FACTORS INFLUENCING THE IMPLEMENTATION OF MATHEMATICAL WORD PROBLEMS IN FOUNDATION PHASE CLASSROOMS: THEORY AND PRACTICE

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FACTORS INFLUENCING THE IMPLEMENTATION OF MATHEMATICAL WORD PROBLEMS IN FOUNDATION PHASE CLASSROOMS: THEORY AND PRACTICE

by

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ABSTRACT

This treatise investigated mathematical word problems (MWPs) and their implementation in Foundation Phase classrooms. Factors influencing the implementation of MWPs, with specific reference to the teachers and learners involved, emerged. Direct and indirect factors influencing the implementation of MWPs were acknowledged. Student teachers' reflections on classroom practices experienced during their teaching practice training period for their initial teaching qualification inspired me as lecturer to embark on my own journey of inquiry and study the phenomenon above.

As this study was undertaken in South Africa, the need arose to take into consideration the changes that have occurred since 1994. Observations of how democratic values and desires feature, or do not feature, when engaging with the phenomenon had to be considered. This study also aimed to emphasise inequalities in everyday practice. The discovery of "good practice" (Cooper 2010:170) contributed towards addressing the factors that emerged as influencing the implementation of MWPs.

Jansen's (2009:170) book *Knowledge in the blood* presents compelling reasons for disclosing the state of current practice and seeks alternatives to promote the required change in mathematics teaching, with one of the perspectives on mathematics education being the emphasis on implementing MWPs in the Foundation Phase. Teachers often extend their own preferences into practice and emphasise their "knowledge in the blood" as their view of good practice. Learners' needs and learner diversity are often overlooked. Learners' assessment scores, both nationally and internationally, have revealed more negative facts. These low scores have often been, and often still are, news flashes, contributing to a negative view of teachers and education. In order to address the widespread sentiment that there is "no hope for teachers" (Jansen 2011:19), and to avoid a recycling of negativity, "good practice" (Cooper 2010:170) is key to success. This study aimed to discover *hope for teachers and learners*.

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TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

CHAPTER 2

LITERATURE STUDY

CHAPTER 4

RESULTS

ABBREVIATIONS

CAPS	Curriculum and Assessment Policy Statement
DBE	Department of Basic Education
DoE	Department of Education
MNP	Mathematical number problem
MWP	Mathematical word problem
MWPs	Mathematical word problems
NCS	National Curriculum Statement
NCTM	National Council for Teachers of Mathematics
NLG	New London Group
NMMU	Nelson Mandela Metropolotan University
RNCS	Revised National Curriculum Statement

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION AND ORIENTATION

South African public school Grade 8 learners scored the lowest in the 2003 Trends in International Mathematics and Science Study (TIMSS) assessment. Although the focus was not on Foundation Phase learners, the concern is that learners in South Africa seem to struggle to perform in mathematics. These low scores are a continuation of the poor scores obtained in 1995 and 1999 (Howie 2001:3). This daunting news raises concerns about the sustainable *quality* of primary schooling. TIMSS focuses on the content domain[1] and the cognitive domain[2] (including mathematical word problems) in mathematics (Reddy 2006:x-xi).

The 2003 National Report on Systemic Evaluation revealed similar shocking mathematics results among South African Grade 3 learners. This assessment was conducted to determine the progress of post-1994 transformational goals (that is, access, redress, equity, and quality). The results cast doubt on the degree of progress achieved with respect to the goals of equity and quality (DoE 2003b:viii, 69). Continuous national assessments, which all include mathematical word problems, in 2007 and 2011 (DBE 2011b) reiterated the findings of poor results in foundation phase numeracy and literacy.

These continuous announcements of negative news on low scores demolish the hope that South African teachers need in order to enhance learner performance. As Jansen (2011:19) asks, “What purpose does it serve to say the obvious[3] over and over again?” Jansen recommends improvements in the training and support of teachers. Jansen also mentions the need “to overcome knowledge deficits in mathematics”. His views tie in with my concerns about school mathematics.

[1] The content domain encompasses numbers, algebra, measurement, geometry, and data.
[2] The cognitive domain encompasses knowledge of facts and procedures, the use of concepts, the solving of routine problems, and reasoning.
[3] Jansen’s refers to South African learners’ “obvious” low scoring and the unnesseary repeating of the same (and “obvious”) information / news.

The habitual poor performance in mathematics by foundation phase learners caught my attention. My research project attempts to focus on mathematical word problems (MWPs) as one aspect that I predict contributes to this deficient learner performance in mathematics and numeracy.

Constant changes in mathematics education, the mentioned assessments, negative research and media reports[4], and positive research and literature contributions require investigation. Change can influence teachers and classroom practice in various ways (Reddy 2006:78). Although educational change is no easy task, and it is complex, it remains a necessity. According to many diverse stakeholders, educational change is necessary (Hargreaves 2000:283). The South African government and the Department of Education (DoE), renamed the Department of Basic Education (DBE), disclose the need to improve basic education (DBE 2011a:4; DBE 2011b:8; News24 2010a[5]).

