). It is recommended that teachers be offered opportunities firstly to gain an in-depth understanding of the philosophy behind differentiated instruction, and secondly be

provided with first-hand experiences of what a classroom looks like where such teaching is practiced.

It is also recommended that teachers in both the Foundation and Intermediate Phase be educated to determine learning profiles and to differentiate their teaching according to learners' preferred ways of learning. They should offer the learners options from which, in order to reach a specific goal, they can select their own learning activities. This would naturally ignite their metacognitive knowledge, since they would have to decide which activity would best match their own knowledge and skills (Frey, 2005).

The Intermediate Phase teachers said they lacked the time to prepare differentiated tasks and that they mainly used the same textbook for all learners. It is recommended that textbooks, not only teachers' guides be compiled in such a way as to provide for differentiation of content, process and product to match learners' readiness, interests and learning profiles. However, to engender change teachers will have to make a paradigm shift that, according to Tomlinson, "proposes that we teach not out of habit or teacher preference but in response to the students we serve" (Wu, 2013, p. 128).

#### **6.3.4 Recommendations for further research**

- This study has illuminated several differences between the practices of Foundation and Intermediate Phase teachers during mathematical problem solving that contribute to a better understanding of the discrepancy between the mathematics results in these two phases. Further research in this area is certainly warranted to deepen our understanding of this phenomenon and to adapt practice accordingly.
- Since poor reading skills were identified as a significant limitation in learners' abilities to solve mathematical problems, research should be undertaken to find out why so many learners struggle with reading and how this matter can be resolved.
- The use of concrete objects or artefacts when solving mathematical problems in the Intermediate Phase could be explored, since this case study identified a lack of concrete objects or artefacts in mathematical problem solving in this phase.
- Replicating this collective case study in a school with a contrasting or even a similar context could offer more insight into common trends in the findings.

#### 6.4 LIMITATIONS AND STRENGTHS OF THE STUDY

It is generally agreed that any research study has limitations. It is important to acknowledge limitations and to assess their influence on the findings and interpretations of the study. Although every precaution was taken to ensure the trustworthiness of this study, a number of limitations need to be noted. One is that all the participants were female teachers. There were no male teachers among the mathematics teachers where this case study took place.

The second limitation concerns the extent to which the findings can be generalized. However, the aim here was not to generalize the findings to a larger population, but to gain a deeper insight into the context of this particular collective case study. Given the rich description of these two cases, readers can decide to what extent the research findings could be transferred to their own contexts (Jensen, 2008; Stake, 2005).

Being familiar with the research site and participants gave me an insider's advantage, but could also be construed as a source of bias. Although I am a private learning support teacher at the same school as the participants, I hold no supervisory authority over any of them. I did have knowledge of the school, the participants and the general context of the research site that would have taken an outside researcher much longer to gain. The participants did not seem reserved during the interviews or observations, which could be attributed to their being familiar with me.

Since I had adopted an interpretivist paradigm that assumed a relativist ontology and subjectivist epistemology, I recognized the likelihood of subjectivity influencing the data collection, reporting and interpretation of findings. Consequently data collection was triangulated and thick and rich details about all aspects of the research process, including the context, participants and research design, were reported.

A major strength of this study was the solid theoretical structure offered by Vygotsky's sociocultural theory, which was built into the design of the inquiry. Elusive concepts such as metacognition, mediation and mathematical problem solving were made overt, guiding me in the empirical part of the research.

## 6.5 CONCLUSION

In conclusion, I found that there are many cognitive, non-cognitive and contextual factors which could influence the quality and outcomes of the mediation of metacognition during mathematical problem solving in diverse classrooms. The study set out to contribute to the body of knowledge on the prominent role of the teacher in helping learners in different ways to solve mathematical problems. It emphasized the significance of the active role the teacher as a more knowledgeable other plays in the mediation process. Furthermore, it underlined the importance of giving learners challenging mathematical problems requiring metacognition within their zones of proximal development. It was also found that the teacher as mediator should not only have the necessary professional knowledge and strategies, but should also consider the affective factors, perceptions and reactions of learners, summed up in Vygotsky's term *perezhivanie*, during the mediation process.

The challenges currently facing education in South Africa are not insurmountable. They can be resolved at least in part through the empowerment of teachers. The search for solutions, involving all those role-players who could contribute to addressing the problems, should continue. Teachers face many obstacles to becoming the great educators they aspire to be. Above all, even though the path to the solution may not as yet be clear, it is important to have a vision of what our schools should look like, once it has all been figured out. In this regard, the following vision is worth considering:

*I'd like to see schools be "dream keepers"—places where adults say to students, "Let's figure out what you can grow up to be." I'd like to see them be places where we work to create the kind of world many of us aspire to live in—communities of respect, where human differences are as valued as human commonalities, where it's not necessary to categorize and separate people, places that concentrate on helping young people become architects of good lives. I'd like to see schools more as zones of creativity than as factories—places that dignify learners and learning.*

*(Carol Ann Tomlinson, Interviewed by Wu, 2013, p. 133).*

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## Appendix A

### Individual Interview Schedule

INDIVIDUAL INTERVIEW SCHEDULE	
<b>1.</b>	<b>TELL ME ABOUT YOUR GREATEST CHALLENGE(S) TEACHING MATHEMATICS?</b>
<b>2.</b>	<b>THE CAPS DOCUMENT FOR MATHEMATICS FREQUENTLY REFERS TO PROBLEM SOLVING AS ONE OF THE CONCEPTS AND SKILLS WHICH SHOULD BE ADDRESSED IN ALL CONTENT AREAS. WHAT DO YOU REGARD AS MATHEMATICAL PROBLEM SOLVING?</b>
<b>3.</b>	<b>MORE OR LESS WHAT PERCENTAGE OF TIME DO YOU SPEND ON MATHEMATICAL PROBLEM SOLVING DURING A WEEK AND WHO DETERMINES IT?</b>
<b>4.</b>	<b>WHAT DO YOU THINK A TEACHER CAN DO TO IMPROVE LEARNERS' ABILITIES TO SOLVE MATHEMATICAL PROBLEMS?</b>
<b>5.</b>	<b>WHICH COGNITIVE FUNCTIONS DO YOU THINK PLAY AN IMPORTANT ROLE WHEN A LEARNER ATTEMPTS TO SOLVE A MATHEMATICAL PROBLEM?</b>
<b>6.</b>	<b>WHAT IS YOUR UNDERSTANDING OF METACOGNITION?</b>
<b>7.</b>	<b>PLEASE DESCRIBE YOUR ROLE IN THE CLASSROOM WHEN THE LESSON FOCUS IS ON MATHEMATICAL PROBLEM SOLVING?</b>
<b>8.</b>	<b>HOW DO YOU HELP LEARNERS TO THINK ABOUT WHAT THEY ARE DOING WHILE THEY ARE SOLVING A MATHEMATICAL PROBLEM?</b>
<b>9.</b>	<b>HOW DO YOU HELP LEARNERS TO PLAN, MONITOR AND EVALUATE THEIR MATHEMATICAL PROBLEM SOLVING?</b>
<b>10.</b>	<b>HOW WILL YOU DESCRIBE THE RANGE OF LEARNERS THAT YOU HAVE IN YOUR MATHEMATICS CLASS IN TERMS OF THEIR DIVERSE ABILITIES AND NEEDS?</b>
<b>11.</b>	<b>PLEASE TELL ME HOW YOU UNDERSTAND THE CONCEPT OF DIFFERENTIATED INSTRUCTION?</b>
<b>12.</b>	<b>HOW DO YOU SUPPORT LEARNERS WITH DIVERSE ABILITIES AND NEEDS DURING MATHEMATICAL PROBLEM SOLVING?</b>
<b>13.</b>	<b>WHAT DO YOU THINK ABOUT COOPERATIVE LEARNING OR GROUP WORK DURING MATHEMATICAL PROBLEM SOLVING?</b>
<b>14.</b>	<b>EVERY YEAR THE ANA'S AND SYSTEMIC ASSESSMENTS SHOW A SHARP DECLINE OF LEARNERS' MATHEMATICS RESULTS FROM THE FOUNDATION PHASE TO THE INTERMEDIATE PHASE. WHY DO YOU THINK THIS IS HAPPENING?</b>

## Appendix B

### Observation Schedule

OBSERVATION SCHEDULE	
NAME OF TEACHER:	
GRADE:	NUMBER OF LEARNERS:
WHAT TO OBSERVE?	COMMENTS
<ul style="list-style-type: none"> <li>● <b>CLASSROOM SETUP/ORGANISATION</b></li> </ul>	
MEDIATION STRATEGIES	
<ul style="list-style-type: none"> <li>● MODELLING /IMITATION</li> <li>● TOOLS/ARTIFACTS</li> <li>● INTERPERSONAL COMMUNICATION</li> <li>● ZPD / PRIOR KNOWLEDGE</li> <li>● LEARNING ACTIVITY</li> <li>● DEBRIEFING</li> <li>● THINKING TIME</li> <li>● VISIBLE THINKING</li> <li>● INDIVIDUAL/PEER SUPPORT</li> <li>● PEREZHVANIE</li> </ul>	
METACOGNITIVE KNOWLEDGE	
<ul style="list-style-type: none"> <li>● <b>DECLARATIVE KNOWLEDGE</b> -METACOGNITIVE HINTS</li> <li>● <b>PROCEDURAL KNOWLEDGE</b> -WHY /HOW THEY ARE DOING WHAT THEY ARE DOING</li> <li>● <b>CONDITIONAL KNOWLEDGE</b> -WHEN THEY SHOULD BE DOING WHAT THEY ARE DOING</li> </ul>	
METACOGNITIVE REGULATION	
<ul style="list-style-type: none"> <li>● <b>PLANNING</b></li> <li>● <b>MONITORING</b></li> <li>● <b>EVALUATION</b></li> </ul>	
DIFFERENTIATION	
<ul style="list-style-type: none"> <li>● <b>CONTENT, PROCESS, PRODUCT</b></li> <li>● <b>READINESS LEVELS, INTERESTS AND LEARNING PROFILE</b></li> <li>● <b>RESPECTFUL ACTIVITIES, FLEXIBLE GROUPING AND ONGOING ASSESSMENT</b></li> </ul>	

## Appendix C

### Focus Group Interview Schedule

FOCUS GROUP INTERVIEW SCHEDULE	
<b>15. WHAT KNOWLEDGE DO YOU THINK A TEACHER NEEDS TO HELP LEARNERS WITH MATHEMATICAL PROBLEM SOLVING?</b>	
<b>16. WHAT STRATEGIES DO YOU USE TO HELP THE DIVERSE GROUP OF LEARNERS IN YOUR CLASS WITH MATHEMATICAL PROBLEM SOLVING?</b>	
<b>17. WHAT FACTORS THAT DIRECTLY RELATE TO THE LEARNERS INFLUENCE THE WAY YOU HELP THEM WITH MATHEMATICAL PROBLEM SOLVING?</b>	
<b>18. WHICH FACTORS ASSOCIATED WITH YOU AS A TEACHER INFLUENCE THE WAY YOU HELP LEARNERS WITH MATHEMATICAL PROBLEM SOLVING?</b>	
<b>19. WHICH OTHER FACTORS HAVE AN INFLUENCE ON THE WAY YOU HELP LEARNERS WITH MATHEMATICAL PROBLEM SOLVING?</b>	

# Appendix D

## Letter of Approval:

### Stellenbosch University Research Ethics Committee



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#### Approval Notice New Application

20-May-2013  
PIETERSE, Susan-mari

**Proposal #: DESC\_Pieterse2013**

**Title: TEACHERS MEDIATION OF METACOGNITION DURING MATHEMATICAL PROBLEM SOLVING**

Dear Ms Susan-mari PIETERSE,

Your DESC approved **New Application** received on **08-May-2013**, was reviewed by members of the **Research Ethics Committee: Human Research (Humanities)** via Expedited review procedures on **17-May-2013** and was approved.

Please note the following information about your approved research proposal:

Proposal Approval Period: **17-May-2013 - 16-May-2014**

Please take note of the general Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

Please remember to use your **proposal number (DESC\_Pieterse2013)** on any documents or correspondence with the REC concerning your research proposal.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Also note that a progress report should be submitted to the Committee before the approval period has expired if a continuation is required. The Committee will then consider the continuation of the project for a further year (if necessary).

This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki and the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health). Annually a number of projects may be selected randomly for an external audit.

National Health Research Ethics Committee (NHREC) registration number REC-050411-032.

We wish you the best as you conduct your research.

If you have any questions or need further help, please contact the REC office at 0218839027.

**Included Documents:**

REC Application  
DESC form  
Informed consent  
Interview schedule  
Permission letters  
Research proposal

Sincerely,

Susara Oberholzer  
REC Coordinator  
Research Ethics Committee: Human Research (Humanities)

# Appendix E

## Letter of Approval:

### Western Cape Education Department



Directorate: Research

[Audrey.wyngaard2@pawc.gov.za](mailto:Audrey.wyngaard2@pawc.gov.za)

tel: +27 021 467 9272

Fax: 0865902282

Private Bag x9114, Cape Town, 8000

wced.wcape.gov.za

**REFERENCE:** 20130422-9876

**ENQUIRIES:** Dr A T Wyngaard

Ms Susan-Mari Pieterse



**Dear Ms Susan-Mari Pieterse**

#### **RESEARCH PROPOSAL: TEACHERS' MEDIATION OF METACOGNITION DURING MATHEMATICAL PROBLEM SOLVING**

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **17 March 2014 till 30 August 2014**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

**The Director: Research Services  
Western Cape Education Department  
Private Bag X9114  
CAPE TOWN  
8000**

We wish you success in your research.

Kind regards.

Signed: Dr Audrey T Wyngaard

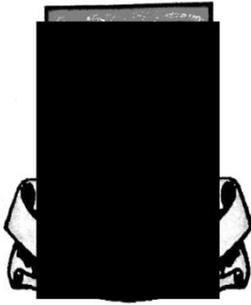
**Directorate: Research**

**DATE: 14 March 2014**

## Appendix F

# Letter of Approval from the Principal to Conduct Research at the School

OFFICE OF THE HEADMASTER/KANTOOR VAN DIE SKOOLHOOF



SKOOLHOOF:  
HEADMASTER:

MNR./MR

LAERSKOOL

PRIMARY SCHOOL

E-POS / E-MAIL:

WEB. ADRES(SE):  
WEB..ADRES(SE):

### TO WHOM IT MAY CONCERN

I, Mr [REDACTED] on behalf of [REDACTED] Primary School hereby give Susan-Mari Pieterse, M.Ed student from the Department of Educational Psychology at the University of Stellenbosch permission to conduct research at the school towards the completion of a master's thesis with the title: ***Teachers' mediation of metacognition during mathematical problem solving***.

The information regarding the scope of the study was explained to me by Susan-Mari Pieterse. I was given the opportunity to ask questions and these questions were answered to my satisfaction.

I hereby grant consent for the completion of her proposed study at [REDACTED] Primary School. We wish her well and are indeed looking forward to the final product.

  
[REDACTED]  
[REDACTED]  
HEADMASTER

2013-04-11

# Appendix G

## Letter of Consent to Participants



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### STELLENBOSCH UNIVERSITY CONSENT TO PARTICIPATE IN RESEARCH

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#### TEACHERS' MEDIATION OF METACOGNITION DURING MATHEMATICAL PROBLEM SOLVING

You are asked to participate in a research study conducted by Susan-Mari Pieterse M.Ed. student, from the Department of Educational Psychology at Stellenbosch University. The results of this research will be contributed to the completion of a master's thesis. You were selected as a possible participant in this study because you meet the selection criteria for this study as you are a foundation or intermediate phase mathematics teacher at the school where this case study will take place.

#### 1. PURPOSE OF THE STUDY

The aim of this qualitative case study is to explore how foundation and intermediate phase teachers mediate metacognition during mathematical problem solving. This is likely to offer a deeper understanding of mediation during mathematical problem solving, the complex interplay between cognition and metacognition and how teachers differentiate the mediation process to provide for diversity amongst learners. This study will furthermore attempt to understand how the mediation process of foundation phase mathematics teachers compares with that of intermediate phase mathematics teachers.

#### 2. PROCEDURES

If you volunteer to participate in this study, you would be asked to do the following things:

##### **Step 1: Sign consent to participate in research form**

Once you have volunteered to participate in this study, you will have to sign this consent form.

##### **Step 2: Interview**

You will be interviewed once by the researcher at the school at a time that suits you. The interview will be approximately 30-45 minutes, during which the researcher will ask you questions on the topic.

##### **Step 3: Observation**

The researcher will observe one of your mathematics lessons where the focus is on mathematical problem solving. The researcher will not participate during the observation.