1.2 THE CONTEXT

1.2.1 The real-life context

Mathematics is a reality in everyday life situations. Mathematical knowledge and problem-solving skills are a necessity to cope successfully in personal and occupational situations, including unfamiliar situations (Mullis, Martin, Ruddock, O'Sullivan & Preuscho 2009:I, 7; NCTM 2000:50-52; Rohlen & LeTendre 1996:1; Nonaka 1994:14). Dewey[6] asserts that "education is not preparation for life, [but] education is life itself" (Feldman & McPhee 2008:29). Therefore, schooling needs to open doors for effective acquisition of mathematical requirements by appropriate progression on learners' lifelong journey of active learning and maturing to become good problem solvers (Pelech & Pieper 2010:14; DoE 2008:1; Christie 2008:41;

[4] Several negative headlines reveal a crisis in SA education, for example, *Education in crisis* (news24 2008a), *SA in literacy, numeracy crisis* (news24 2008b), *Literacy, maths shocker in SA* (news24 2009), *Teachers fail school tests* (news24 2010b), and *SA bottom of African literacy list* (fin24 2010).

[5] Government realises that "we are at a point in [SA], politically and otherwise, where there is huge consensus that we face a crisis in basic education that requires urgent remediation".

[6] Read more about Dewey in Dewey, J. 1916/1980. Democracy and education. In J.A. Boyston (ed.). *John Dewey: the middle works, 9.* Carbondale: University of South Illinois Press. (The book could not be located for this study.)

Monroe & Panchyshyn 2005:27; Kamii[7] 2000:ix; Beesey & Davie 1991:20). MWPs can bridge classroom mathematics with real-life situations (Monroe & Panchyshyn 2005:27).

Japanese learners are consistently amongst the most successful scorers in TIMSS (Reddy 2006:10). Nonaka (1994:14), a Japanese business researcher, reports on the importance of problem-solving skills in the unrestricted environments of life and business. Several of the cited everyday life mathematical problems occur as MWPs. Both routine and non-routine problems feature, demanding of problem solvers to process information and reveal a positive problem-solving attitude. In acknowledging this life need, Japanese schooling approaches mathematics education from a problem-centred perspective, with the emphasis on the processes used, and not only the final solution (Lee, Graham & Stevenson 1996:173-174).

As people communicate, receive instructions, and are faced with written text, language also contributes to the complex everyday life mathematical situations. Therefore, the connection between mathematics and language needs to be recognised (Vilenius-Tuohimaa, Aunola & Nurmi 2008:409-426).

The term “(mathematical) word problems”, or “story sums”, often creates feelings of fear and anxiety. Fear of MWPs exists among adults, including teachers. These negative thoughts and feelings are passed on to learners in the teaching and learning process (Monroe & Panchyshyn[8] 2005:27; Hansen 2005:65). Jansen (2009:170) refers to “knowledge in the blood”[9]. To Jansen it means “knowledge embedded in the emotional, psychic, spiritual, social, economic, political, and psychological lives of a community”.

With all the above-mentioned fears and anxieties in mind, Emerson’s assertion “the great teacher makes hard things easy” (Feldman & McPhee 2008:46) needs exploring in the context of MWPs in the classroom. In my study I will interpret “the great teacher” in three different ways, namely the higher education institution (HEI)

[7] Kamii (2000:ix) adapted her views of 1985 by adding MWPs to mathematics teching and learning classroom activities. Previously she excluded MWPs to feature in line wth basic mathematics.

[8] “Word problems! The mere mention of them strikes a chord of dread and loathing in the hearts of many adults – including a sizable number of elementary school teachers…” is an interesting article to read in this regard.

[9] The Irish poet Macdara Wood is the author of this term. Jansen obtained permission to use this term as the title of his book.

lecturer (as teacher-educator and researcher), the student teacher (as HEI student exploring theory and practice during teaching practice opportunities), and the qualified school-based teacher. Such knowledge in the blood is "habitual" and challenging to change or adjust (Jansen 2009:171).

HEI research initiatives (1988) have contributed positive results of foundation phase learners solving various types of MWPs successfully. The Stellenbosch researchers Murray, Olivier and Human (1998:169) posed more complex MWPs, based on familiar learner-related contexts, to foundation phase learners in the Western Cape, South Africa. A learner-centred constructivist approach was implemented. Their contribution resulted in international recognition and inspired similar research projects abroad (Kamii 2000:x).

1.2.2 Personal professional context

Initially I qualified as an foundation phase teacher and have several years of classroom practice experience. My active involvement as HEI lecturer in foundation phase teacher education[10] and special needs education[11] has increased my concerns about teaching and learning mathematics and numeracy in South African classrooms. I lecture both foundation phase mathematics subject content and the methodology of numeracy/mathematics. It is alarming to witness the low scores of several student teachers and in-service teachers in doing mathematics and solving MWPs. Their occasional immature handling of mathematical support materials and their struggle to plan mathematically coherent problem-based lesson plans using constructivist and connectivist approaches add to the concerns. However, some student teachers do attempt to implement the mentioned approaches in more coherent lesson plans during their teaching practice experiences. I have had the opportunity to witness their attempts and successes during teaching practice assessments, or to receive their reflective feedback. It is especially rewarding when student teachers reflect on their discovery of underestimated learner potential to solve MWPs when multiple opportunities are created in lessons.

[10] BEd (Foundation Phase) as an initial qualification and BEd (Foundation Phase) as an upgrade qualification in the late 1990s and early 2000s (when it was offered).
[11] I have an Advanced Certificate in Education: Special Needs Education (ACE: SNE).

The constant disturbing reports of holistically viewed low scores in mathematics by South Africa learners, and my knowledge that this is not a true reflection of all foundation phase teachers and the learners in their classrooms, added to my concerns and questions.