**Step 4: Focus group discussion**

You will participate in one focus group discussion about the topic. Other mathematics teachers who are teaching in the same phase as you will also be part of the focus group discussion. The researcher will facilitate the discussion which will last approximately 1-1 ½ hours. A venue and time will be arranged by the researcher to suit all participants.

**Step 5: Dissemination of data**

An audio recording of the interview, observation and focus group discussion will be made to facilitate gathering of accurate and complete data. The researcher will be the only person to listen and transcribe the recordings.

To confirm agreement on the data, the researcher will provide you with copies of the transcripts of the events where you were directly involved. You will be invited to make any amendments necessary and to approve of the accuracy of the data before it will be used in the study.

**3. POTENTIAL RISKS AND DISCOMFORTS**

Although the nature of this topic will make it highly unlikely to experience any risks or discomforts, please note that you are under no obligation to answer any questions that may make you feel uncomfortable.

**4. POTENTIAL BENEFITS TO PARTICIPANT AND/OR TO SOCIETY**

There might not be a direct benefit to you as a participant, but at an academic level, it can contribute to a deeper understanding of this important mediation process during mathematical problem solving and the complex interplay between cognition and metacognition.

Furthermore it may be useful in professional development programs for teachers empowering them to support diverse learners in the improvement of their metacognitive ability during mathematical problem solving. Ultimately it can be to the advantage of learners who will be empowered to take control of their own learning by defining learning goals and monitoring their progress in achieving them. This research can potentially expand teachers' pedagogical repertoire to work more effectively with disengaged and reluctant learners.

**5. PAYMENT FOR PARTICIPATION**

Participation is voluntary, therefore no form of remuneration will be provided.

**6. CONFIDENTIALITY**

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of a pseudonym (fictitious name) that will be used instead of your real name to respect your confidentiality.

The audio-recordings will be stored on the researcher's computer, which is password-protected. The transcripts will be distributed to the relevant participant to crosscheck information and make amendments where necessary. The findings will be reported in a master's thesis without any identifiable data about the participants or the school where the research takes place.

**7. PARTICIPATION AND WITHDRAWAL**

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The researcher may withdraw you from this research if circumstances arise which warrant doing so.

## 8. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact the researcher: Susan-Mari Pieterse at [REDACTED] or 17245575@sun.ac.za or the supervisors of this study: Dr M.M. Oswald at [REDACTED]; mmoswald@sun.ac.za and Mrs C Louw at [REDACTED]; cl1@sun.ac.za.

## 9. RIGHTS OF RESEARCH PARTICIPANT

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

### SIGNATURE OF RESEARCH PARTICIPANT

The information above was described to me by Susan-Mari Pieterse in Afrikaans/English and I am in command of this language. I was given the opportunity to ask questions and these questions were answered to my satisfaction.

I hereby consent voluntarily to participate in this study. I have been given a copy of this form.

\_\_\_\_\_  
**Name of Participant**

\_\_\_\_\_  
**Signature of Participant**

\_\_\_\_\_  
**Date**

### SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to

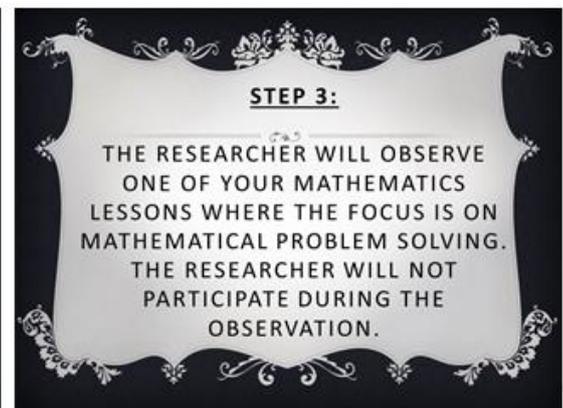
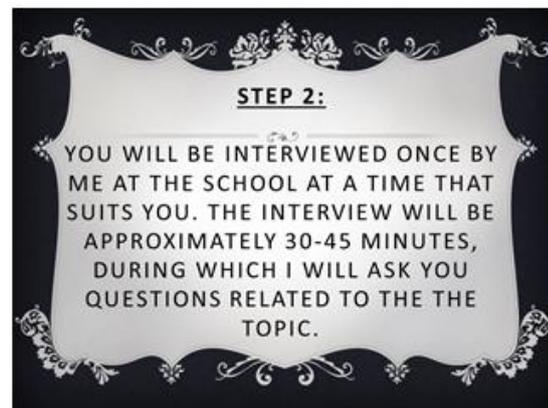
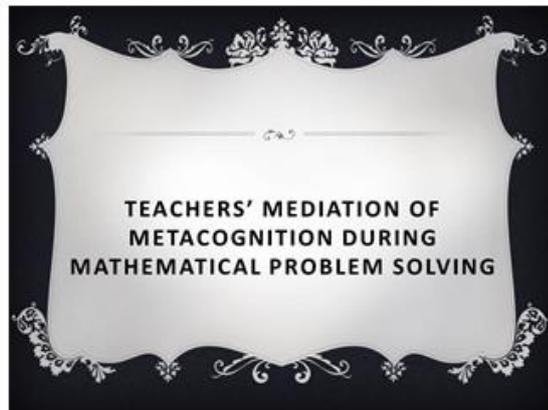
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The participant was encouraged and given ample time to ask me any questions. This conversation was conducted in Afrikaans/English.

\_\_\_\_\_  
**Susan-Mari Pieterse (Researcher)**

\_\_\_\_\_  
**Date**

## Appendix H

### Participant Recruitment Presentation



**STEP 4:**

YOU WILL PARTICIPATE IN ONE FOCUS GROUP DISCUSSION ABOUT THE TOPIC. OTHER MATHEMATICS TEACHERS WHO ARE TEACHING IN THE SAME PHASE AS YOU WILL ALSO BE PART OF THE FOCUS GROUP DISCUSSION. THE RESEARCHER WILL FACILITATE THE DISCUSSION WHICH WILL LAST APPROXIMATELY 1-1 ½ HOURS. A VENUE AND TIME WILL BE ARRANGED BY THE RESEARCHER TO SUIT ALL PARTICIPANTS.

**STEP 5:**

AN AUDIO RECORDING OF THE INTERVIEW, OBSERVATION AND FOCUS GROUP DISCUSSION WILL BE MADE TO FACILITATE GATHERING OF ACCURATE AND COMPLETE DATA.

TO CONFIRM AGREEMENT ON THE DATA, I WILL PROVIDE YOU WITH A COPY OF TRANSCRIPTS OF EVENTS WHERE YOU WERE DIRECTLY INVOLVED. YOU WILL BE INVITED TO MAKE ANY AMENDMENTS NECESSARY AND TO APPROVE OF THE ACCURACY OF THE DATA BEFORE IT WILL BE USED IN THE STUDY.

**PAYMENT FOR PARTICIPATION**

PARTICIPATION IS VOLUNTARY, THEREFORE NO FORM OF REMUNERATION WILL BE PROVIDED.

**CONFIDENTIALITY**

ANY INFORMATION THAT IS OBTAINED IN CONNECTION WITH THIS STUDY AND THAT CAN BE IDENTIFIED WITH YOU WILL REMAIN CONFIDENTIAL AND WILL BE DISCLOSED ONLY WITH YOUR PERMISSION OR AS REQUIRED BY LAW. CONFIDENTIALITY WILL BE MAINTAINED BY MEANS OF A PSEUDONYM (FICTITIOUS NAME) THAT WILL BE USED INSTEAD OF YOUR REAL NAME TO RESPECT YOUR CONFIDENTIALITY.

**THANK YOU**

# Appendix I

## Participant Biographical Information Form

<b>BIOGRAPHICAL INFORMATION</b>		
<b>NAME:</b>	<b>SURNAME:</b>	
<b>HOME LANGUAGE:</b>	<b>LANGUAGE USED TO TEACH MATHEMATICS:</b>	
<b>YEARS OF TEACHING EXPERIENCE:</b>	<b>YEARS AT CURRENT SCHOOL:</b>	
<b>GRADE CURRENTLY TEACHING:</b>	<b>YEARS TEACHING CURRENT GRADE:</b>	
<b>WHAT OTHER GRADES HAVE YOU TAUGHT BEFORE?</b>	<b>YEARS TEACHING MATHEMATICS:</b>	
<b>HAVE YOU RECEIVED ANY FORMAL TRAINING IN DIFFERENTIATED INSTRUCTION? IF YES, WHERE AND FOR HOW LONG?</b>		
<b>HAVE YOU RECEIVED ANY FORMAL TRAINING ON HOW TO TEACH METACOGNITIVE SKILLS AND STRATEGIES TO LEARNERS? IF YES, WHERE AND FOR HOW LONG?</b>		
<b><u>HIGHEST QUALIFICATION</u></b>		
<b>NAME OF INSTITUTION:</b>	<b>QUALIFICATION:</b>	<b>YEAR:</b>

**THANK YOU ☺**

## Appendix J

### Observation Procedure Information to Participants

#### Observation during mathematical problem solving

In the next phase of my research I will observe one of your mathematics lessons that focuses on mathematical problem solving.

- As with the interview I would like to see what normally happens in the classroom during mathematical problem solving.
- My role is a non-participant observer, which means that I am not to take part in the lesson, and therefore preferably not be involved in the lesson.
- You can inform your learners in advance that I will be present and that it is my goal to see what happens during mathematical problem solving in their classroom.
- I do not need a lesson plan.
- I would appreciate it if you give me two possible times for the observation. I will then confirm the selected time.

Thank you in advance. I'm really excited to see what happens in your class.

Susan-Mari

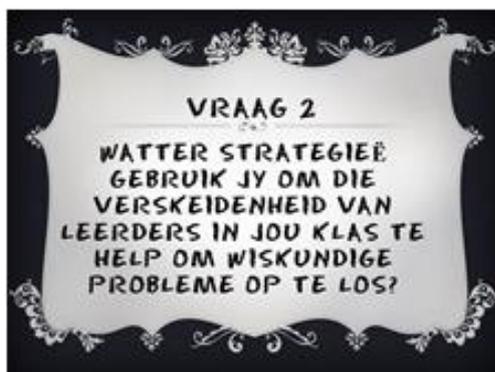
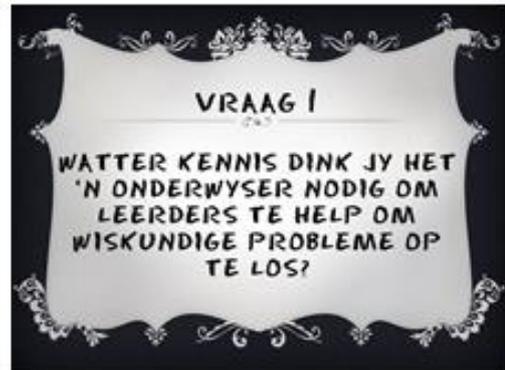
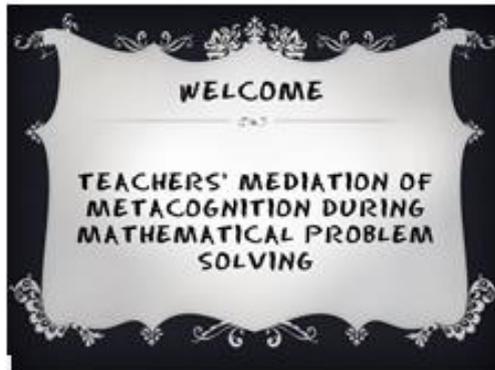
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#### Observation during mathematical problem solving

<b>Name:</b>		
	<b>Date:</b>	<b>Time:</b>
<b><u>Time 1</u></b>		
<b><u>Time 2</u></b>		

## Appendix K

### Focus Group Schedule Presentation



## Appendix L

### Extract of Individual Interviews Transcript: Foundation Phase

#### 9. Hoe help jy leerders om te dink oor wat hulle doen, terwyl hulle besig is om 'n wiskundige probleem op te los?

Retha: Ek sal baiekeer... as ek byvoorbeeld sien 'n kind is op die verkeerde pad, sal ek by die kind gaan staan en ek sal sê goed... kom juffrou lees gou weer die probleem vir jou, maar dan gaan die ander aan. Dan sal ek byvoorbeeld sê... goed... ek vra spesifiek wat ek wil hê hulle moet dit sê... dan sal ek sê... goed kyk gou op jou prentjie... het jy dit gedoen of het jy dit gepak? Onmiddellik as jy vir hulle... ek maak hulle attent op dit wat ek hulle wil lei om by die antwoord uit te kom. Sonder om dit vir hulle te sê, want ek bedoel... ek kan vir hulle sê, maar hoor hierso hoeveel wile het 'n motor, maar ek WIL dit nie sê nie. Ek wil sê... nou goed hoeveel motors is daar? Goed teken vir my die motors. En dan sal hulle dalk net twee wile teken... dan sal ek sê... goed dink gou as jy om julle motor stap... hoe lyk julle motor? Dan sal hulle agterkom... sodra hulle om die motor beweeg in hulle kop... dan kom hulle agter... oe juffrou ek het 'n fout gemaak. Dan sal ek sê... goed nou gaan jy aan. So dis half 'n vragie wat jy vra of hulle in daai situasie sit en dan kom hulle agter... o jitte... dit was eintlik nie so moeilik nie. So ek sal daai kinders spesifiek gaan en daai stuk weer lees en sê goed... wat sien jy? Kan jy dit pak of hoe lyk dit? Vrae vra wat hulle sal lei om by daai antwoord uit te kom. Hulle is impulsief... dis asof hulle die vinnigste... 'n antwoord net wil gee. So daai kinders wil net 'n antwoord gee... dan sal ek sê... nee, nee, jy moet mooi dink. Ek bedoel... jy weet mos daai kinders wat alles-tellers is, wat letterlik van vooraf moet begin... nou daai kinders sukkel BAIE met probleemoplossing, want hy sal weet die antwoord is ses, maar hy weet nie hoe lyk ses nie, so daar's daai kinders wat... en tot in die middel van die jaar... tot in die derde kwartaal is daar kinders in jou klas wat swak is... wat sukkel om syfers te herken tot by tien... hy weet die antwoord is ses, maar hy weet nie hoe lyk dit nie. Dis hoekom ek sê met probleemoplossing... jou getalgebied... jou syfer... jou getalname... alles moet jy so goed vaslê, want as tot tien goed vasgelê is... daarna... baie van probleemoplossing gaan oor telwerk... hulle moet maar aantal en terugtel... telwerk is ongelooflik belangrik by probleemoplossing... veral vir ons in graad een. As ons byvoorbeeld sê... goed daar is drie mandjies in elke

mandjie is drie appels. Hy moet daai mandjies kan sien en kan tel... maar baie van die kinders kan nie... so dan moet hulle dit gaan teken... so daai lei... dan sal ek sê... teken jou mandjies, want hulle weet nie altyd hulle kan dit teken nie. En baiekeer sal ek sê... pak dit op die mat. Kom teken dit in jou boek. Dan kom hulle agter... maar ek kan alles... ek kan letterlik gaan en ek kan dit gaan teken.

Marli: Ek dink dit kom maar daarop neer dat mens nie alles vir hulle die healtyd sê nie. As jy hulle leer dink soos ek nou verduidelik het... vir hulle vrae te vra en hulle denke te stimuleer, dan gaan dit deurgaans op al die ander areas... op die probleemoplossing selfs. Ek dink dit gaan maar oor hoe jy in die klas is, want ek dink nie mens kan probleemoplossing afsonder nie... ek bedoel dit is mos... jy kan nie net dat hulle dink in probleemoplossing nie... hulle moet leer dink in al die areas... van lees tot... 'n kind moet leer dink... verstaan as jy nie die kind leer dink nie, dan is dit nie vasgelê nie, dan is dit maar net my goeters wat ek sê en die kind na-aap dit soos 'n papegaai. Ouers by die huis... ouer mense... ouers... sê vir 'n kind wat om te doen, want hulle het nie daai tyd, daai geduld om te wag vir die antwoord nie. Om eerder die kind te vra... wat moet jy nou volgende doen, sê hulle dan vir die kind die antwoord, want jy het nie nou tyd om te wag vir hom om te dink wat om te doen nie, so ek dink dit is waar ons as ouers... nie net as onderwysers, maar as ouer nie die kind die geleentheid gee om te dink nie... uhm ek dink as ons enigiets in plaas daarvan om te sê vat jou potlood en gaan sit, is om te vra wat het jy nodig? Dis eintlik so iets eenvoudigs soos dit... uhm dis maar beplanning, maar ek dink jy moet kom op 'n plek waar jy eerder vrae vra as om te sê, want as jy vrae vra, dan begin die kind outomaties dink. So ek dink dis eintlik maar dat jy nie alles probeer self doen vir die kind nie.

Sue: Ek gaan dan maar gewoonlik weer op die stappies terug. Sê nou maar daar het nou fout gekom by die antwoord, dan vat ek hom nou maar weer van vooraf en ons lees weer die vraag deur en dan sê... soos ek weer sê ek sê vir hulle maak 'n prentjie in jou kop. Sien die bak vrugte, sien wat jy daarin sit. So ek probeer baie om vir hulle te lei om dan... as hulle dan nou nie fisies die konkrete goed het nie... dan maak 'n prentjie in jou kop dat jy weet wat is jou probleem... wat is jy besig om te probeer oplos hierso. Ek lei hulle dan deur die vrae wat jy vra en hoe jy dit vra.

Sonja: Ek dink die dinkproses kom by die sommetjie wat hulle kry uitmekaar uit te haal, want ons lees hom eers alleen, elke ou sê sag, dan lees ons die sommetjie hardop saam en dan die vraagstelling... wat sê hulle wat het mamma... twee eiers... uhm wat is die vraag wat ek wil vra, waarheen is ek op pad. So die healtyd is hulle eintlik

besig om die sommetjie uit te redeneer, terwyl ons eintlik net gaan kyk na wat is die vraag wat in die sommetjie... of wat is die uhm... dit wat ek weet wat in die sommetjie staan en wat is dit wat ek uithaal wat in die sommetjie staan en wat vra hulle vir my. So eintlik terwyl jy met die leesbegrip besig is, is hulle alreeds besig om te dink hoe hulle by die oplossing gaan uitkom.

Amy: Jong... ek praat gereeld met hulle. Ek sal... sê nou maar een kind het 'n vraag oor die spesifieke som en ek sien okay dit gaan nou vir almal bietjie trigger, dan sal ekke daai groepie... hulle is mos in groepe opgedeel... dan sal ek daai groepie bymekaarkry en dan vra... wie verstaan die som. Dan sal ek gewoonlik die een kind wat sê hy het dit nou so en so gedoen... en dan dat hy dit verduidelik. Partykeer verstaan hulle dit beter as 'n ander maat dit verduidelik... uhm, want hulle werk mos in hulle eie terme en al sulke goeters... uhm... en dit help nogals baie. Ek doen dit gereeld... uhm... partykeer is die som nie lekker verduidelik op die kaartjie nie, maar daar is kinders wat dit snap. So dit is hoekom ek daai metode gebruik. Die ander is maar net... ek sal die heelyd vrae vra oor dit wat hulle besig is om te doen. As ek so tussen hulle deurloop of ek sien daar is op daai oomblik iemand wat met 'n vraag sukkel... sonder om na my toe te gekom het... dan sal ek sê... remember... when we do this... net dat hulle bietjie... o, ja... dis actually van toepassing nou. Dan snap die kind.

Lea: Hulle moet dit vir my teken, maar hulle weet nou al hoe om dit te doen. So ek het nie meer nodig om... seker in graad twee, maar as hulle by ons kom dan sal... ja, want kyk as ons dit begin doen, sal ek vir hulle sê goed... uhm hoe het jy dit in graad twee gedoen? Reg nou teken ons dit nie meer nie, ons skryf nou die vywe, so wanneer ons dit doen... dan is dit... goed nie meer soos in graad twee nie, soos in graad drie, sodat ons nou van die tekenwerk af wegkom. So dis maar leidrade... afhangende van watter probleem dit is, want kyk hulle kom met pylnotasie van graad twee af... uhm... en ons versterk dit net. Die uitvalle wat daar is maak ons reg. Die wat nog nie heeltemal on par is met die ander nie, help ons daarmee, maar hulle het al 'n redelike idee hoe om dit te doen. Al wat ons eintlik verder vir hulle vat is die maal en die deel gedeelte waar die kinders rêrigwaar nog tekeninge gemaak het, so dan sê ek nee ons teken nie nou meer nie... die potlode of die blokkies of wat ook al nie, ons skryf nou die vyf, vyf, vyf. Dit het nou meer na die semi-konkrete toe gegaan as wat dit rêrigwaar die ou tekeninkie is nie.

## Appendix M

### Extract of Individual Interviews Transcript: Intermediate Phase

#### 9. Hoe help jy leerders om te dink oor wat hulle doen, terwyl hulle besig is om 'n wiskundige probleem op te los?

Mia: As ons 'n nuwe metode of 'n nuwe tegniek aanleer dan sal ek dit eers vir hulle wys... okay so doen ons dit en dan doen ons 'n oefenlopie op die bord. Dan vra ek vir die kind... okay waar begin ons nou? Wat is ons eerste stap? Dan sal die kind nou vir my die regte antwoord gee of nie en as ons nie... nee okay dis nie daai nie... wie kan andersins vir my sê... dan reg en dan die volgende een... so gaan dit... so hulle sê vir my wat ek moet skryf. En dan oefen hulle dit en dan later sal ek klomp somme op die bord doen van daai metode... dan sal ek sê... okay jou beurt... jy doen nommer een... jy doen nommer twee en dan is daar omtrent agt kinders wat voor staan en die goed doen en dan kyk ons dit saam... die antwoorde as 'n klas... dan bespreek ons dit saam. En op so 'n manier kan ek nou sien... ja-nee... die kind verstaan dit en hulle sal ook self sê... no that's not right. Wie het dit nie gekry nie... okay dan is die hande op... okay kom ons kyk na jou ding... hoekom het jy dit nie gekry nie? Of hoe is joune anders? Hoekom is joune anders? Ek laat hulle dit ook self merk, want ek wil hê hulle moet SIEN waar hulle verkeerd loop.

Santie: Weet jy ek hou nie daarvan om vir hulle dadelik net te sê... nee man jy maal daai met mekaar... ek vra vir hulle... goed waarom gaan dit? Watter prentjie het jy in jou kop? Wat moet jy uitvind? Die belangrikste is die vragie op die einde... wat moet jy uitvind? Moet jy lermoene uitvind... moet jy die bedrag uitvind? Ek moet sê ek begin eintlik daar. As 'n kind vir my by die vraag sê hy weet nou nie eintlik wat hy moet uitvind nie... dan het hy nie eers die hele som gelees nie. Dit is nogal vir my belangrik, want WAT moet jy uitvind en dan lei dit na verder... dan is dit... dink jy jou antwoord gaan meer wees of minder... daai is nogal vir my... ek het dit al 'n paar keer nou genoem, maar dis vir my belangrik en as hy minder raak... dan weet hy mos... dis nie sommer net van bymekaarsit nie, maar waarom gaan dit? Ek sê baiekeer vir hulle... vertel gou vir my in jou eie woorde wat moet ons uitvind. Ek moet sê baie van die goed word ook nie lekker reg gestel nie... nie op hulle leesvlak nie... ek sê altyd as ons mekaar se vraestelle moet modereer... ek dink as 'n buitestander... en ek kyk... ek sê

daai kind dink aan goed waaraan ons nie dink nie... so jy moet dit so fyn vra dat die kind so gelei word dat hy dink aan dit wat jy wil hê. Baiekeer gee 'n kind byvoorbeeld in 'n breukvorm of in 'n desimale vorm... dan sê ek... maar dit is nie gevra vir jou nie. Hy dink anders... dis nie spesifiek gevra vir jou nie jy weet... Mens se vraag is bitter belangrik... jy weet hoe jy dit vra, want jy dink anders as ek en jy interpreteer anders as ek.

Faye: Dis 'n moeilike vraag. Gee my net gou 'n oomblikkie... ek weet dit eintlik... uhm... sjoe... dalk maar uiteensetting... dat dit moet sin maak. Uhm... dit moet in die eerste plek... ek raak partykeer kwaad vir die kinders as hulle nie logika het nie... uhm... ek leer vir hulle nie rympies nie... maar as hulle bewerkings op die bord doen... dan sê ek altyd presies dieselfde woorde vir die soort bewerking. So met aftrek sal ek die heelyd sê... uhm... inplaas van vier minus vyf... sê ek altyd... kan jy sê vier minus vyf? Dan moet jy dink daaroor... en as jy dit so half in 'n vraag sê dan moet jy dink oor die antwoord... met optel dan sê ek... ag plus sewe is vyftien... hier kom die vyf... waar kom die een? Anders vergeet hulle om die een oor te dra. So dis weer 'n vraag... so ek sal maar sê deur vraagstelling.

Emma: Hulle sal vir my baiekeer vra... kan ek net 'n antwoord skryf? Dan sê ek... nou maar waar gaan jy die antwoord kry? Ja, maar juffrou... ek kyk hom. Ek sê... nee, nee, nee, iets moet jou wys hoe kom jy by daai antwoord uit wat jy vir my wil gee en hoe gaan jy weet of daai antwoord reg is. Ek sê jy moet nou teruggaan... daai getalle wat daar vir jou gegee word... dit sê dat jy iets moet doen. Ja, ek weet. Ek sê... maar in jou kop sien jy dit en dit en dit. Sê vir my wat is in jou kop. Verduidelik vir my wat sien jy om by die antwoord uit te kom? En dan kan party van hulle met 'n verskriklike omdraai kom om by dit te kom... dan sê ek kyk... kom ons kyk nou... as ons nou... ek skryf op die bord... sien jy wat dit is... ja juffrou, maar daar's my antwoord. Ek sê... okay... kan ons dit korter maak? Kan ons dit op 'n ander manier doen wat vir jou presies dieselfde antwoord gaan gee sonder dat jy deur al hierdie stappe gaan wat jou kan deurmekaarmaak? So lei jy hom totdat hy 'n kort gewone, basiese bewerking kan doen.

Carin: Ek sou sê oor die algemeen is vraagstelling die maklikste... uhm veral omdat ek 'n groot groep het... ook selfs al het ek 'n kind by my tafel... uhm, want as jy vir 'n kind byvoorbeeld vra wat is vyf plus vyf en hulle weet nie... dan sal ek vir hulle vra... maar okay hierso is jou handjie... daar is vyf en vyf... en as dit nog nie werk nie dan teken ons maar goedjies en ek het stokkies en goetertjies hierso... uhm dis nou jou

baie swak kind. Ek moedig aan dat hulle vrae vra... jy moet vrae vra en ek moet sê consciously het ek nog nie metakognisie probeer toepas soos wat ek nou weet om dit te doen in tale nie. Ek het nie die kennis in wiskunde nie... honestly.

Adri: Ek sê vir hulle... teken 'n prentjie. Veral soos sê nou maar by 'n woordsom... of enige som. Gaan kyk wat vir jou gevra word... sê ses gedeel deur sewe... of nee, nul gedeel deur sewe... gaan teken... al moet jy gaan teken in graad ses en jy sê okay... hierso is my ronde eiertjie... hierso het ek sewe eiers... ek moet nou met hulle werk om 'n antwoord te kry. So laat ek hulle meeste van die tyd... woordsomme laat ek hulle 'n prentjie teken, maar ek leer hulle ook... moet nou nie gaan skilder nie... teken dit vir jou vinnig... okay... sit dit dan in syfers en kom dan tot jou oplossing en jou antwoord. So vir my gaan dit oor... uhm... prentjies... dis vir my een en lees. Lees wat vir jou gevra word en maak seker jy verstaan wat vir jou gevra word, maar dit werk ook net by negentig persent van die kinders. Die ander persoon lees hom, hy dink hy verstaan en hy dink hy weet wat om te doen en wat vir hom gevra word en hy gaan aan. So dit is ook half twee-twee. Ek kan met hom gaan sit en ek kan vir hom sê... jy dink nie... jy besef nie wat vir jou gevra word nie... kom ons kyk saam hierna, maar hy kan by my sit, maar sy aandag kan nogsteeds op 'n ander plek wees, want dit wat voor hom is, wil hy nie hê nie... so dis ook of die wil daar is.

## Appendix N

### Transcript of One Observation: Foundation Phase

Observation: Grade 2

Teacher: Sue

When I enter the only English grade 2 class there is already a group of 12 learners on the mat. The mat area is at the back of the class. The teacher's table is in the left back corner of the classroom. The rest of the learners are sitting at small tables on small chairs which are arranged in long rows directly facing the board. The learners at the tables are doing board work. There are many posters pertaining to mathematical concepts on the display boards such as 2D and 3D shapes, money, number lines and number names, time words and a clock, days of the week and months of the year. There is an A4 poster to show the steps of how to solve a word problem. The steps on the poster are: 1. Draw; 2. Show how you count; 3. Write the answer e.g. 6 apples. There is a large roll of white unprinted newspaper mounted on one of the display boards above the mat area that the teacher uses to write on during mat work. I sit at the teacher's table which is close to the mat area from where I can clearly observe the teacher and the learners on the mat.

The teacher revises the work from the previous day. She shows them the names of fractions a quarter, a third, a fifth and a half. She asks them to say the names of the different fractions.

*T: Now this is a group of words and I wonder who can remember that word that I used so many times yesterday? It starts with a "f".*

*L: A fourth*

*L: A fifth*

*T: No, listen to my question it means all these words it means a part of a whole. All these words. Okay I will help you a little bit more, it starts with a "fr".*

*Chorus: Fractions!*

*T: Fractions, yes, this is just a quick reminder of what we did yesterday. Okay, that is subject closed now. Now I want your attention for something else. What I want to know is. That word fractions means one word for all of those names. Now listen to my question. We are having a problem sum this morning and we have not done this before. Now when we solve problems, children, what is the first thing we do?*

*L: You draw a picture.*

*T: No, no, no, first thing.*

*L: You write the..*

*T: Noooo, do you know what the problem is?*

*Chorus: No*

*T: So what do we do first?*

*L: We read the problem!*

*T: So to be able to do maths, we have to be able to read otherwise we can't understand the problem. So let us read the problem.*

The teacher prepared the word problem on an A4 page and used a thick black marker to write the word sum, making it clearly visible to all learners on the mat. She pastes the word problem on the display board and the learners read the problem together in chorus.

*Chorus: Mum bought 12 apples and 7 pears. How many fruit altogether?*

*T: Did you all understand the problem?*

*Chorus: Yes.*

*T: Now the question is.. can you just repeat the question, how do I know which one is the question?*

*L: The one with the question mark.*

*T: Right, now can you repeat the question.*

*Chorus: How many fruit altogether?*

*T: So what do I call.. what is the word.. like that was fractions for all those words [points to the fraction words on the display board] apples and pears and bananas and pineapples, what do we call that?*

*Chorus: Fruit*

*T: So the collective name for that is fruit. So it is very important, because this is still easy, but when we do another sum, you will see why teacher emphasised that pears and apples are part of..?*

*Chorus: Fruit.*

*T: Now what are the two numbers [asks specific learner].*

*L: 12 and 7.*

*T: Can you come and build me the number 12.*

Learner uses Flard cards to build the 12 using a 10 and a 2 and pastes it on the display board as the teacher directed him to do.

*T: So he says the first number, children, is 12. Now what is the other number?*

*Chorus: 7*

Learner pastes the 7 next to the 12.

*L: Teacher I know the answer.*

*T: Yes, I know you know the answer, but I want you to go and think of what is my number sentence going to be. In other words what am I going to do? What is your number sentence?*

*L: 12 + 7.*

*T: Yes, 12+ 7. I am going to put that on the board. He says to be able to solve the problem he knows he is working with 12 and 7. What words here [points to A4 sheet with sum on] told you it was plus?*

*L: Altogether.*

*T: Altogether! So we must take the 12 and take the 7 and put them altogether in a basket. Right, now 12 +7, let's figure that out.*

Learners' hands go up and teacher asks specific learner to answer.

*L: 19*

*T: 19. Sweetie, look here, I first make it an OPEN number sentence. [Writes =□ after 12+7 on the board].*

*L: That's what I wanted to do.*

*T: Okay, right. What is my answer going to be? [Whispers question].*

Learners excited to give the answer. Many hands go up.

Teacher points to specific learner.

*T: Yes.*

*L: 19 fruits.*

*T: Why must I write 19 fruits?*

*L: Because that is the answer.*

*T: Because the question was.. how many fruit altogether? [Points to question on A4 page]. Let's read it altogether one more time.*

Group reads the whole word sum again in a chorus with the teacher.

*T: And what is the answer, children?*

*Chorus: 19 fruit.*

*T: Now that was an easy sum, because that was a two-digit number plus a one digit. And if I close this [teacher holds her hand over the digit 1] I know that 2+7 makes nine, so that is why 12+7 gives me..?*

*Chorus: 19.*

*T: Right, do you understand that?*

*T: Could the answer be a 12?*

*Chorus: NO!*

*T: Could the answer be a 7?*

*Chorus: NO!*

*T: So I can't use those two numbers, we can say that those could not be the mystery number. We had to PLUS those two numbers to get the mystery number and our mystery number was..*

*Chorus: 19*

*T: Okay now I am going to take a sum that works with bigger numbers.*

*L's: Yeah!*

*L: Teacher a three-digit number.*

*L: Yes, like 100!*

*L: No, 200!*

The teacher takes off the first word sum from the board and pastes a new sum on the board. She tells the learners to read the sum with her.