My personal teaching philosophy is that the young child's home-based learning requires recognition when he or she starts school. It needs to serve as a contextual frame of reference on which I as a teacher base my mathematics concept development of numbers, and MWPs. I believe that all learners can learn mathematics, that all learners deserve equal opportunity, and that all learners can achieve some level of success. However, I also acknowledge diversity and realise that learners have their own individual aptitude, which requires respect and nurturing.

I have personally experienced the late 1980s/early 1990s renewal of thought about mathematics education in classroom practice. This new balanced perspective on number facts and problem solving, especially the new role of MWPs in daily problem-based lessons, has been inspiring and a relief to me. Making changes to daily planning and teaching was challenging in the sense that I had to redo and adapt my comfort zone of well-established years of plans, often recycled from one year to the next. I also had to make additional activity cards and worksheets, reflecting the changed approach. This was time-consuming and a lot of work. However, reflecting on my learners' positive responses, it was worth all the extra work. Therefore, I feel comfortable motivating student teachers and teachers that efforts to change and make adaptations to enhance teaching and learning are worthwhile and ultimately rewarding.

1.2.3 Teaching practice experiences

An integral part of the Bachelor in Education (Foundation Phase) qualification is teaching practice. These teaching practice experiences occur in natural settings, namely foundation phase classrooms at schools. The student teachers have the opportunity to observe qualified teachers' actions in practice and their interactions with their learners.

The student teachers are also granted the opportunity to apply their theoretical knowledge in practice. Through these experiences, connected with their own beliefs and discoveries, the student teachers can develop their own teaching philosophy.

1.2.4 The South African context

It is a well-known fact that South Africa underwent a dynamic political change in 1994. The Constitution promotes a democratic environment. Curriculum 2005 (C2005), which was initiated in 1998 as the first coherent National Curriculum Statement (NCS) for school, brought about drastic changes for the implementation of the curriculum in the classroom. C2005 was adapted to the Revised NCS (RNCS 2002), and then to the Curriculum and Assessment Policy Statement (CAPS 2011). All these changes have had, and will continue to have, various effects on teachers and teaching practice. Classrooms have to reflect democratic skills, attitudes and values, to contribute positively to life beyond the classroom and school.

Although the NCS Mathematics document (DoE 2002b:8) reveals the inclusion of MWPs in the school curriculum, and thus requires mathematics teaching and learning opportunities, the mentioned mathematics assessments (which all include MWPs) indicate consistently low scores.

Critical outcomes and developmental outcomes, inspired by the Constitution, and designed for development in a democratic process, are general outcomes which school education is striving towards. Several critical outcomes (COs)[12] and developmental outcomes (DOs)[13] explicitly refer to problem solving (which includes MWPs, although they are not referred to as such). Therefore, problem-solving skills development is essential, and needs to be a critical part of implementation of the RNCS (DoE 2003a:58; DoE 2002c:1-2).

The RNCS was the curriculum that was being implemented at the time that this study was in progress and at the time that it was completed.

[12] Critical Outcome 1 (CO1) states "Identify and solve numerical-type problems and make decisions using critical and creative thinking". CO2 states "Work effectively with other learners while solving problems, doing numerical investigations and engaging in a variety of practical activities as members of a team or group". CO7 states "Demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation".

[13] Developmental Outcome 1 (DO1) states "Explore a variety of strategies to learn more effectively by appreciating that there is more than one correct way to solve a problem or to describe a problem situation".

A comparative study between the teaching and learning of mathematics in Japan and the USA was conducted in 1996 (Lee, Graham & Stevenson 1996). This study revealed interesting information, which can be learned from, especially since Japan was one of the top-scoring countries in the 2003 TIMSS. It would appear that both the USA and South Africa have surprisingly good policy, curricula and informational documents, but lack quality implementation.

1.3 JUSTIFICATION FOR THE STUDY

Stellenbosch researchers have identified, as mentioned in 1.2.1, the MWP-solving abilities that foundation phase learners possess (Murray, Olivier & Human 1998:169; Fraser, Murray, Hayward & Erwin 2004:26-27). These learners' positive results have been recognised and supported internationally (Kamii 2000:x). The history of low mathematics and MWP-solving scores triggers the thinking that these teachers' captured pedagogical theory had little significant impact on their teaching practice.

The 2003 TIMSS report (Reddy 2006:78) reflects and acknowledges the various changes that teachers have been confronted with in post-1994 South Africa, their grappling with these changes, and the resulting frustration and anxiety. These changes have had an enormous impact on classroom practice. The DoE communicated the changes via policies and teacher guides. Accompanying the DoE workshops were information sessions rather than training sessions. All the DoE changes, initiated by the political changes, did not register any successes, according to international and national assessments. Besides this, there were messages from various academics and the media of predicted failure. Several teachers reverted to the content that they were familiar and comfortable with and taught *that* content in their classrooms, thereby creating the impression that they could be ignoring the changes made to the South Africa curriculum.

The learning area of Mathematics, as core learning area to the Numeracy learning programme, is quite different from the previous NCS version. The intended implementation also differs to what teachers have been used to before the C2005 was initiated and implemented. This change requires an alternative approach in classrooms. It appears as if several teachers have not yet changed or adapted their classroom practice to suit the latest curriculum and current envisaged society. As much as the latter reflects on the whole curriculum, as well as on general teaching and learning, it also includes mathematics teaching, and therefore MWPs. Therefore, the following question posed by Charlie Brown, a character in the *Peanuts* cartoon holds significance: “How can you do new math with an old math mind?” (as quoted by Feldman & McPhee 2008:93).

Analysing and understanding the RNCS learning area of Mathematics (the core learning area of the Numeracy learning programme) has furthermore created confusion for teachers. The TIMSS report indicates that the Mathematics RNCS document places much less (direct) emphasis on basic knowledge and skills, the understanding of mathematical concepts and principles, and mathematical reasoning, than do the curricula of performing countries. The evident emphasis of the South African mathematics curriculum is the application of mathematics in real-life situations, communicating mathematically, the integration of mathematics in other learning areas, and teaching mathematics from a cultural perspective (Reddy 2006:82-84).

The mentioned changed views regarding mathematics education, both internationally and by Stellenbosch researchers, practice-based reflections of Initial Teacher Education student teachers, and an analysis of the current state of education in South Africa and curriculum policy documents have contributed to the emerging research question of my study. The intention of this study is to collate international and national views regarding the teaching and learning of mathematics from a problem-centred perspective, in an attempt to suggest ways in which the understanding of the teaching of MWPs can be improved. In order to have a more holistic view on this matter, some of the challenges with regard to the teaching and learning of mathematics will be researched and identified, and suggestions will be made to address these challenges.

1.4 THE PURPOSE OF THE STUDY

Observed from a general perspective, conducting a study is a way of learning. A study of this nature incorporates three purposes, namely an institutional purpose, a personal purpose, and a communicative purpose (Glatthorn & Joyner 2005:4).

1.4.1 An institutional purpose

HEIs contribute to academic disciplines in various ways (Glatthorn & Joyner 2005:4). One way is to assist students to complete higher degrees. This study is an example of an institutional requirement to expand knowledge and qualifications. This treatise aims to interrogate some data regarding certain factors that influence the implementation of MWPs in foundation phase classrooms. The study also attempts to design a framework for "good practice" (Cooper 2010:170) for teacher education regarding the topic at this institution, and it envisages assisting student teachers in gaining an in-depth understanding of how the implementation of MWPs can fit into and can contribute to holistic mathematics education in foundation phase classrooms.

1.4.2 A personal purpose

In order to determine what I know, what I want to know, and what I can do to enhance my own knowledge regarding the topic I selected, a research study can contribute towards this personal goal (Glatthorn & Joyner 2005:4). Despite the desire to earn the degree in question, my topic has multiple values, namely to enhance my personal theoretical and practical knowledge, to determine what my student teachers experience in this regard, to observe practice personally, and then to combine or connect these multiple perspectives in an attempt to determine a more holistic truth. The study will furthermore assist me as lecturer to enhance the quality of my own lecturing, in order to assist student teachers in implementing MWPs in foundation phase classrooms. In the same breath, I also anticipate that as lecturer I can connect the theory and practice more effectively, and narrow the gap between these two entities. The power of expressing thoughts and knowledge in writing assists one to truly discover what one actually knows and understands (Glatthorn & Joyner 2005:4). This kind of learning will promote one's personal and professional knowledge. Feldman and McPhee (2008:53) concur, by using the words of Deming: “You don’t just learn knowledge; you have to create it [...] get in the driver’s seat, don’t just be a passenger [...] you have to contribute to it, or you don’t understand it.”

1.4.3 A communicative purpose

The purpose for communicating the results obtained from the study could vary. The immediate impact will be on student teachers whom I teach and assess. A broader impact will possibly be on academics, who can use the study for further studies and/or research. As lifelong learners, teachers can expand their knowledge by reading the study. Communication of the study will contribute not only to teachers in South Africa, but will also enable any academics or teachers to be more in touch with global knowledge. As my study is comparing South Africa knowledge with global knowledge, with the intention of enhancing South Africa learners’ success with MWPs in the classroom, and in life generally, the communicative purpose also has the responsibility of supporting.

It is essential to take note that a connection between these three kinds of purposes is necessary to design a more holistic message (Glatthorn & Joyner 2005:4).

1.5 RESEARCH QUESTION AND SUB-QUESTIONS

Following from the above, the main question of this study can be stated as follows:

> **Which factors influence the implementation of mathematical word problems in Foundation Phase classrooms?**

The following sub-questions emerge from the main research question:

- What challenges, if any, are encountered in the teaching or implementation of mathematical word problems?
- What challenges, if any, accompany the learning of how to solve these problems?
- How can the discovered challenges, if any, be addressed?

1.6 DELINEATION OF THE STUDY

This study investigates the implementation of MWPs in foundation phase classrooms from a theoretical and a practical perspective in an attempt to reveal a more holistic picture from the sample selected for the data collection. The intention is to identify factors that influence this implementation. For quite a number of years, student teachers were requested to provide written reflections on the implementation of MWPs in the classrooms that they had visited for their experiential teaching practice. The data reveal the student teachers' views on the implementation of MWPs.

In order to reveal a larger "truth", I gathered data by means of classroom observations in participating schools. Some foundation phase teachers and their learners participated by continuing their everyday engagement with mathematics/numeracy in their natural learning situations.

For validity reasons, an independent observer accompanied me to the classroom observations. As Glatthorn and Joyner (2005:45) state, "observations are made to determine what is occurring and what individuals are doing".

1.7 DEFINITIONS AND EXPLANATIONS OF TERMS

1.7.1 Mathematical word problems

The complexity of the term "mathematical word problems" cannot be ignored. At face value, it seems to belong to the discipline of mathematics. This is true, as the main focus of the MWP is mathematics, but one cannot ignore the fact that there is a strong language component within which the mathematics is embedded. Tucker, Singleton and Weaver (2002:132) view word problems as "a bunch of words" which needs to be converted "into a situation".