*Chorus: There are 24 boys and 13 girls. How many learners are there in the class?*

The teacher asks the girls to read the sum together again.

*T: What are the 2 numbers that are in your question?*

Teacher asks specific learner.

*L: 24*

*T: Two numbers*

*L: 24 and 13.*

*T: 24 and 13. Now if you look at the story there. 24 WHAT were there?*

The learners are not able to answer the question immediately.

*T: Okay, look the answer is on there [points to the word sum on the board].*

*L: 24 bananas*

*T: Uh-uh. Read your problem again.*

*L: Boys.*

*T: There were 24 boys. 24 boys. Right and what was the 13? The 13 was what?*

*L: Girls.*

*T: What I know now children is that there are boys AND girls. Now teacher wants to know how many learners are there. What can I immediately tell?*

*L: Plus!*

*T: It is a plus sum, we know it is a plus sum. Okay [says specific learner's name] come and take out the biggest number in the problem. How will you build the biggest number?*

Learner takes out the 20 and the 4 using the Flard cards. The teacher tells her to paste the cards on the board.

Teacher asks another learner to do the same with the smallest number in the sum.

Now there is a 24 and a 13 pasted on the board with a blank space between the two numbers.

*T: Now what is the sign that we need here? [Points to the blank space between the two numbers].*

*L: A plus.*

*T: A plus. [Writes the plus between the two numbers on the board]. Now I want you to write the sum in your book. I want you to write.. what is the number sentence that we have to write?*

*L: 24+13*

*T: Is equal to and make your block. [Writes =□ after 24+13 on the board]. I want you to write that in your book. What numbers are you working with?*

*L: 24 and 13.*

*T: Do you all.. now in your book.. we are working with 24 and with 13. And I know I have to PLUS. Children it is very important that when you read your problem you must know.. [whispers] am I going to plus or am I going to minus. And then the other sums that we were working on, what were the other two things that we could do in a sum?*

*Chorus: Group*

*T: Or?*

*Chorus: Share.*

*T: Group or share. You must be able to distinguish between those. Right so I've got  $24+13$ . And that is equal to what number? [Whispers] What am I going to do now?*

Some of the learners look at the 120-block that is in front of them.

*L: 2 plus the 10 and the 4 plus the 3.*

*T: I wonder who knows the answer.*

Many hands go up and some shout "teacher". Teacher asks specific learner to answer.

*L: 37.*

*T: Aha! She says it is 37. What did I do?*

Hands go up.

*L: Add the tens and the units together.*

*T: That's right. So  $24 + 13$  is equal to 37. [Writes the sum on the board]. Now, last step. Let's read the question..*

*L: Teacher, it is supposed to be 36.*

*T: What is  $4+3$ ?*

*L: Oh, 7.*

*T: What is  $40+30$ ?*

*L: 70*

*T: 70, that is right. So do you have your bearings now?*

*L: Yeh [giggles]*

*T: The main thing I want you to learn today is.. you know the sums, you know the answers, but what I want you to get to is what is MY ANSWER going to be? Read the question first.*

Learners read the word sum together in a chorus. When they read the sum again, they put emphasis on the word learners without the teacher's help.

*T: So it is 37*

*Chorus: Learners!*

Teacher writes 37 learners on the board.

*T: Right, did you write all three those steps for me? First the open number sentence, then you make it true and then you give me the answer. [Points to steps on the board]. So when we are going to paste in story sums, children, you know your three steps.*

Learners complete the sum in their matwork books.

*T: Everybody ready, can I carry on?*

*Chorus: Yes.*

*T: Now I want you to think very clearly about this question. Now, the first one we did was we put fruit together, then you had to take all the boys and girls and put that together to make learners [points to previous two sums on the board]. Now listen to my question now. I want everyone to focus now. Let us read now [puts up a new word sum on the board], think, [whispers] put your thinking caps on, switch on your cameras, right, let's read.*

The whole group reads the sum from the board in chorus.

*Chorus: There are 47 fruit in a bag. There are 6 bananas. How many apples are there?*

*T: Without saying anything, teacher is going to read it again to you, just focus now again. Now get the picture, see the bag, there are 47 fruit in a bag. Of the 47 fruit, children, there are 6 bananas. How many apples are in the bag? Here you must think.*

Learner puts up her hand.

*T: Yes?*

*L: Minus sum*

*T: Okay, I agree with you, it is a minus sum.*

Another learner puts up his hand.

*T: Yes, what do you want to say?*

*L: I was going to do the number sentence now.*

*T: Okay, you can give me the number sentence.*

*L: Uhm.. 47 minus 6 is equal to the blokkie.*

*T: Wonderful!*

*L: Teacher, I know the answer.*

*T: Just hang on; let's just go through it again. What are the two numbers again that we are working with.*

*Chorus: 47 and 6*

*T: Okay, how am I going to make 47? [Points to Flard cards]*

*L: It is a 40 and a 7.*

*T: Right so here is my 47 and my 6. [Pastes the two numbers on the board with a space between them]. I want you to write the two numbers in your book and I want you to put in the signs and show your books to me.*

Learners write the number sentence and show the teacher. She confirms that it is right.

*T: Good, good, I like that, you are so clever! Now you can find the answer. So now you write  $47-6$  is equal to..?*

*Chorus: 41.*

*T: And the answer is?*

*L: 41 fruit*

*T: Huh?*

*Chorus: Apples!*

*T: So let's read the question quickly.*

*Chorus: How many apples are there?*

*T: So what is my answer?*

*Chorus: 41 apples.*

*T: Can you see it is just the other way around from the previous one?*

Learners write the sum in their matwork books.

*T: That was very clever children.*

Teacher tells the group on the mat to take their books and pencils and proceed to their desks where they will first complete the work on the board and then fetch their math task cards in the front of the class. The teacher asks the next group of 15 learners to come to the mat with their matwork books, a pencil and a coloured pencil. Teacher arranges learners on the mat and the learners sit in a semi-circle facing the teacher. The teacher reminds the previous group to first do their counting exercises on the board and then they must do the two activities set out in the front of the class.

The teacher writes the words “grouping” and “sharing” on the board at the back of the classroom so the learners sitting on the mat can see the words clearly.

*T: I wonder who can read these two words.*

Teacher points to first word.

*Chorus: Grouping.*

*T: And this word. [Points to other word].*

*Chorus: Sharing.*

*T: Sharing you know since you are so little, because remember when you were small and your mommy said there are four apples and your brother and you can share it. What did you do with it?*

*L: Cut it in half.*

*T: [Laughing] remember there were four apples.*

Many hands go up and learners are very eager to give the answer.

*L: She gave you two.*

*T: Yes, yes and how did she do it? She said one for you..*

*Chorus: ..one for you, one for you and one for you.*

*T: And then you looked at it and you see well, I've got exactly the same as my brother, because mommy said one for you and one for you, one for you and one for you. So they were exactly the same amount. But say for instance now there are..*

Teacher puts up a word sum written on an A4 sheet on the display board. Some learners immediately start to read the question aloud.

*T: Okay, wait, let's read it altogether first. Let's read our question.*

*Chorus: Share 9 chocolates among 4 girls. How many each?*

*L: There is no picture [giggles]*

*T: Yes, we are going to draw a little bit of a picture still. We are still going to. But now I want you to get the idea. Do I do grouping now?*

*Chorus: No, sharing.*

*T: How do I know that? Because the word tells me. Share. Now when we did sharing, children, [whispers] what is the other magic word.*

*Chorus: Each*

*T: Yes! The moment we use the word share, our magic word is..*

*Chorus: Each.*

*T: Those two words are very important words in our story sum. Now what is the next thing you must look for? What do we need to know? We know we must share. We want to know how many each will get.*

*L: Four girls?*

*T: Yes, yes, yes, yes, but what is the next thing that I am looking for?*

*L: You share it?*

*T: You must look for the..?*

*Chorus: Numbers.*

*T: The numbers and then we must decide what to do. Okay let's read it one more time.*

Group reads the word sum in chorus.

*T: We decided now, I am not going to group, I am going to..*

*Chorus: Share.*

*T: What is the first thing that we must do?[Whispers] What are you going to draw there on your page first?*

*Chorus: 4 girls*

*T: Aha! The four girls. Neatly draw the four girls in your book and you can use your coloured pencils.*

Learners draw the faces of 4 girls in their books while the teacher draws the faces on the board.

While the teacher is busy on the mat with the group, another boy comes from the tables to join the group. He however doesn't have pencils or the correct book with him. The teacher tells him to rather go back to his desk, because she will work with him and one of the other boys who is also still busy with the task cards when she is done with the group on the mat. The boy goes back to his table. He plays with a ruler, rubber and his pencils, building constructions with it at his table.

*T: We decided that we are going to share, and we share amongst 4 girls. Now I want you to take the 9 chocolates and I want you to share it out. [Whispers]. Let me see how you share it.*

Teacher walks to each learner on the mat to see how they are doing the sum.

*T: And how did you share? Did you count them out?*

*Chorus: Yes*

*T: And how did I do it? I say.. look [points to board and writes the sum on the board and there is only one chocolate left]. Is there enough for all of them again?*

*Chorus: No*

*L: Cut it up.*

*T: Yes, let's draw it there. [Draws a chocolate on the board and tells the learners to do the same in their books]. Okay now share it between the four girls.*

Teacher walks to each learner to see what they did with the last chocolate.

*T: Children, this is a very important thing here. Say now if this was not a chocolate, say it was a marble. What would you write as the answer?*

Most learners shout a different fraction such as half or quarter or third. The teacher reminds them again that it is a marble. One of the girls says something very quietly.

*T: Say that again [points to the girl who said something quietly].*

*L: I will put it away.*

*T: I will put it away. Why, because it is left over. That was a very clever answer, because you can't share a marble.*

*L: It will not be a marble anymore.*

*T: Yes, hundred percent right. Okay, let's just go back on our tracks again. Remember when we do the drawing [points to work on the board] put a line underneath it and decide first, when we share it out equally, each one got..*

*L: Two*

*T: That is why I am using the word each, but now see that this is a chocolate we draw a rectangle because that is the shape of the chocolate and it matches up with the story. If it was a pizza, we could use a circle. To be very fair when I am sharing out. What am I going to do with this one whole chocolate that is left over?*

*L: Halve it.*

*T: No.*

*L: Eat it yourself.*

*T: Eat it yourself!? But did I share it equally then? Can I share the last chocolate evenly?*

*Chorus: Yes.*

*T: Yes, I can do that.*

*L: Cut it in half.*

*T: Not in half, because if I cut that in half, will there be enough for all of them?*

*Chorus: No.*

*T: How many pieces would I have?*

*L: Two.*

*T: Only two pieces. And how many children are there?*

*Chorus: Four.*

*L: Teacher you must cut it in four.*

*T: Yes, and what is the word, we cut it into..*

*Chorus: Four*

*T: Fourths.*

*L: Quarters.*

*T: And quarters is the word. Now make a plan, show me how will your cut your chocolate.*

Learners work in their matwork books and the teacher look at what they are doing.

*T: Now I wonder, who can tell me, how many chocolates..*

Many hands go up and are very eager to give their answers.

*L: Two chocolates each.*

*T: And what?*

*L: And one left over.*

*T: But I shared the chocolate between them.*

*L: Two each and a fourth.*

*T: She said two each and a fourth. Can I give you a better way of putting your sentence?*

*Chorus: Yes.*

*T: Don't you think it will sound better if I say, let me write it for you. [Writes the answer on the board]. Two and a.. would you like to use the word quarter or fourth?*

*Chorus: Quarter.*

*T: Right, two and a quarter chocolate and our fairy word?*

*Chorus: Each!*

*T: Okay now copy that into your books.*

Learners copy the answer into their books.

*T: Now let's say the answer again; I want you to read it from your books.*

*Chorus: Two and a quarter chocolate each.*

*T: So that means that each child will get two and a quarter chocolate each. So they will each get two whole chocolates and a little bit of the one that was left over. What do we call something like a quarter or a fourth when it is a part of a whole one?*

*L: Fraction*

*T: Yes, we call it a fraction.*

Teacher checks all the books to see if they copied the answer correctly. One of the learners draws a cloud around the word each in his answer.

*T: I am very glad to see that you made a little cloud around your word 'each', because this word is very important when we do sharing.*

The teacher tells the group to go back to their tables and complete their task cards.

## Appendix O

### Transcript of One Observation: Intermediate Phase

Observation: Grade 6

Teacher: Carin

All the grade 6 English learners are settled at their desks. Most learners have someone sitting next to them. The desks are arranged in 6 groups. The groups in the middle of the classroom directly face the board while the groups positioned at the sides of the room are facing the middle of the classroom. All learners have a clear view of the board. There is limited space to move between the desks as the learners backpacks are in the walkway. In one area of the display boards at the back of the classroom there are two store bought posters one representing geometric shapes and another angles. There are also handwritten A3 size posters in the same area about inverse operations, prime numbers and composite numbers.

The learners are told to take out their maths homework.

*L: I did not understand the long division.*

*T: We will go through it now.*

*T: Right, grade 6 whose homework is incomplete, stand.*

The teacher tells the learners what work was for homework. Some learners finished only one of the exercises. They tell the teacher that they did not realise they had to do the other exercise too.

The learners who did not complete their homework stand up and the teacher writes their names in the right-hand side of the board. More or less a third of the class didn't do the homework.

*T: Grade 6, I have told you this before.. we have so much work to do and we do not have enough time to do all the exercises in class, that is why I gave you 14.4 as well. And now some of you did not get the exercise.*

*T: Right, who wants to tell me what did we do yesterday? [Say specific learner's name.]*

*L: Long division*

*T: Long division and what did we say about long division? Who can remember? I said there is a first step we do and then I said.. remember the little rhyme I told you that you can remember the steps. I want to know.. when you write down the sum.. the first, first, first thing you do. [Say specific learner's name.]*

*L: You make the little..*

*T: ..clue board, and what do we write on the clue board?*

*Chorus: The multiples.*

*T: The multiples. Who can tell me what is a multiple again? [Say specific learner's name.]*

*L: Uhm.. its numbers that you times.*

*T: Yes.. you times it..*

*L: You count in that number..*

*T: .. or you count in that number. Good! What is the little rhyme I taught you?*

Lots of hands go up. [Say specific learner's name.]

*L: Does McDonalds sell burgers.*

*T: Good. Who wants to tell me what "does" stand for?*

*L: Divide.*

*T: And McDonalds?*

*L: Multiply.*

*T: Sell?*

*L: Subtract.*

*T: And burgers?*

*L: Bring down.*

Teacher writes the steps on the board.

*T: So we have four steps we have to complete. All right. Who struggled with this?*

Half of the class' hands go up.

*L: I didn't really understand the "bring down" part.*

*T: Okay. What did you struggled with [say learners name]?*

*L: Ma'am it is just confusing.*

*T: Right it is confusing.*

*L: I can do it with one number, but I don't know what to do if it is a big number.*

*T: Okay, the big numbers scare you?*

*L: Yeah.*

Teacher ask specific learners what they struggled with, most indicates that it was either the big numbers or the "bring down" part.

*T: Okay, who found this easy?*

A few hands go up.

*T: Okay who used colours for the different steps?*

Only two hands go up.

*L: Ma'am using colour takes a lot of time.*

*T: I am going to explain the steps one more time. Then I am going to ask some of you to do the sums on the board and you must EXPLAIN your steps as you go along. Right?*

Teacher goes over the steps again using the rhyme. Teacher has already prepared the sum on an A3 page using different coloured markers which she put up on the board. She explains that she knows it is a bit small, but she can't use coloured chalk on the board, because some of them can't see it then.

Teacher does the sum on the A3 page and involves learners by asking leading questions.

*L: Ma'am, I can't see.*

*T: I am going to hand you out the answers right now. I just want you then to listen to the steps.*

*L: Okay.*

*T: Right, I will write the second one bigger on the board for you.*

*T: I wrote down the clue board. Grade 6 this is where most of you struggled. You have to write the clue board.*

*L: Ma'am in a test, if we write the clue board and the clue board is wrong, but the answer is still right, what then?*

*T: Grade 6 we don't assess the clue board, so if the answer is right and the clue board is wrong, you will still get the marks.*

*L: Do we have to do a clue board?*

*T: If you can do it out of your head.. no. But if the numbers get to big, can you do it out of your head?*

*L: No.*

*T: Then you use a clue board.. alright?*

*L: It was really easy; I didn't need to use the clue board.*

*T: I hope your answers are correct. Grade 6, the clue board is a tool. It is effort, but it is a tool to help you.*

Teacher continues to model the sum on the board. She asks leading questions and learners answer in chorus.