Bogomolny (1996-2008) characterise word problems, or story problems, as "a first glimpse into how mathematics is used in the real world". The solving of word problems requires a translation into "the language of mathematics, where we use symbols for numbers – known or unknown – and for mathematical operations". Monroe and Panchyshyn (2005:27) describe MWPs as follows: "[W]e encounter real problems that must be described with words and numbers – i.e. word problems – and we must structure them and make meaning for ourselves."

Verschaffel, Greer and De Corte (2000:ix) draw on the views of Semadeni (1995) that "it is not simple to provide a precise and complete definition of 'word problem'". Verschaffel, et al. (2000:ix) define word problems as follows [italics mine]:

> Word problems can be defined as verbal descriptions of problem situations wherein one or more questions are raised about the answer which can be obtained by *the application of mathematical operations to numerical data available in the problem statement*. In their most typical form, word problems take the form of brief texts describing the essentials of some situation *wherein some quantities are explicitly given and some are* not, and wherein *the solver […] is required* to give a numerical answer to a specific question by making explicit and exclusive use of quantities given *in the text and mathematical relationships between those quantities inferred from the text.*

The above definition contains a characteristic feature "in the use of words to describe a (usually hypothetical) situation". The selection of the "appropriate operation to find the unknown element contained in the situation" is the outcome that a problem solver anticipates achieving (De Corte & Verschaffel 1985:363-381).

Beesey and Davie (1991:24) recommend using a problem in context. A context allows children to learn in a real situation, rather than providing them with a whole lot of isolated skills and expecting them to transfer these skills to a problem. These *problems in context* can be used in verbal or written format, for example:

> Henru wins 4 marbles in a game and now has 9 marbles. How many marbles did he have before the game?
>
> or
>
> Valmarie has 9 dolls. Her friend has 4 dolls. How many more dolls does Valmarie have than her friend?

These are examples of a mathematical word problem (a problem in context). To solve these MWPs, the abstract mode 4 + 9 = 13 will be executed. When 9 + 4 = ___ is presented to learners to solve in isolation of a context, it is not a word problem, based on the ideas of Verschaffel, et al. (2000:ix). When lecturing, I refer to the latter calculation as a "mathematical number problem (MNP)".

MWPs are also referred to as "stories" in mathematics. Lomofsky, in Engelbrecht, et al. (1999:93), also promotes the use of stories when teaching problem solving. As stated, "Use stories that are of interest to the learners and within their field of experience."

Taking into account what various descriptions of MWPs disclose, MWPs can be described as everyday contextual occurrences, which include explicit or hidden mathematical problems, which are communicated as stories or descriptions in words, with the intention that the receivers are required to make sense of the language and solve the embedded mathematical problems, with the intention to answer the MWP question.

1.7.2 Foundation Phase

The current school system in South Africa consists of four phases, with the foundation phase being the first phase. The foundation phase includes Grades R, 1, 2 and 3. These learners are normally in the range of 5 to 10 years of age. The learners can enter the formal school system in one of two ways, that is, they can start Grade R in the year that they turn 6 years of age, or they can start their schooling at Grade 1, as Grade R is not yet compulsory[14] (Harris 2004:7). This study will focus on the formal foundation phase grades, namely Grades 1, 2 and 3.

1.7.3 Student teachers

The term “student teachers” refers to the students at our HEI who are receiving their initial teaching qualification. Although these students are also ‘learners’, and are referred to as ‘learners’ in the Policy Handbook for Educators (Brunton 2003:A-47), the term “student teachers” is used for the purposes of this study, to differentiate between the different kinds of learners featuring in this study.

1.7.4 Numeracy, and Mathematics

For the purposes of this study, the terms “Numeracy” and “Mathematics” are in line with the understanding as communicated by means of the NCS Mathematics policy curriculum document. Numeracy refers to the learning programme, and Mathematics refers to the learning area, as contained in the RNCS policy. With CAPS, only the term “Mathematics” remains as the name of the subject.

[14] As all schools do not have the necessary facilities to offer Gr R, this is still the case in 2012.

1.8 RESEARCH FRAMEWORK

Chapter 2 provides an overview of the literature studied to gain insight and understanding into the teaching and learning of MWPs in South Africa and abroad. Specific attention is given to mathematics education, how children learn, and the influence of problem solving, with explicit reference to MWPs. A disconnected approach needs to be avoided. Therefore it is necessary to draw from more general literature, in order to gain a more holistic insight. Furthermore, attention is given to the context in South Africa, influenced by post-1994 changes in society, the need for a changed education system to suit this society, and paper evidence of policies and supportive documentation which directly and indirectly influence the topic of this study.

In Chapter 3, I elaborate on the research framework that this study is based on. An overview of the research paradigm and aspects of the qualitative research approach are explained. In addition, this chapter focuses on the data-collection strategies and the data-analysis methods utilised.

Chapter 4 presents the results. It also serves as a presentation of the interpretation of the findings in terms of the focus of this study.

The insights and conclusions of the research findings, as well as recommendations, are discussed and explained in Chapter 5.

CHAPTER 2

LITERATURE STUDY

2.1 INTRODUCTION

Change is a constant of life, as we frequently experience a changing world, and we ought to change with it (Obama 2009:3; Houston & Clift 1990:212). Competing perspectives and controlling influences pressing for change are intellectually, educationally, ideologically, socially, politically, historically and/or technologically driven (Siemens & Tittenberger 2009:5; Noyes 2007:vii; Hargreaves 2000:283). During the 1980s, global and local perspectives concerning school mathematics and problem solving (including MWPs) changed and/or were adapted. These changes opened doors to purposeful renewed education (Christie 2008:41; Van Wyk & Mothata 1998:5; Murray, Olivier & Human 1998:169).