*T: Grade 6, these sums have many steps, so you will get confused at first. Do you understand it now a little bit better?*

Ask specific learners who indicate that they struggled with long division at the beginning of the lesson if they understand it now. Most nod their heads up and down, but one girl says: *Ma'am not really.*

*T: Then I am going to do it again, but then you must concentrate. No, what I think we must do.. Who could do number 2 and 3 on the page?*

Few hands go up. Teacher asks one girl to do number 3 on the board and another girl to do number 4.

*T: Okay, you are not just going to do the sum. You are going to explain to the class your steps. Just what I did now. You are going to explain the steps.*

Learner starts with the sum on the board.

*T: I am not hearing you talk. What are you doing? I want to hear you explain what you are doing. Did you use a clue board?*

*L: Well, no..*

*T: Can you write one down for the class.*

Learner writes down clue board.

*T: That is fine. Now explain to them the steps. What must be now the first thing we do when we start now with our calculations?*

Learner makes her thinking visible. Teacher prompts here and there telling where next step starts, while learner explains calculations.

When sum is completed on the board the teacher asks who got the same answer and most of the learners' hands go up.

*T: Well done, well done!*

Now the second learner will do another sum on the board. Learner writes question on board and immediately starts writing clue board. She starts with sum and there are fewer prompts from teacher than with first learner. When the learner gets stuck, the teacher asks class who can help her and one of the learners say what to do. When the sum is done on the board, the learners instinctively start to clap hands.

When the sum is completed on the board the teacher asks who got the same answer and less learners than with the first sum got it right.

Teacher talks about the remainder in a division sum.

*T: What is significant about the remainder?*

*L: It is not zero.*

*T: Yes, but what else do we know about the remainder? It can't go into the.. divider. So if any number less than the divider was there, then it would be a remainder. Does that make sense?*

In a chorus some learners answer yes, some answer no and some are not reacting to the question.

*T: Who doesn't understand that?*

A few hands go up.

*T: Okay, I will do an example about that now on the board.* Teacher hands out the memorandum of the sums the learners had for homework which they have to paste into their books.

*T: Now you are going to look if you had any mistakes. I want you to take a coloured pencil and I want you to highlight or draw a circle.. what was your mistake? I want you to see what. was. the. mistake. You don't have to do the corrections, but I want to see that you have indicated where your problem is. Grade 6, even if your multiples were wrong, then you highlight the multiples.*

The teacher points out that even though she told them the previous day that only number 7 and 8 have remainders she noticed when she prepared the memorandum that number 5 also had a remainder.

*L: But ma'am I did not get a remainder at number 5.*

Some of the other learners also indicate that they did not get a remainder.

*T: Okay, maybe I made a mistake.*

Some learners are still talking about whether number 5 has a remainder or not. Learners look at each other's work.

*T: Relax.. relax.*

One of the learners tells the teacher that she didn't do long division where the divisor was eleven. She used short division.

*T: Grade 6, I explained to you yesterday that we have to do long division. You didn't do it last year, you did the short method. We have to.. when we work with remainders.*

Learners get time to compare their answers to the memorandum. One learner puts her hand up.

*T: Yes?*

*L: Your clue board at number 5 is wrong.*

*T: [Catches her breath and put her hand in front of her mouth]. Did I make a mistake? Okay, where is my mistake?*

Learner tells teacher where the mistake is.

*T: Good for seeing that one, hey.*

Teacher does the clue board on the board and she involves the learners to find the multiples.

*T: Do you see grade 6, if you make a mistake on your clue board, then your whole sum is wrong. Thank you for seeing that [says girl's name].*

Teacher does number 5 on the board.

*T: I need you to look at the board, I want you to look at what I am doing, I need you to follow my steps. [Calls out specific learners' names to get their attention].*

Teacher does the sum on the board and asks leading questions such as *what is my next step?* or *4 times 11 is?*

*L: Ma'am I didn't do long division, because it was just confusing.*

*T: Do you understand it now?*

*L: But I did get the right answer.*

*T: I asked you to do long division. You must practice the steps.*

*L: But long division takes so long.*

*T: Ja, maths is effort, you have to work hard in maths.*

*T: Right, is number 6 correct? Whose answer is the same as number 6?*

Some learners put up their hands. Teacher tells learners whose hands are not up to highlight their mistakes.

*L: Ma'am, ma'am so far I got nothing wrong.*

*T: Good.*

Teacher gives learners time to highlight their mistakes. One of the learners asks the teacher when they are writing maths exam. She answers the question. The teacher asks who didn't do the second exercise. She tells the class that they will do the work now. The memorandum for the second exercise is handed out to the learners who have completed their homework. She tells the learners that if they have time, they will continue with word sums after everyone did the second exercise.

*L: Oh no!*

*T: Why do you say oh no?*

*L: I hate word sums.*

Teacher smiles and tells learners to paste in the memorandum and compare their answers.

Teacher stands in front of the board and tells learners that she wants to explain the remainder. She claps her hands five times and then the learners clap their hands five times in chorus.

*T: I want you to focus.. eyes here.. eyes here. The rest of the class will get the answers grade 6, but I have to force you to practice the maths, otherwise we do it in break.*

Teacher explains the sum on the board and involves the learners by asking questions.

Teacher asks learners who got the sum right and asks those learners who did not get it right if they can see their mistake. Teacher asks if anyone has any questions. None of the learners respond. Teacher tells learners to compare their work with the memorandum and raise their hands if they disagree with the answers from the memorandum.

Teacher attends to individual learners who have questions.

*T: So, what do you know?*

*L: I know I must write a clue board.*

*T: What was the little rhyme I taught you?*

*L: Does McDonald sell burgers.*

*T: What does the 'd' stand for?*

Learner correctly responds to all the questions.

*T: Okay, let's do the sum.*

Teacher sits next to learner in the desk and writes in the learner's book. She asks the learner questions about the procedure of the sum and writes it down in the book.

While the teacher is assisting the individual learner, I notice some learners taking out other books, not related to maths and work in them. One of the boys stands up and walks to one side of the classroom where there is a stack of posters the learners made. He takes out a poster [probably his] about Hinduism, which he takes to his desk and writes on it for the remainder of the maths period even though he was one of the learners who did not complete all the homework.

*T: Okay, now we have a little bit of a problem, because our clue board only goes to 3. Okay.. let's see.. 16 times 10 will be what?*

*L: 160*

*T: Okay, 10 will be a 160.*

The other learners get a little noisier and the teacher asks them why they are talking. She tells them that if they have a problem they should please just wait. Teacher's attention is back at individual learner.

*T: Let's see, 136.. let's see.. maybe 16 times 8 will work out. 8 times 6 is?*

Learner is not sure what the answer is.

*T: Use your fingers, whatever.*

*L: 6, 12, 18, 22..*

Teacher starts writing the multiples in the book. She writes 6, 12, 18, 24, 32.

*T: 32 plus 6 is?*

*L: 32 plus 6 is 39.*

*T: 2 plus 6 is*

*L: 38*

*T: Okay, that [points to 38 in the workbook where she wrote the multiples] plus 6 is?*

*L: 44*

*T: No.. okay.. 6 plus 6 is 12. Then I need 2 more.. so? 8 plus 6 is?*

*L: 8 plus 6 is 14.*

*T: Is 44 a multiple of 6? What is our problem here? We don't know our.. tables.. right?*

Teacher closes the learner's book and look on the back cover of the book where all the tables are printed.

*T: Let's see how far we got? 6, 12, 18, 24, 30, 36.. and 36 plus 6 is?*

*L: 42*

*T: Okay.. plus 6 is?*

*L: 48*

Teacher numbers the multiples from 1 to 8 which she wrote underneath each other in the learner's workbook, correcting the multiples they got wrong the first time.

*T: Right, so 6 times 8 is?*

*L: 48*

Teacher continues to do the sum in the learner's book, while asking him what to do next.

*T: 128, okay, that is not exactly where I want to be, but I know that 8 is 128. So now it is easy. Plus 16 to get to 9.*

*L: 8 plus 6 is 14*

*T: What do I do with the 1?*

*L: Put it with the 2.*

*T: Okay.*

*L: 6 plus 2..*

*T: No, you are multiplying now. 1 plus 2 plus 1 is?*

*L: 4*

Teacher completes the rest of the sum.

*T: Okay so, that will be 9. So what is closest? 128 or 144.. with no remainders.*

*L: 128*

*T: Okay so 16 goes into 136 eight times. Do you agree?*

*L: Yes.*

The teacher writes the rest of the division sum while she asks the learner questions in order to complete the sum.

*T: Did you sleep enough last night?*

*L: Yes. I can do it, but on my own I get confused.*

*T: Okay, where do you get confused, here where you have to minus?*

*L: No, I think it is where I have to get the clue board.*

*T: Okay, what you are going to do while I help some of the others, you are going to get the clue board for 28. See if you can get it. You can either add 28 all the time or you can multiply. Right.. are you sure you understand?*

Learner nods his head up and down.

Teacher stands up to proceed to next learner who needs help. She tells the class if she can't attend to them immediately they should take out their Rainbow books and continue with the work in it. Teacher continues to provide support to learners who are struggling with the homework. Teacher does the work in the learners' books when she helps them.

One of the learners who did all the homework tells the teacher there is a mistake at number 9. The teacher informs the rest of the class about the mistake and apologises.

*L: I did the sum, but I don't know if it is right, because it is not the same as the answer on the page [memorandum].*

*T: Okay, let's do the inverse to check if the answer is right.*

The teacher sits next to the learner and does the inverse calculation in her book. The girl sitting behind her leans over to see what the teacher is doing. Teacher explains that you multiply the quotient with the divisor and if the answer is the same as the dividend then you know your division sum is correct.

The bell rings and the teacher tells the learners that she will continue with the work the next day and if they have any questions, they should write it down.

The teacher tells them to take out their Natural Science books. The Natural Science teacher enters the classroom.

## Appendix P

### Extract of Focus Group Interview Transcript: Foundation Phase

**Watter faktore wat direk met die leerders verband hou beïnvloed die manier waarop jy hulle help om wiskundige probleme op te los?**

Lea: Dis mos maar hulle intelligensie wat 'n faktor is.

**Marli: Getalbegrip**

Sue: Oe, getalbegrip is 'n groot ding en ook watter foute hy gister gemaak het...

Lea: Ja, sy voorkennis...

Sue:... dan sien jy maar kyk hy het nou nog nie daai bousteen nie, ek moet weer teruggaan soontoe, sodat hy die volgende probleem kan oplos.

Lea: Dis nou lekker van jou assessering, want dan groepeer jy nou weer jou kinders heeltemal anders, dan bring jy byvoorbeeld daai wat bewerkingsfoute gemaak het almal saam, want party van hulle vergeet en as jy dit dan oordoen... dan... o, ja... ek het net vergeet en ander kom jy agter, maar sjoe hier is nog regtig 'n probleem, so...

**Sonja: En 'n ou se taalvermoë... sy begrip en sy taalvermoë, dit het op die ou einde baie te doen met hoe hy probleemoplossing kan doen.**

Chorus: Ja, presies (heads nodding)

**Sonja: As jy vir hom half die sommetjie vir hom woordeliks sê of lees, dan kan hy dit doen, maar gee vir hom 'n storiesom... hy het nie 'n idee nie.**

Retha: Die swak lesers kan dit nie doen nie.

Lea: En woordeskat speel 'n groot rol daar, soos 'n woord spandeer...

Sue: Oe... yes, yes, yes.

Lea:... baiekeer weet hy nie wat beteken die woord spandeer nie, dan kan hulle dit nie doen nie, dis nie omdat hulle nie die som sou kon doen nie, dis net omdat hy nie verstaan wat die woord beteken nie. So woordeskat by wiskunde speel 'n baie groot rol. Daar het ons nou reeds geleer by CAPS om vir jou verskillende woorde wat pas by plus op jou muur te sit en so ook vir die ander bewerkings, so dit help nogal baie, maar woordeskat is baie belangrik.

Sue: Soos ek nou altyd vir hulle sê, die woord sharing... you must have the word each... want as jy dit gelykop moet deel tussen almal, dan share jy.

Lea: Daar moet jou kinders ook weer fyn lees, want as daar staan... deel uit tussen die maats, dan hoef dit nie gelykop te wees nie, maar as daar staan elkeen moet presies ewe veel kry, dan moet hy dit presies uitdeel, so dis fyn lees.

Retha: Ek lees byvoorbeeld, sê nou maar die som is twee of drie sinne lank, dan lees ek eers net die eerste sin, dan vra ek vir hulle is daar al iets, weet julle al iets, kan nou al

iets doen daarmee, kan ons iets teken, kan jy iets uitpak, dan sê hulle nee... dan sê ek maar dan moet ons verder lees...en sodra ons iets kan doen...dan stop ek net daar dan doen ons dit eers so...

**Marli: ...so luistervaardighede**

Retha: Ja, luistervaardighede, dan sal ek sê goed, dan gaan ons aan. Dan op die einde moet hulle kan omkring, want vir hulle is dit baiekeer... hulle kan die antwoord sê, maar hulle weet nie hoe hulle daar gekom het nie. Wat het hulle gedoen om die antwoord te kry, dan moet hulle 'n probleem of 'n som daaraan kan koppel en dis vir hulle baie moeilik. Hulle moet altyd die antwoord omkring vir my, want die antwoord wat hulle omkring is die antwoord wat hulle gaan neerskryf.

Sonja: En dan ook as ek kyk na die een outjie wat baie sukkel wat by my is, die eerste kwartaal het dit gelyk... hy gaan dit nie maak nie, hy het dries omtrent vir alles gekry, omdat hy emosioneel op so 'n slegte plek was en hierdie kwartaal het sy situasie 'n bietjie meer gestabiliseer... en dit wys in sy punte, sy punte... waar dit 'n drie was, is dit nou 'n 5 en 'n 6...

Lea: Wow! Dis fantasties...

Sonja: ...net omdat hy emosioneel op 'n beter plek is, want omdat hy so bekommerd is oor mamma wat weg is, kan hy nie normaal dink nie, niks nie. Hy kan nie sy sinne maak nie, hy kan nie wiskunde doen nie, want sy gedagtes is net nie daar nie... so emosionele faktore het 'n BAIE groot invloed om hulle.

**Marli: Ja, hulle werk soos hulle voel.**

Lea: Ja, ja.

Sonja: Kyk maar as 'n outjie nie lekker voel nie, as hy siek is, kan hy ook nie daai dag sy wiskunde klaarmaak nie.

Lea: En dan kan 'n mens selfbeeld daaraan haak. Uhm... selfbeeld, veral wat wiskunde betref... daai sukses wat hulle kry, so as jy weet daai kind kan nie dit doen nie, of hy het 'n probleem of wat ook al, dan gee mens vir hom net makliker somme... dat hy ook net daai sukses kan smaak. En sodra hy agterkom dat hy kan dit doen... baiekeer is dit net daai... uhm... mental block... van oe ek kan nie, maar sodra hulle agterkom, haai maar ek kan dit ook regkry, dan is dit verby... dan gaan dit aan.

**Marli: Ek het ook al agtergekom... ouers by die huis... jy kan sien wanneer die ouer by die huis negatief is teenoor die kind of baie druk op hulle sit... dat hulle eintlik so half crack... eerder as om hulle op te bou en aan te moedig... jy kan baiekeer sien hoe die ouers by die huis ook met die kinders werk.**

Sonja: Selfs ook in mens se klas... met positiewe motivering... nè. As jy vir 'n kind sê ... kom ek WEET jy kan, dan gaan dit sommer ook beter.

Lea: Ja en mens het nie elke dag daai mindset nie... kom ek vat gou myself as 'n voorbeeld, dis nou al my 28ste jaar wat ek skoolhou en jy raak so afgestomp van jaar na jaar... dit voel asof jy net voortploeter... daai lekker wat jy eintlik moet terugsit in die onderwys of vir die kinders in die klas... verdwyn basies, want ek voel nie... dit is nie vir my lekker nie... en nou hierdie iKwezi het die vrou weer vir ons soveel idees gegee... en onmiddellik is dit... wow, dis oulik en onmiddellik kom jy skool toe met 'n positiewe mind set... en dit maak dit nou weer lekker... so

Sonja: Dis wat ek nou by jou wil aansluit... mens dink so wat die kind se emosie is, maar die onderwyser se emosie...

Sue: ... ja, ek wou ook nou net sê...