Despite opportunities to improve mathematics schooling, research data consistently reflect generally poor performance in mathematics, and even lower scores in solving MWPs. Intertwined conditions contributing to the complexity of the situation which teachers and learners encounter have been identified. Several research reports communicate expectations and recommendations to improve mathematics education (Wetzel 2008:1; Reddy 2006:78; Van de Walle 2004:150). These recommendations cannot be ignored, and require synchronisation with the expectations of education policies.

In this chapter, I review literature, as this remains a necessity to determine diverse theoretical and practical influences, triggering a rethinking of mathematics and MWP teaching and learning, while creating connections with general education philosophies. Due to the two-way flow of information between teaching and learning, a complete separation of the two activities is not possible. Emerging sections in this chapter focus, firstly, on teaching, and then on learning, with cross-referencing where applicable, as teaching involves learning, and vice versa.

2.2 CHALLENGES WITH RESPECT TO THE TEACHING OF MWPs

Mathematics teachers are confronted with complex and multifaceted challenges in general, and in mathematics and MWP-specific education, in particular, influencing their teaching and their degree of success. Several of these challenges are dealt with in this research. This limited study does not imply that any challenges that have not been included are any less important.

2.2.1 Multiple changes in South Africa since 1994

Various changes have had an impact on classroom practice in post-1994 South Africa and need to be acknowledged. For the purposes of this study, I chose to focus on factors that influence the implementation of MWPs, embedded in mathematics teaching and learning, in some foundation phase classrooms in South Africa.

2.2.1.1 Political transformation

Political transformation has triggered educational change. The general imbalances in education, the unequal learning context prior to 1994, and the barriers to teaching and learning required rectification (Christie 2008:41; DoE 2002a:1). Rectification of the pre-1994 system is incorporated not only in the Constitution, but also in several curriculum reform initiatives.

The Constitution of South Africa (Act 108 of 1996) implies a democratic educational framework, reflecting both social and liberal democracy (Coleman 2003a:131; Steyn 2001:26; Steyn, Du Plessis & De Klerk 1999:6-12). Social democracy includes equality, and liberal democracy refers to reconciliation of quality and freedom.

Schools are social constructions, developed for educating society's youth and addressing society's needs. Domestic needs are voiced in the general outcomes in the versions of the NCS, namely the critical outcomes and the developmental outcomes in the RNCS, and the principles in CAPS (DBE 2010:2; Christie 2008:13; DoE 2003b:1; DoE 2002a:1; DoE 2002c:1).

An example of the connection between the Government's requirements and the policy instruction to schools and teachers (communicated in the curriculum) is the stated need to develop good problem solvers in various contexts. Teachers are also challenged to prepare learners to develop as democratic citizens in local communities and to be sensitive to global imperatives (DBE 2010a:2; Christie 2008:13; DoE 2003b:1; DoE 2002a:1; DoE 2002c:1). Government's message includes the requirement that problem-solving skills be taught from the Foundation Phase (DBE 2010a:3; DoE 2002a:1). This latter, although viewed as one aspect of the whole situation, indicates the relationship between the political changes and the accompanying curriculum changes.

2.2.1.2 Curriculum changes

A series of NCS editions (C2005 implemented from 1998; RNCS implemented in 2002; CAPS initiated in 2010, but implemented from 2012) has emerged, which has strived to improve the quality of basic education[15]. C2005 confronted teachers to transform their traditional content-based approach to Outcomes-Based Education (OBE) for a modern classroom practice reflecting social justice and the democratic principles of *access*, *redress*, *equity*, and *quality* (DoE 2003b:viii; DoE 2003b:100; Coleman 2003a:131; Pretorius 1998:v; Van Wyk & Mothata 1998:4; DoE 1995:14-16). OBE required teachers to create multiple learner-centred and inquiry-based cooperative learning experiences through group engagement and teamwork, while reducing pure rote learning. OBE learning opportunities promote critical thinking, reasoning, active and reflective responses, an integration and expansion of knowledge across the curriculum, connections to real-life situations, as well as the collection and organisation of data. At the same time, learners can enhance confidence and attitudes through taking ownership of their learning. It is essential for teachers to differentiate between their various roles at different times during their daily engagement with learners (Bhengu 1997:4).

The NCS consequently offered teachers greater flexibility in choosing what, where, when, how, and at what pace to teach. However, the very freedom that the NCS provided became a criticism of C2005, due to the radical changes to the curriculum, which involved enormous practice changes in the classroom. When teachers are comfortable in their daily practice, an inherent resistance to change

[15] The 2011a ANA report and guidelines continue to communicate this need and undertake to strive to improve the quality of education.

contributes to the complexities they are experiencing. Therefore several teachers reverted to the content and teaching approach[16] that they were familiar and comfortable with, creating the impression that they were ignoring C2005 and OBE (Reddy 2006:79).

The above-mentioned changes require knowledge of certain principles of pedagogy (Cochran-Smith 2004:65). Teachers therefore continually need to invest time in adjusting their curriculum knowledge and understanding, fine-tuning their current practice to accommodate and integrate constant change within a more *democratic framework* (Reddy 2006:76-111; Coleman 2003a:131).