Sonja: DIT beïnvloed ook hoe mens werk.

Retha: Dit hang ook af hoe voorbereid mens is. Ek was al party dae onvorbereid en dan dink ek... ek moes net hierdie ding bietjie beter beplan het, dan was dit vir my makliker...

Sue: Voorbereiding is baie belangrik...

Retha: En dan baiekeer, veral met wiskunde dan beplan ek iets, maar dan beland ek heeltemal op 'n ander plek, want die kinders kom net nie daar waar jy wil hê hulle moet kom nie... dan voel dit vir jou môre begin ek maar weer van vooraf, want jy het nie dit bereik wat jy wou bereik nie.

Lea: Dink net aan tyd... die tydsaspek... as ons net meer tyd kan hê... gaan ons net soveel beter voorbereid kan wees, want daar is nie tyd om deur boeke te gaan blaai vir idees nie... uhm... daar is nie tyd rêrigwaar om voor 'n rekenaar te gaan sit en te gaan soek op die internet vir oulike prentjies of wat ook al nie.

Retha: Om terug te kom na die kinders toe ook, party kinders is so impulsief... ek het een dogtertjie... sy skree letterlik net enige getal net om 'n antwoord te gee... sy dink glad nie.

Sonja: Ek dink ook net ons is so bewus van hierdie werk moet ek vir die kinders aanleer... om nou die heelyd te moet aandag gee aan die kind wat nie wil saamwerk nie... dan werk ek met die wat wel wil werk net om deur die werk te kom. Ten minste kan ek sê vanmiddag sê... sjoe, nou kan ek aanbeweeg. Hierdie ou het dit dalk nou by verbygegaan, maar ja...

Lea: Sekere kinders doen goed... hy doen 'n ding... maar eintlik lyk dit of hy nie aandag gee nie, maar dan gee hy aandag...

Marli: Ja, partykeer sit hulle net met iets en speel om hul hande besig te hou, maar hy gee nogsteeds aandag.

## Appendix Q

### Extract of Focus Group Interview Transcript: Intermediate Phase

**Watter faktore wat direk met die leerders verband hou beïnvloed die manier waarop jy hulle help om wiskundige probleme op te los?**

Santie: Ag, ek dink nou sommer aan jou kinders wat erg aandagafleibaar is en konsentrasieprobleme het, jy weet. Ek meen jy moet dit in ag neem.

Adri: Dit gaan oor die buddy-sisteem, die kinders van my wat aandagafleibaar is, het 'n buddy langs hom... nie beheer hom nie, maar hou hom net intoom. Daar is ook sekere kinders by wie jy nie 'n buddy kan sit nie. Ek het nou al hoeveel kinders langs haar probeer, maar die ander persoon is daar om te help, maar sy sien dit as dis heeldag pouse dan. Dis iemand langs haar om mee te praat, maar sodra ek haar op haar eie sit, voor in die klas, dan is die aandag voor by juffrou, maar om iemand langs haar te sit, werk nie.

Faye: Vir my is een ding met wiskunde, veral met wiskunde is onsekerheid, so baiekeer weet die kind wat om te doen, maar sal nie in enige gesprekke in die klas deelneem nie, sal nooit 'n som op die bord kom doen nie. So hulle ontnem hulleself eintlik daai voorreg om hardop te dink en ook omdat hulle onseker is vat dit verskriklik baie tyd en ek kom nou terug na woordsomme toe, want dis maar eintlik waar die probleem lê wat meeste van die kinders hulle tyd in beslag neem. Daar kom soveel kinders na my toe wie sê juffrou ek verstaan nie die som nie, ek weet nie hoe om dit te doen nie en al wat ek doen... ek verduidelik niks wiskunde nie, ek lees net die som vir hulle en dan gaan doen hulle die som op hulle eie en dan doen hulle dit reg. So onsekerheid vat ontsettend baie tyd, veral in 'n toets of eksamen wat hulle sit en sit en sit en hulle kan die werk doen, maar hulle kom nie sover nie, want hulle is bang vir die vraag. So dit vat baie tyd in die klas is om daai onsekerheid weg te kry. Die een kind wat ek verlede jaar gehad het se punte het van die een kwartaal na die ander kwartaal met omtrent 20% opgekom, want ek het net met haar gepraat dat die wiskunde is nie so moeilik soos wat sy vir haarself wysmaak nie. En toe sy eers oor dit kom dat sy nie meer onseker is nie, toe verbeter haar werk vanself.

Santie: Baiekeer maar van die huis af ook jy weet. As ma en pa... oe ek kon nie wiskunde doen nie, dan is daai persepsie al klaar gelê by die kind van ek kan nie wiskunde doen nie, ek hoor dit heeldag, gaan vra vir jou pa, want ek kon nie wiskunde doen nie.

Adri: Ek het die in my klas ook waar die stiefpa vir die kind wys hoe om 'n som te doen en hy bly net by wat stiefpa leer. Ek kan sê wat ek wil, hy leer by die huis. 'n Ander ouer weer wat vir my gesê het sy en haar man is nie sterk met wiskunde nie, so sy het net vir haar dogtertjie gesê sy moet net wiskunde deurkom, so daai kind sit in die klas met... ek gee nie om oor wiskunde nie, maar die ouers gee ook nie om nie, so ek dink daai invloed ook. Ek as onderwyser wat 'n liefde vir wiskunde het, kan ook net soveel motivering doen as dit nie van die ouerhuis af ook kom nie.

Carin: Ek dink om aan te sluit by Adri, die interne motivering van die kinders is verskriklik laag. In my klas is dit amper non-existent. Uhm... ek kan ekstern motiveer met plakkertjies en positiewe inskrywings en lekkertjies uitdeel, maar dit vul nie daai

gap wat hulle het van die interne motivering nie. En ek dink ook 'n faktor wat vir my 'n baie groot rol speel is dat hulle net 40% moet kry vir 'n slaagsyfer. Ek dink regtig hulle kyk vas in daai 40% en ek weet nie hoe mens dit verander gaan kry nie. Ook my klas, omdat hulle van graad R af al saam is, is daar verskriklike gedragsprobleme, hulle ken mekaar te goed, hulle ken mekaar se knoppies en soos ek sê hulle wil nie eintlik hard werk nie, daar is geen rede nie, daar is geen motivering nie, uhm... en dit is nogal 'n faktor wat ek nie weet hoe om te oorbrug nie.

Emma: Met die jare se ondervinding dink ek leer mens maar om die kind op verskillende maniere te benader en ja jy het die probleme wat hulle aanspreek, jy sien dit en jy besef jy moet daarmee werk, maar jy benader dit op so 'n manier dat jy daardie kind eintlik belangrik moet laat voel, jy moet daai kind intrek op so 'n manier dat hy of sy voel, ek beteken iets in die lewe, ek is nie 'n mislukking nie. Ek dink dis verskriklik belangrik om vir 'n kind sy vertrouwe terug te gee en as 'n kind voel jy as onderwyser het nie vertrouwe in hom nie, dan gaan jy vir hom niks beteken nie, want hy gaan teen jou ingaan en hy gaan nie saam met jou werk nie, want jy glo ook hy kan nie. So jou heel eerste ding met sulke kinders is ek vertrou jou, ek weet jy kan en ek wil hê jy moet vir my wys jy kan. Nie met 'n beloning nie, ek glo nie in belonings nie, die beloning is wat hy kan regkry. So waarop kom dit maar neer, ken jou klas, weet wat sit voor jou en dit maak nie saak... ek sê ook vir hulle, julle wat wiskunde ken en wat glo dat julle alles weet, julle weet nie alles nie, maar as ek 'n ding op hierdie bord 50 keer oordoen dan bly jy stil en jy luister, want elke 50 keer hoor jy iets wat jy nie geweet het nie totdat hierdie ander kind by my is, sal ek dit doen. En jy werk maar so met hulle.

Santie: Net om by Emma aan te sluit, ja, mens dink jy kom in 'n klas en jy het 'n moeilike klas, al kan jy net 'n verskil in een kind se lewe maak, dan is dit die moeite werd, al sit jy met ander 32 wat jy nie... dis maar hoe ek... as jy net in een kind se lewe 'n verskil maak, dan is dit die moeite werd.

Adri: Dis moeilik, want ek is self jonk, ek het self nog baie wat ek elke dag leer en dan moet ek nog ander kindertjies onder my ook leer en vir my wat 23 is, is dit verskriklik moeilik, maar elke dag leer ek hoe om dit te hanteer.

## Extract of Codes, Categories and Themes

Intermedia te Phase participant	Knowledge Dimension					
	Professional Knowledge			Knowledge of learner		Knowledge of metacognition
	Subject Content Knowledge	Pedagogical Knowledge	Pedagogical Content Knowledge	Knowing learner as a learner / thinker	Perezhvanie	
<b>Mia</b>	Soos woordsomme?	Ek sal begin met die maklike probleme.. dan kan jy nou sien.. goed almal kan dit nou doen. Reg.. dan gaan ons aan na die volgende bietjie moeiliker probleme. Jy moet iets gee wat op hulle vlak is of 'n bietjie hoër dat hulle kan streef daarnatoe.	..ek dink dit is maar die oefening.. uhm dril.. maaltafels dril. Ek weet nie of dit die beste altyd is nie, maar dit lyk vir my asof dit help. Net die konstante oefening.	Terwyl as jy dit in 'n sin oorsit.. dan gooi dit hulle heeltemal en hulle verstaan nie wat beteken die woord produk nie.. hulle verstaan nie die woord som van nie.. uhm.. tot vyf meer.. tel vyf meer by.. dan sukkel hulle omtrent.	..ek wil hê hulle moet voel hulle is veilig in die klas en dis hulle klas.. so ja ek wil vir hulle bietjie daai erkenning gee, want dis so 'n groot klas en hulle raak so weg.	... daar iets in taal oor jy dink oor jouself oor hoe jy dit doen...Ja, ek dink dis moeilik op hierdie graad om dit te doen, want die kinders gaan nie noodwendig.. hulle verstaan nie daai konsep nie.
<b>Santie</b>	Met ander woorde 'n woordsom. Ons praat van probleemsumme of woordsomme.	Die beste is seker maar.. begin by wat hulle weet.. die ou storie.. en lei hulle verder	..maar ek meen as jy nie daai verkeerde goed gaan opvolg nie dan is dit van nul waarde.	..veral as jy twee begrippe het in een woordsom. Twee begrippe wat hulle moet saamvoeg.. ja dit is hulle grootste probleem.	So ek moet nogals vir jou sê om dit vir hulle lekker te maak.. rêrig lekker te maak en om daai stresfaktor heeltemal weg te vat..	Maar hoër denke.. dis eintlik waaroor dit gaan... om te kan dink en rêrig te redeneer daaroor.
<b>Faye</b>	Vir my is dit.. gewoonlik as 'n som sê.. solve the problem.. okay en dan is dit gewoonlik 'n woordsom..	So my werk is om leiding te gee en as die kind regtig sukkel dan.. nudge, nudge ek hulle so op die regte spoor	Mens moet ook probleemoplossing van verskillende rigtings af benader.. uhm.. dis die lekker ding van wiskunde.. daar is nie net een reg en verkeerd nie..	Die swakker taal kinders is ook die swakker wiskunde kinders. Kinders wat vir hulp gaan vir taal, gaan ook vir hulp vir wiskunde.	..ek dink dis dalk 'n selfvertroue-ding.. die kinders oor die algemeen is my klas nie.. het hulle nie selfvertroue met wiskunde nie.. so hulle is onseker.. hulle vra die heelyd vrae.	Okay.. ek dink nie ek het al ooit die woord vantevore gehoor nie.. ek weet nie of ek moes nie..
<b>Emma</b>	Eintlik alles. Uhm.. nee, want probleemoplossing gaan nie vir my oor 'n woordprobleem nie. Dis wiskunde.. elke wiskunde aspek wat jy aanpak is 'n probleemoplossing. Jy kan hom nie van mekaar skei nie al wil jy.	Dit beteken dat ek elke kind op sy eie vlak moet benader wat onmoontlik is in 'n klassikale groep wat jy nie kan doen nie.	Dis hoekom jy voor daai tyd leer jy die basiese goed.. ek moet met tien vermenigvuldig dan sit ek 'n nul by.. eers dan vermenigvuldig jy.	Ek het al geleer om dit in hulle gesigte te kyk. Ek kyk dit uit en uit in hulle gesigte. Ek kan dadelik sien snap hy wat ek nou van praat en watter kind geen idee het wat ek van praat nie en ek sal hom pertinent aankyk en sê.. jy weet nie nou waarvan ek praat nie, nè.. en dan sal hy vir my sê.. nee juffrou.	..die een wat sukkel sal ek vreeslik boost as hy iets reggekry het en ek sal regtig.. in my hart is ek verskriklik bly ook. Dis net te wonderlik om te weet hulle kon dit gedoen het en hulle kon iets bereik het. Dis vir my ongelooflike gevoel en vir daai ene wat goedgeedoene het skryf ek in sy boek.. pragtig.. mooi gewerk..	Ooee.. hoekom gee jy nou vir my so 'n lelike woord? Ek weet nie, ek weet nie wat moet ek vir jou sê nie. Ek gaan nie eers gorrel nie.. ek is nie so 'n mens nie.
<b>Carin</b>	wiskundige probleem is.. jy word inligting gegee of data gegee en jy moet dit interpreteer.. hetsy jy moet 'n antwoord kry of jy moet 'n grafiek teken of jy moet vrae beantwoord oor 'n grafiek...	Ek het ook die boek.. The trouble with maths.. iewers. Ons het dit op kampus van oorsee laat kom.. daarin het ek gelees dat jy moet begin by die konkrete.. jy weet en dan abstrak toe.	..want ongelukkig praat mens.. chalk en talk jy meeste van die tyd.. en as die kind nie ouditief sterk is nie.. veral as jy die groot getalle met hulle doen of 'n woordsom vir hulle lees..	Soos ek sê hulle het 'n blok.. hulle het 'n blok as dit kom by woordsomme, want ek dink nie hulle kan altyd die probleem identifiseer nie, so dan sukkel hulle om die oplossing te kry, want wat is die probleem?	Dis nie lekker om in 'n groep te werk en dan sê 'n kind vir jou maar jy is stupid nie.. ek kry ongelukkig gereeld sulke lelike goed en ek wil nie my kinders blootstel daaraan in wiskunde nie...	..ek moet sê consciously het ek nog nie metakognisie probeer toepas soos wat ek nou weet om dit te doen in tale nie. Ek het nie die kennis in wiskunde nie.. honestly.
<b>Adri</b>	..wiskunde probleemoplossing is elke sommetjie wat jy doen, want jy moet hom ontleed om 'n antwoord te kry of 'n berekening te doen om hom op te los.	Almal is uniek...van agtergronde, vermoëns, talente.. hoe ook al en vir my gaan die onderrig daaroor.. jy gaan nie almal kan op hulle vlak kan help of aanmoedig of ondersteun of onderrig nie... ek kan streef daarna, maar ek kan nie almal doen nie.	So ek dink dis die basiese van.. die basiese van optel, aftrek en die tafels.. waarop jy enige wiskunde.. as jy daai kan verstaan.. kan jy.. dink ek kan jy ver gaan in jou wiskunde	Dit is 'n daaglikse uitdaging vir my. Hulle sien dit te moeilik. Hulle maak dit vir hulleself te moeilik.	Ek dink vir my gaan die groot ding oor die motivering, om nie die kind af te kraak en te sê.. ek het nou net vir jou verduidelik.. gaan sit en probeer dit nou eers nie. Om daai motivering of daai positiewiteit deur te bring.. die lekkerheid daarin te sien.	Ek weet nie of ek die terme daaglik gebruik nie, maar metakognisie is net nie vir my bekende terme nie.