2.2.1.3 Initiators of change

Role players at schools, the DoE, and HEIs experience the implementation of a changing school curriculum in diverse ways. Teachers ought to be comfortable with and confident in their abilities to implement change, while acquiring and maintaining a positive attitude towards these changes (Henson 1998:15-16). However, design agents of change often neglect the reality of varied acceptance and experience, negative emotions, concerns, fears, dissatisfaction, and suspicion which teachers as implementers experience regarding change (Pretorius 1998:v). Although expectations exist that schools will engage in continual renewal and improvement, the system tends to maintain the status quo. Several authors have identified the traditional manner in which schools have been organised, the way teachers have been trained, the way the hierarchy operates, and the way political decision-makers treat educators as causes of lack of success (Christie 2008:13; Henson 1998:244; Fullan & Stiegelbauer 1991:12).

2.2.2 Poor mathematics performance in South Africa

The continual messages about low mathematics, science and literacy scores from international comparable norms and the national systemic assessments are daunting. All these assessments have included MWPs. I explored this by looking at assessment releases, as well as the contributing factors, and the impact on teachers and learners, as communicated through the literature.

[16] Some teachers are more confortable with a behaviouristic teaching approach. Therefore, little cooperative, constructivist and/or connectivist learning with more comprehensive understanding are evident in their teacing approach.

2.2.2.1 Assessment releases

Learners' bottom-of-the-list mathematics and science scores in TIMSS[17] (1995, 1999; 2003) raise concerns.

Noteworthy 2001/2002 national systemic assessments mirror low scores in Grade 3 numeracy, namely an average of 30% (DoE 2003b:vii). The DoE 2007 mathematics assessment indicated that only 10% of learners scored 70% or more, while the majority scored below 40% (News24 2008b). The average 2011 Annual National Assessments (ANA's[18]) scores for foundation phase numeracy for Grade 3 were even lower, namely an average of 28% nationally and 35% in the Eastern Cape (DBE 2011a:20).

The continual low Grade 12 mathematics scores remains a national concern (DBE 2011b:4; News24 2010a). The quality of performance by matrics, in relation to the number of matrics who wrote the final examination, is a concern (Du Plessis 2011:1).

2.2.2.2 Contributing factors

The 2003 TIMSS report identified several contributing factors to the poor performance in mathematics by learners at school. Included among these factors are the drastic shift to the philosophy of NCS and OBE, an unclear understanding of OBE principles and learner-centredness, and insufficiently structured guidance for teachers. Other factors responsible are inadequate time invested in problem-solving activities, and relevant conversations versus the majority teaching time allocated to basic operations, mainly by rote learning, as teachers view cooperative learning as too time-consuming. An alternative organisation of classroom activities is still required. The low percentage of teachers attending professional development opportunities to deliberately improve mathematics knowledge, and a belief among some teachers that they feel knowledgeable despite research indicating the opposite, has been highlighted (Reddy 2006:76-111).

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[17] South African learners did not participate in TIMSS 2007.

[18] See the following website for the ANA question papers: https://www.sites.google.com/site/2011annualnationalassessments/home/09-feb-2011

In addition, insufficient contact time and time on task, as well as heavy assessment loads, have been indicated (DoE 2003b:viii-x). Furthermore, literacy is identified as a major barrier to learning, especially where the home language differs from the language of classroom instruction (News24 2010b, 2008b).

The lack of a teaching culture and work ethic, contributing to a deficient learning culture among learners, and the gap between achievers and non-achievers, were mentioned as contributing barriers (Steyn 2001:24-26). Supplementary barriers are teachers' own lack of mathematical and reading abilities and knowledge, their low level of subject-matter and pedagogical content knowledge, and their deficient decision-making abilities with regard to teaching (Fleisch 2008:124-125; Steyn 2001:24; Sunday Times 1996).

2.2.2.3 Impact

Assessment releases, such as those referred to in 2.2.2.1, highlight unequal learning contexts, an issue that the NCS intends to rectify (Fleisch 2008:2; DoE 2002a:1). Poor performance and a foundation phase initiated achievers gap have a negative long-term impact on learners' education journey[19] (Fleisch 2008:30; News24 2008b). In the context of MWPs, one needs to remember that the MWPs are posed through the medium of a language which requires comprehensive abilities, such as interpretation and understanding. This two-way impact of numeracy/mathematics and literacy/language increases the dilemma which teachers need to deal with.

2.2.3 Changes to the teaching and learning of mathematics

Teachers have been confronted with multifaceted changes in mathematics education. This requires acknowledgement of both general educational and subject-specific changes.

The 1980s were benchmarked by various global research-based contributions that were significant for mathematics schooling, with specific reference to learning

[19] More negative headlines which were taken into sonciderations, are: "Low attainment levels in literacy and numeracy are unacceptable because they reduce chances of success in further education" (News24, 2008b), "…numeracy and literacy [are] the key to improving educational performance", and "If we don't get that right, you don't have what educational psychologists call the platform on which to build" (News24, 2010b).

for and *by means of* problem solving, including the use of MWPs. An eye-opener for US researchers and the mentioned global research interests was that teachers were underestimating the potential that MWPs have in mathematics education (Kamii 2000:x).