Intermediate Phase participant	Strategies Dimension				
	Mediation of metacognition			Differentiated Instruction in the mediational process	
	Mediation of metacognitive knowledge	Mediation of metacognitive regulation	Strategies to mediate metacognition	Differentiation of content, process and/or product	Differentiate to match learners' readiness, interests and/or learning profile
<b>Mia</b>	Dan vra ek vir hom.. uhm.. verstaan jy wat hier aangaan? Kan ek vir jou help? En dan baiekeer sal daai kind sê.. yes ma 'm, I need help.	..okay kom ons kyk na jou ding.. hoekom het jy dit nie gekry nie? Of hoe is joune anders? Hoekom is joune anders? Ek laat hulle dit ook self merk, want ek wil hê hulle moet SIEN waar hulle verkeerd loop.	..okay jou beurt.. jy doen nommer een.. jy doen nommer twee en dan is daar omtrent agt kinders wat voor staan en die goed doen en dan kyk ons dit saam.. die antwoorde as 'n klas.. dan bespreek ons dit saam.	Ek gaan nie moeilike goed gee vir kinders wat sukkel nie.. Jy moet iets gee wat op hulle vlak is of 'n bietjie hoër dat hulle kan streef daarm toe	So ek vat hulle as 'n groep dat hulle kan verstaan.. almal moet die werk doen.. jy kry nie verlof om dit nie te doen nie.. Almal moet dieselfde aantal werk doen
<b>Santie</b>	Weet jy ek hou nie daarvan om vir hulle dadelik net te sê.. nee man jy maal daai met mekaar.. ek vra vir hulle.. goed waarom gaan dit?	..dan moet ek sê ek probeer nogal aandag gee aan die inverse metode.. hoe toets jy dat jou antwoord reg is? Ons doen te min inverse.. dis mos lekker om te weet of ek reg is, dis hoekom ek sê al doen jy helfte minder somme elke dag.. maar doen die inverse.. mens behoort eintlik al die inverse te doen.	Ek sê baiekeer vir hulle.. vertel gou vir my in jou eie woorde wat moet ons uitvind.	Ek druk nie 'n kind om al agt te doen nie. Ek doen dit baie met my swakkes.. ons het 'n sekere.. of as die tyd om is en die kind kom nie daarby uit nie of ek het hom nou baie gehelp dan stop ons daar.	
<b>Faye</b>	.. lees deur jou som en dan kyk ons eers vir woorde wat jou kan lei soos verdeel of verskil of som of so iets, want dan weet jy mos maar watter bewerking dit is..	..ek leer vir die kinders inverse operations.. uhm.. ek laat hulle ook heel eerste kyk.. want hulle is nog klein.. dan moet hulle eerste kyk of hulle die getalle reg oorgeskryf het van die handboek af in hulle number sentence.. van die number sentence reg afgeskryf het in die som..	.. as hulle bewerkings op die bord doen.. dan sê ek altyd presies dieselfde woorde vir die soort bewerking .. om meer te praat terwyl jy verduidelik dink ek.. dat die kind nie net die som op die bord sien nie.. uhm.. dat jy dit kan hoor op verskillende maniere..	Mens moet ook probleemoplossing van verskillende rigtings af benader.. uhm.. dis die lekker ding van wiskunde.. daar is nie net een reg en verkeerd nie.. jou kind kan verskillende bewerkings gebruik.	..ek benader dit maar kind vir kind benader, want almal dink nie op dieselfde manier nie..
<b>Emma</b>	Ek sê.. maar in jou kop sien jy dit en dit en dit. Sê vir my wat is in jou kop. Verduidelik vir my wat sien jy om by die antwoord uit te kom?	Ek sê.. nee, nee, nee, iets moet jou wys hoe kom jy by daai antwoord uit wat jy vir my wil gee en hoe gaan jy weet of daai antwoord reg is. Ek sê jy moet nou teruggaan.. daai getalle wat daar vir jou gegee word.. dit sê dat jy iets moet doen..	Ek is daar om dit vir hulle te verduidelik die oomblik wat hulle vashaak. Ek vereenvoudig dikwels net die taal van die boek vir die kind en onmiddellik weet hy wat om te gaan doen..	Daarom sal jy werk doen op 'n manier wat vir elke een ten minste voel.. ek kan dit doen.	So jy moet fisies kyk waar fouteer daai kind. Soos 'n kind sal by my kom staan met lang-vermenigvuldiging.. waar fouteer hulle? Hulle los almal die nulle uit voordat hulle aangaan om te vermenigvuldig.. nou daar kan jy 'n hele klompie betrek..
<b>Carin</b>	Ek leer vir hulle die stappe.. eerstens.. watsie inligting het jy? Uhm.. wat vra hulle vir jou? Wat is jou bewerking.. en uhm.. dan hoe gaan jy nou te werk.. gaan jy nou.. dan doen jy mos nou die bewerking.	..monitor.. ek sê vir hulle altyd.. gaan terug en kyk wat vra hulle, want baiekeer dan raak hulle weer van die pad af.	Ek moedig aan dat hulle vrae vra.. jy moet vrae vra..	..byvoorbeeld, die outjie wat nou nie weet wat is afronding nie.. dat hy ten minste aan die einde van die periode weet wat afronding is, maar dat my honderd persent kandidaat byvoorbeeld kan afrond tot vyf, tien, honderd, duisend en tienduuisend..	Ek het kinders wat verskriklik vinnig werk en verskriklik stadig.. uhm en nou weet ek nie.. moet ek aangaan en die agter-ossie nou maar los.. so as dit nou gebeur, dan moet hulle in hul Reënboogboeke werk.
<b>Adri</b>	Lees wat vir jou gevra word en maak seker jy verstaan wat vir jou gevra word, maar dit werk ook net by negentig persent van die kinders. Die ander persoon lees hom, hy dink hy verstaan en hy dink hy weet wat om te doen en wat vir hom gevra word en hy gaan aan.	Ek laat hulle die inverse doen... met die maalsomme waar die getalle bietjie groter is laat ek hulle liewer die som twee keer doen.	Ek sê vir hulle.. teken 'n prentjie. Veral soos sê nou maar by 'n woordsom.. of enige som.	..as ek vir die kind ekstra hulp kan aanbied of ekstra aktiwiteite gee, dan bespreek ek dit altyd met my ander kollegas en ons gee dit, maar nie noodwendig net vir 'n spesifieke kind nie, maar vir almal.. jy kan nooit te veel.. genoeg oefening kry nie.	..ek sit my kinders ook dat hulle half 'n buddy langs hulle het wat hulle kan help wanneer ons goed merk.. Sekere kinders sit ek alleen, want dit gaan die beste vir daai kind wees.. en jy moet as jy agter is, gaan kyk by jou maatjie.. gaan maak seker..

Intermediate Phase participant	Context Dimension						
	Extrinsic influences on teachers' mediation				Intrinsic influences on teachers' mediation		
	Learners	Context of school	Professional collaboration	DBE	Teacher reflection	Teacher autonomy	Teacher's beliefs/ attitude
<b>Mia</b>	As die kind al so ver agter is.. hy het al so 'n groot agterstand het met wiskunde dat jy omtrent nie kan vorentoe gaan nie, want hy is te agter.. jy moet eintlik weer van vooraf begin met hom.	..daar is nie plek nie.. daar is nie ruimte om 'n groepie te vat nie en daar is letterlik nie plek vir 'n mat of iets nie, ek meen ek moes die banke bymekaar skuif net om loopplek te kry.	..die kinders wat wel sukkel.. wat al vir jare al sukkel.. wat 'n geskiedenis al het van sukkel.. hulle gaan na die leerondersteuner toe. Ons het toestemming gekry van die ouers.. vorms is ingevul..	.. ons gaan wel volgens die dokument.. die CAPS dokument, ons werk daarvolgens, maar jy verander ook dit volgens hoe jou kinders se behoeftes is..	Uhm.. en daai drilling met maaltafels het ek agtergekom hulle wiskunde is sommer al klaar baie beter.	..sy sal byvoorbeeld sê.. uhm die mental maths doen jy net drie keer per week..Ek doen byvoorbeeld mental maths elke oggend al is dit net tien minute, want ek sien hoe die kinders daarby baat.	..hulle kan vir my dadelik sê as hulle nie verstaan nie. Ek raak nie kwaad nie, ek raak nie geïrriteerd nie. Ek verstaan dat wiskunde is mos nou heeltemal anders as die ander vakke..
<b>Santie</b>	.. op die oomblik spandeer ons hoopeloos te min tyd daaraan, want die kinders sukkel nog met die basiese.. jy weet.. hoe kom ek nog by 'n antwoord uit? Ons voel ons moet dit eerste doen voordat jy 'n probleem kan doen.. jy weet. In 'n probleemson.	..ek is nog besig om te praat dan kom die volgende onderwyser al in my klas in. Nou dit moet ek nogal vir jou sê.. ek weet die mense is teen klasonderrig in graad vier, maar ek dink jy gaan nogals baie bereik daarmee.	.. en baie met die ouers ook.. ek skryf baie in die huiswerkboeke.. vra vir mamma om net weer gou vanmiddag dit te verduidelik. Ek dink nogals as 'n mens goeie ondersteuning van die ouers kry.. dan.. dit help baie. Dit help rêrig baie..	..dit is vir my meer kommerwekkend.. kyk jy kan nog hier en daar 'n foutjie maak, maar met ander woorde dis nie vasgêl nie en dis CAPS.. jy moet gaan kyk. Ek sou sê maak 'n begrip klaar lê hom vas voor jy by 'n volgende begrip kom.	Dit was nogals vir my iets om oor na te dink oor hoe 'n belangrike rol ons eintlik hier vervul.	Dit is hoe ek dit sou gedoen het, maar jy sit met 'n CAPS boek wat vyfmiljoen sommetjies se oefeninkies en sulke goed het. Ek sal eerlik amper alles soos jy sê in 'n probleemoplossing doen.	..jou trots wat jy het en jou verantwoordelikheid teenoor jou werk. Ek meen as jy die vinnigste en die maklikste pad wil gaan.. hoekom is jy in die beroep? Dis die tipe beroep waar jy SO kan lyf wegsteek..
<b>Faye</b>	..dan het ook kinders in my klas wat Tourette's het en wat ADHD het en een sukkel met gehoor so dit alles beïnvloed hoe ek my lesse moet gee..	Ja, dis hoekom ek sê probleemoplossing partykeer vir my moeilik is met die klas.. met die hoeveelheid kinders, want ek het nogal 'n groot groep wat nie so sterk akademies is nie.	Ek het 33 kinders in my klas en omtrent vyftien van hulle gaan na die leerondersteuner toe.	So hulle vra dit op maniere wat die kinders nie die vrae verstaan nie. Dis werk wat hulle kan doen, maar hulle verstaan nie hoe die vraag gestel is nie. Hulle woordeskat is te groot..	..dit is hoe ek op skool was. Dit het vir my honderd persent sin gemaak in die boek en op die bord, maar ek kon nie lekker al die stappe self onthou het om dit in my boek te doen nie.	.. ek bly nie altyd by die CAPS met die mental maths nie, want partykeer is dit net te maklik en my klas sukkel spesifiek met aftrek en deel..	..maar verder bly ek weg van groepwerk af oor ek slegte ervarings het van groepwerk en oor uit my skoolloopbaan uit het ek die gevolgtrekking gemaak dat groepwerk nie werk nie.
<b>Emma</b>	My eertlike ding met hulle is.. ek sê dit ook vir hulle.. as jy sukkel met 'n probleem en jy wil daai probleem oplos dan gaan ek vir jou help oplos, maar as jy sukkel en jy wil nie.. my kind.. dan gebruik ek my tyd op 'n ander een wat wil.	Maar kom jy nou in graad vier en vyf en ses.. het jy mense wat wiskunde op verskillende maniere aanbied. En ongelukkig moet ek dit ook sê het jy mense wat wiskunde gee en dit NIE kan aanbied nie. Met die gevolg jou kind begin daaronder ly.	Ek sê ook vir die kinders.. ek is hier om jou wiskunde probleme op te los. Moenie vir jou ma en pa gaan vra nie. Toe hulle in die skool was, was dit heeltemal anders as wat ons nou in die skool doen. Hulle gaan jou verwar	CAPS dwing vir jou in 'n rigting in.. met die wat in hulle boeke aan elke dingetjie gehap en gehap word.. kan jy nie met daardie kind wat sukkel in die klas dit leer nie. Ek is baie jammer, maar dit werk nie..	Jy het nie altyd genoeg tyd nie.. en dit hinder, uhm.. ek dink dis seker maar omdat ek al so lank in die onderwys is dat ek.. ek sit met die goed en dit hinder my, want ek kan nie by hulle uitkom by wie ek wil uitkom nie..	Dis hoekom.. my kinders kry nie wiskunde huiswerk nie. Ek is daar om dit vir hulle te verduidelik die oomblik wat hulle vashaak.	..maar moenie vir my groepwerk gee nie. Ek gaan vir jou dadelik sê nee, want ek gaan dit nie doen nie. Ek is seker verkeerd, maar dis vir my net.. ek glo nie almal leer daaruit nie. Dit werk nie vir my nie. Ek sal dit nooit doen nie.
<b>Carin</b>	.. ons kan nie woordsomme doen nie.. kan dit nie doen nie.. uhm.. en 'n baie negatiewe houding teenoor woordsomme.	My klas is groter, hulle dissipline is nie altyd waar dit moet wees nie, hulle vaardighede om in 'n klas te wees.. hulle sosiale vaardighede is ook nie goed nie.	In ons graad-groep beplan die een kollega die wiskunde en dan gee sy dit vir ons.	..omdat dit nou van HNKV na CAPS verander het.. uhm het ek nie altyd geweet waar om aansluiting by die kinders te vind nie.	So ek sou sê ons doen nie probleemoplossing soveel soos wat ons moet nie.. ek dink ons doen baie ander nonsens	.. in ons handboek sê hulle heeltyd/die hele tyd.. en ek weet CAPS sê dit.. estimate the answer.. en dit doen ek nie met hulle nie, want daar is geen begrip nie.	.. die numeracy kursus wat ons nou moet doen... Ek weet dis in die vakansie en dis horrible.. ek is baie opgewonde daaroor, want ek hoop ek kan iets leer..

Foundation Phase participant	Knowledge Dimension					
	Professional Knowledge			Knowledge of learner		Knowledge of metacognition
	Subject Content Knowledge	Pedagogical Knowledge	Pedagogical Content Knowledge	Knowing learner as a learner / thinker	Perezhivanie	
<b>Marli</b>	..as ons sê nou maar probleemoplossing op ons beplanning sit, is dit soos 'n storiesommetjie..	..dit terug te vat na hulle.. verstaan.. hulle verwysingsraamwerk eintlik maar..	..ietsie te vat wat hy wel sal verstaan en dit net.. ja.. bietjie meer konkreet te maak.	Dis moeilik om in graad een, veral aan die begin van die jaar, sê nou maar die eerste ses maande, vir hulle te leer.. uhm om jou antwoord te check, as ek dit so kan stel. Hulle verstaan nog nie altyd daai konsep nie.	Ek ken hom rêrig, so ek weet hy het te laat gaan slaap, hy het nie geëet vanoggend nie en dis hoekom hy nie die somme kan doen nie.	..dis maar die inligting, dis dit wat jy klaar is, dis jou omstandighede en hoe jy grootgemaak is plus nou nog die ekstra inligting wat jy inkry en hoe jy dit prosesseer en dit jou eie maak.
<b>Retha</b>	Ek voel as daai basis gelê is van 'n goeie getalbegrip dan is probleemoplossing vir hulle net soveel makliker.	Dis nie net op matwerk nie, dis ook in die boeke en.. ek bedoel gedifferensieerde onderwys is dat rêrigwaar sal kyk dat jy 'n geleentheid bied vir al die kinders	..daai terugvoering is vir my rêrig baie, baie belangrik.. veral by probleemoplossing, want as jy nie nou aandag gee aan 'n fout wat 'n kind maak met die manier hoe hy dit doen nie, dan word dit so.. hy kom in 'n patroon en hy kan dit later nie verander nie.	..aan die begin van graad een kan hulle dit nie lees nie, so dis eintlik soos 'n groot barrier vir hulle omdat hulle dit nie kan gaan lees nie.	..want baie van die kinders hou nie daarvan om 'n voorbeeld gemaak te word as hulle agterkom hulle sukkel nie. Party kinders vat dit maklik, maar party kinders raak angstig en ek wil reeds nie daai angstigheid by hulle hê nie, want hulle raak.. party van die kinders wil sommer huil..	Ek weet glad nie wat dit is nie.
<b>Sue</b>	..hy weet sewe plus agt is vyftien en jy sit dan 'n storie rondom dit, want vir baie kinders trek dit hulle aandag af..	En natuurlik daar kan ek ook byvoeg dat verskillende kinders leer op verskillende maniere.. daar moet jy ook differensieer.	Jy weet orals moet jy dit link aan wiskunde. Ek dink as 'n kind meer wiskunde beleef dan gaan dit vir hulle natuurlik kom om te wys hoe maklik maak dit jou lewe as jy eintlik wiskundig dink oor goed.	Jy weet watter ou gaan nog baie op tel staatmaak en hy gaan byvoorbeeld nog met sy honderdblok wil sit as ons by groter getalgebiede werk. So.. en dan die ander ou.. hy het dit al meer gememoriseer.		Nee, gits, daar's ek nou dom, nou weet ek nie wat dit is nie.
<b>Sonja</b>	..enige getalle wat die kinders in enige konteks eintlik raakloop is eintlik 'n wiskundige probleemoplossing.	So jy moet op meer as net vermoë differensiasie toepas, want jy moet gaan kyk na sekere aspekte ook wat hulle snap. Wat nie altyd net vermoëns is nie.	Om dit vir hulle in die klas so aan te leer dat hulle dit eintlik buite klas kan gaan toepas	En dit is baie keer juis die enetiese wat vir my die antwoord kan gee, maar hy kan nie regtig vir my wys of sê hoe hy by die antwoord uitgekom het nie, want.. juffrou ek weet dit net.	Waar die swakker outjie het nie in die eerste plek die waagmoed om dit te doen nie, maar jy moet nogsteeds vir hom kan lei om by die antwoord uit te kom, sodat hy voel, maar hy het dit self uitgevind of self ontdek, want anders gaan hy dit nie volgende keer weer aanpak nie.	Ek weet regtig nie wat die beteken nie. (Meta?) Soos in baie? Ek is jammer..
<b>Amy</b>	..enige som wat hulle moet kan oplos, wat hulle moet kan redeneer oor.. sien ek as probleemoplossing en dit kan in enige vorm wees.	..groepwerk.. waar ek met die groepe werk of waar my assistent met die groepe werk is my eerste, belangrikste, want dit is waar hulle hulle vaardighede leer.	Ek sal nooit vir hulle net sê.. okay dis 'n plus of minus som gaan doen dit nie.	.. hulle is kleiner groepies, hulle kan beter konsentreer.	..so jy moet waak teen al daai dinge. Jy moenie die kind negatief maak nie.. jy moet hom positief maak deur jou kommentaar en deur die manier hoe jy dit doen.	Dis mos om te dink om te dink. As ek dit reg onthou
<b>Lea</b>	..'n afleiding wat hy moet maak van woorde wat vir hom gegee word..	Presies wat ons nou doen. Volgens die vaardighede van elke kind.	..jy begin by wat die kinders reeds kan doen, die bestaande kennis moet jy dan weer gaan opdiep.. dan sê jy.. goed wanneer ons dit doen, onthou jy dit?	En so rustig en so logies moontlik sit jy daai goed vir die kinders uiteen, want hulle gaan vir jou so begin kyk en dan weet jy, jy het hulle totally verloor.	Weet jy ek dink selfvertroue is een van die belangrikste goed wat 'n kind moet hê, want as hulle bang is, gaan hulle nie waag nie en as hulle 'n probleem lees dan is dit.. ek kan nie, ek kan nie..	Nee, sê jy maar.. (lag!). O, heng...

Foundation Phase participant	Strategies Dimension				
	Mediation of metacognition			Differentiated Instruction in the mediational process	
	Mediation of metacognitive knowledge	Mediation of metacognitive regulation	Strategies to mediate metacognition	Differentiation of content, process and/or product	Differentiate to match learners' readiness, interests and/or learning profile
<b>Marli</b>	..ons sal die sommetjie nou deurlees en nou sal ek vra.. ek leer hulle hoe om te beplan.. waarom gaan die sommetjies?	Dan moet hulle vir my sê wat doen ek volgende?... ek leer hulle op 'n indirekte manier om hulle goeters te beplan, uit te voer en dan te evalueer. So dan doen hulle dit eintlik op die einde outomaties in hulle probleemoplossing...	.. uhm dis maar beplanning, maar ek dink jy moet kom op 'n plek waar jy eerder vrae vra as om te sê, want as jy vrae vra, dan begin die kind outomaties dink.	Die sterker kind sal ek moeiliker getalle gee en die swakker kind 'n meer basiese iets soos een en twee.. net wat hy kan verstaan	So dis eintlik maar net een van twee dinge, jy verstaan of jy verstaan nie, so ek gee vir jou 'n som wat jou bietjie meer uitdaag of ek begin by die begin, want jy kan nie in die middel lewers begin nie.
<b>Retha</b>	Wat belangrik is, is ook om dit op te breek.. die probleem wat jy vir die kind gee.. ek lees nooit net 'n probleem en sê vir die kind doen dit nie. Die probleem is altyd in stukkes opgebreek. Ek sal die stukkie lees en stop en sê.. kan jy nou al iets doen.. weet jy nou al iets.. vertel hierdie stukkie wat juffrou vir jou gelees het iets?	Goed teken vir my die motors. En dan sal hulle dalk net twee wiele teken.. dan sal ek sê.. goed dink gou as jy om julle motor stap.. hoe lyk julle motor? Dan sal hulle agterkom.. sodra hulle om die motor beweeg in hulle kop.. dan kom hulle agter.. oe juffrou ek het 'n fout gemaak.	.. hulle kry dan kans om te praat oor hoe het hulle by die antwoord uitgekome.	..die take moet.. jy moet gedifferensieerde take gee.. ek bedoel jy kan nie vir almal dieselfde werkie gee nie.	Dan het ek 'n seunsgroep en 'n dogtersgroep en dan uit hulle uit haal ek my swakker leerders en ek meng my derde groep. So dis 'n seunsgroep en 'n dogtersgroep wat dieselfde werk doen en dan het ek my swakker groep.
<b>Sue</b>	..moet ek bymekaartel.. moet ek wegneem nie. So daai begrippe toets mens redelik deur die probleemoplossing.	Ek gaan dan maar gewoonlik weer op die stappies terug. Sê nou maar daar het nou fout gekom by die antwoord, dan vat ek hom nou maar weer van vooraf en ons lees weer die vraag deur en dan sê.. soos ek weer sê ek sê vir hulle maak 'n prentjie in jou kop.	..ek sê ook vir hulle.. maak jou prentjie in jou kop van die storie wat jy nou gelees het. Wat is die probleem.. sien dit in jou kop.. visualiseer dit voordat jy dit gaan aanpak.	Waar jy dan nou weer met jou swakker kind gaan jy dan nou meer weer makliker taakkaarte gee en miskien in laer getalgebiede werk. Dieselfde probleem aanspreek, maar dan net in kleiner getalle werk.	.. daar is nie meer spesifiek groep een, twee en drie meer vir my nie. Dit is nou nogal 'n nuwe ding wat ek nou self agterkom wat dit vir my makliker maak en ek vorder vinniger en die kinders raak nie verveeld nie.
<b>Sonja</b>	So ons moet op 'n manier die kinders aan die probleme so blootstel dat jy half die kennis wat hulle alreeds opgedoen het, dat hulle dit kan identifiseer in die probleem en dat hulle die vrymoedigheid dan het om binne jou ruimte wat jy vir hulle gee dat hulle by die probleemoplossing kan uitkom sonder dat die onderwyser die een is wat sê teken dit nou so.	En om dan weer terug te gaan om te gaan kyk, maar het ek dit geteken wat hulle vir my gesê het waarmee ek begin het en is die antwoord dit wat hulle vra.	..hulle dit eintlik fisies kan wys met blokkies of met stokkies, uhm... kan hulle dan vir jou sê	Of ek sal die res van die groep gaan vandag met 'n taak aan en ek werk net met my individuele leerders, want jy het nie dan tyd vir groepeerwerk as sulks nie.	So die groepe is wel in vermoë om basiese telwerk en getalbegrip aan te leer, maar die nuwe begrippe vorm eintlik dan weer 'n groep op hulle eie.. afhange.. en dit is ook nie altyd dieselfde kinders nie... maar dis 'n ander groepeer kinders wat met voor en na sukkel, so hulle is weer 'n ander groepeer wat jy bymekaartrek.
<b>Amy</b>	Watse woorde kyk jy na in die som en dan as jy daai woorde sien.. okay.. nou moet jy 'n plus som doen..	..hulle kan baiekeer sien as hulle die antwoord het.. okay maar dit maak nie sin nie. Dan sal ons weer teruggaan met die stappe oor hoekom maak dit nie sin nie. Waar het jy daai fout begaan?	Dan sal ek gewoonlik die een kind wat sê hy het dit nou so en so gedoen.. en dan dat hy dit verduidelik. Partykeer verstaan hulle dit beter as 'n ander maat dit verduidelik.. uhm, want hulle werk mos in hulle eie terme en al sulke goeters.. uhm.. en dit help nogals..	Dan my sterker groepeer sal altyd eerste klaar wees. As ek nie vir hulle iets ekstra het om te doen nie.. hulle wil baie graag help en dit help vir hulle om langs 'n maatjie te gaan sit wat nog ver agter is en wat nog sukkel om dan met hulle te gaan sit en saam met hulle te werk.	Ek sal.. sê nou maar een kind het 'n vraag oor die spesifieke som en ek sien okay dit gaan nou vir almal bietjie trigger, dan sal ekke daai groepeer.. hulle is mos in groepeer opgedeel.. dan sal ek daai groepeer bymekaarkry...
<b>Lea</b>	.. wanneer ons begin.. doen ons DIT eerste. Hulle het dit nodig. Dan as jy dit nou klaar gedoen het, wat is die volgende stap? So ek sal dan vir hulle sê.. goed onthou wat was die eerste stap, wat sal ons daarna doen, wat volg dan.	Beplanning begin daar waar hy begin lees. So jy gaan hom dadelik begin lei.. kom ons lees dit, kom ons soek die sleutelwoord.	As die probleem klaar is, dan vergelyk hulle met mekaar.. en dan redeneer hulle met mekaar, maar hoekom is my som reg en joune verkeerd?	..weereens jou heel swakste kind, dan gee ek vir hulle 'n takie wat minder is, sodat dit nie so baie werk is soos die ander s'n nie, want dit maak hulle ook moedeloos as hulle so baie werk moet doen.	..ek maak 'n lys met die kinders se name. Hierdie kinders het met uitdeelsomme gesukkel, hierdie kon nie probleemoplossing doen nie, die kon nie dit doen nie

Foundation Phase participant	Context Dimension						
	Extrinsic influences on teachers' mediation				Intrinsic influences on teachers' mediation		
	Learners	Context of school	Professional collaboration	DBE	Teacher reflection	Teacher autonomy	Teacher's beliefs/ attitude
<b>Marli</b>	So ek dink dit is belangrik dat mens eintlik by die root uit te kom, hoekom die kind sukkel.	..maar ek weet net hier is baie goeie juffrouens by die skool, so ek weet dat die juffrouens alles in hulle vermoë sal doen om wel goeie resultate te kan kry, want dit reflekteer tog op hulle..	.. so ons doen die weekbeplanning saam en dan besluit jy self hoe jy dit in jou dag gaan inwerk.	Ek weet ons ANA's is baie maklik in graad een. Dis makliker as die assessering wat die departement stuur, so dis vir hulle so eenvoudig dat hulle goed doen.	So ek dink ek leer ken my kinders.. ek love hierdie groepe van vier, so ek sal nooit weer anders wil klas gee nie. Ek sal huil as ek dit nie mag doen nie.	So ek het my metode aangepas sodat dit vir my werk.	..ek geniet dit om nie in vermoë-groepe te werk nie.. So ek dink ek leer ken my kinders.. ek love hierdie groepe van vier, so ek sal nooit weer anders wil klas gee nie.
<b>Retha</b>	Ek bedoel 'n kind wat sukkel om hoër vlak denke toe te pas, hulle sukkel.. hulle kan nie.. jy kan op jou kop staan.. hulle sukkel met probleemoplossing	Ek dink getalbegrip-ontwikkeling van klein af.. stadig en sistematies deur getalbegrip gaan. Daar's so baie skole wat so vinnig deur getalbegrip gaan..	Weet jy hoe ondersteun ek as kinders sukkel ook? Ek sal ook nie net in die klas nie.. ek sal die ouers inkry.	En ook in daai departementele boeke is daar spesifieke plekke waar daar probleemoplossings in is, dan sal ons die blaai aanteken in ons beplanning en ons sal praat oor watter probleme ons gaan doen..	Dit het ek ook al geleer. Jy wil partykeer vir 'n kind dwing om dit so te dink, maar hy dink nie soos jy dink nie.	..ek weet almal werk nie so nie, maar ek werk so. My kinders is gewoonlik gebalanseerd.. seuns en dogters. En dan ek werk.. ek roep my seuns mat toe en ek roep my dogters mat toe.	Ek leer so baie by daai READ program, want weet jy al gee ek al so lank graad een.. daar's net 'n ander uitkyk vir 'n mens.. ek dink anders oor dinge en dis vir my lekker..So ek sien rêrig uit na hierdie nuwe wiskunde-ding ook..
<b>Sue</b>	Dit hang maar baie van die kinders se vaardighede ook af.	So met ander woorde ek het 'n baie sterk eerste groep.. uhm.. maar my tweede groep is half op hulle stert.. hulle is ook nogal baie oulik en dan het ek so twee of drie kinders wat werklik nog sukkel	.. jislaaik, maar ek het nog nooit so daaraan gedink nie. Deur saam te werk en die goed te bespreek maak dit die goed duideliker en maak dit meer jou eie dan.	.. ek is meer bereid om daai boek te gebruik, want ek weet ek moet dit vir my kind ook gee, want die ANA's is daarop gebaseer.	So dis nie net vir my om die kind te toets nie, maar om jousef ook.. hoe deeglik jy dit.. of hoe verstaanbaar jy dit vir die kinders verduidelik het.	Dit word in ons weeklikse graad-beplanning besluit en dan kan jy dit in jou dae indeel soos dit vir jou pas en soos dit vir jou klas ook nodig is.	..maar ek dink waar mens se liefde ook maar lê.. ek hou van wiskunde gee.. so dan trek jy die kinders ook half bietjie op
<b>Sonja</b>	..kinders te help wat nie 'n natuurlike insig in wiskunde het nie..	..maar ons het nog altyd 'n ongelooflike wenresep gehad, vandat ek by die skool gekom het en dit is nou 25 jaar.		Dit voel vir my met CAPS beweeg die getalgebied te vinnig..	..die vrymoedigheid het om dit uit 'n sommetjie uit te haal.. uit 'n woordsom uit te haal en dan daai begrippe so bymekaar te sit en toe te pas. Dis is nogal vir my elke jaar 'n wow!	Ons is nie so deeglik en stadig in 'n getalgebied soos wat ek persoonlik voel dit moet wees nie	So ek dink nogal dit wat ons nog al die jare gedoen het, het eintlik aanleiding gegee tot die wiskunde wat eintlik op 'n baie hoë vlak is.
<b>Amy</b>	Uhm.. ek het kinders wat omtrent nooit nodig het om vir my iets te kom vra nie, maar wat meer wil gestimuleer word, hulle is verveeld met dit wat hulle doen, hulle wil meer gestimuleer word.	.. ek kan in die nuwe kind se boeke sien aan die manier hoe dinge gedoen is en hoe ons goed doen. Ek kan dit ook maar so gaan doen, maar dis net nie vir my aanvaarbaar nie.	..dit help my baie om 'n klas assistent te hê, want ek gebruik haar spesifiek net vir wiskunde..	..ja so dit is eintlik waarop die CAPS dan nou fokus as jy dit basies so kan sê.. 'n society wat nie so hard hoef te dink nie.	..hoe kry ek dit in hulle koppies op die manier wat ek nou dink.. Doen ek dit reg? Of hulle dit reg verstaan.	Ek dink dis meer op 'n persoon gerig as op enigiets wat dokumente vir jou kan sê. Uhm.. dit hang van die onderwyser se individualiteit af.	..dit hang ook maar af van die attitude van die juffrou.. Uhm.. dit hang van die onderwyser se individualiteit af. Maar dan kan jy ook sê daar is individualiteit wat kom van dryf af..
<b>Lea</b>	..dan sit jy met jou swakste kind wat jy absoluut konkreet mee moet werk en elke stap moet verduidelik en elke dingetjie vir hom moet leer.	Ons het groepsonderrig, so ons werk met ons vaardigheids-groepe so ons weet presies watter kinders waarmee sukkel om dit aan te spreek.	Dan bespreek ons ook die probleem hoe ons dit ook vir die kinders gaan aanleer, want partykeer raak jou idees net op en dan weet jy nie verder nie.. so ons ondersteun mekaar en ons dra dit basies deur na die kinders toe.	Met CAPS het hulle vir ons gesê met ons opleiding ..dat jy 20 minute 'n nuwe begrip klassikaal vir die kinders moet aanleer.. toe het ek vir hulle so gesit en geluister en gedink.. doen jy dit maar!	En dan gaan dink jy die middag, maar hoe gaan ek nou dit vir die kinders op 'n makliker manier verduidelik?	.. dan sit ek maar daai tydjie die dag by die groep by. So as my eerste groep 'n nuwe begrip moet doen, dan vat ons daai 20 minute by hulle mat-tyd dan het hulle nou 30 of 40 minute op die mat. Waar die ander dan nou vyftien, vyftien is.	.. uhm ek gaan sit sommer plat op die mat by hulle en dan begin ons konkreet werk.