Assessment releases of the National Council of Teachers of Mathematics (NCTM), which was established in 1989, promote the process of *change of thought* for problem-based mathematics education in the USA (Van de Walle 2004:2). Connecting thoughts from this change are the shift from mainly number algorithms (that is, MNPs) to a more problem-solving approach[20], indicate the need for all learners to learn mathematics, become confident mathematics doers, problem solvers, communicators and mathematical reasoners[21], communicate a vision of good and significant mathematics teaching and learning with problem solving being integral in the process[22], and reveal the necessity to integrate assessment with instructions[23]. Teachers need to assess learners' development, performance, and support requirements throughout the teaching and learning process. The core function of assessment during curriculum implementation has been emphasised. The changes promoted by the NCTM are evident in the NCS process of change, especially in the RNCS and CAPS.

Despite changed views regarding general teaching and mathematics teaching, teachers who have been trained from a traditional perspective often think that passing on knowledge to their learners is their main or only responsibility. Pre-1994 South Africa teacher training was even more diverse, due to the lack of a national system of education and training (RSA 1995:5). Teachers' preparation for implementing the changes to the curriculum has been very inadequate, as the workshop sessions consisted more of information sharing than training. Teachers' complaints included the lack of diverse contextual classroom-based practical information for curriculum usage (Jansen & Middlewood 2003:57). Government acknowledges that significant progress has been made by certain teachers, while the problem related to teaching in practice remains (News24 2010b). The ANA

[20] The problem-solving appraoch was influenced by the *Curriculum and Evaluation Standards for School Mathematics* (1989).
[21] These requriements were influenced by the *Principles and Standards* (1989).
[22] These requriemetns were influenced by the *Professional Standards for Teaching Mathematics* (1991).
[23] This requriement was influenced by the *Assessment Standards for School Mathematics* (1995).

guidelines (DBE 2011b:8) contain realisations of knowledge which teachers require to improve their classroom practice.

2.2.4 Teachers' complex workloads

Stressed feelings are shared by teachers globally (Fullan 2007:130-138), as they are dealing with both obvious and ambiguous roles and pressures (from colleagues, learners, school management, parents, the DoE and Government, business, media, and higher education institutions). Some of these pressures are government policies, contradictions within these policies and constant changes that Government enforces, the immediate implementation that these changes require, various conflicts of interest, and "a great deal of power being forced on teachers from external agencies" (Cullingford 2010:1).

Seven roles for South Africa teachers have been identified, namely the following: learning mediator; interpreter and designer of learning programmes and materials; leader, administrator and manager; scholar, researcher, and lifelong learner; a community, citizenship and pastoral role; an assessor; and a learning area/subject/discipline/phase specialist (DoE 2002c:3). The Policy Handbook for Educators, commissioned by the Education Labour Relations Council (ELRC), clearly defines each role and indicates the associated practical, foundational and reflexive competencies it entails (Brunton 2003:A-47–A-53). This is a requirement of the National Educational Policy Act 27 of 1996. Generic interpretation of these roles, viewed in the context of a specific subject (e.g. mathematics) and/or a specific concept (e.g. MWPs), is vital.

Teachers' roles often distort their core focus of teaching learners (Fullan 2007:130) and creating learning opportunities (Cullingford 2010:x). An Education Labour Relations Council (ELRC) report acknowledges various influences contributing to a shift away from teaching, such as the following: (1) A "policy overload" for instant implementation, experienced by teachers as confusing, overwhelming, an information overload, and time-consuming; (2) The "vast majority" of teachers experience an unbearable increase in workload due to multiple, complex, and constantly changing requirements in teaching and learning contexts; (3) Large classes with diverse teaching and learning needs; and (4) OBE, and especially its intensive assessment requirements. These experienced challenges noticeably influence teachers' time-spending on various tasks. Although policy requires more teaching time, the mentioned challenges create a visible gap between policy and practice. This data also reveals that "schools most in need of improvement are least able to respond to new external requirements" (Chisholm, Hoadley, Kivulu, Brookes, Prinsloo, Kgobe, Mosia, Narsee & Rule 2005:184-185). Therefore, teachers need positive support to avoid exposure to blame and criticism (Cullingford 2010:xi; Chisholm et al. 2005:185).

2.2.5 Mathematics curriculum: theory and practice

2.2.5.1 Reference to MWPs in the NCS

C2005 lacked emphasis on problem solving, with no specific references to MWP-type problems. Although problem solving was more explicitly provided for in the RNCS, MWPs were still not explicitly mentioned in the assessment standards. Teachers had to realise that MWPs were embedded in generic references to problem solving (DoE 2002c:8). However, the Foundation Phase Teachers' Guide (DoE 2003a:65-68) explicitly reveals the DoE's acknowledgement of the importance of problem solving and MWPs in learners' mathematics education, but refers to *contextual problems*, and not to MWPs per se. CAPS clearly indicates that MWPs, or *word problems*, need to be included in everyday teaching (DBE 2010a:33, 43). MWP types in CAPS are based on basic operations for application of this mathematical knowledge, that is, primarily mathematics learning *for* problem solving.

2.2.5.2 Implementation of MWPs, and teachers

Despite calls to include MWPs in mathematics education, the emphasis remains on basic number operations, with little time invested on problem solving. There is little attention paid to the connection between school mathematics and mathematics in everyday life, and the exploring and comparing of answers, with the least time being spent on exploring diverse procedures for solving complex problems (Reddy 2006:103-104; Nickson 2000:123; Beesey & Davie 1991:20-21). This negligence to adhere to these vital problem-solving skills needs of complex societies has caused the South Africa government to be concerned about the country's ability to be globally competitive in the 21st century (News24 2008a).

Teachers' fear of MWPs is multi-faceted and influenced from various perspectives. This mentioned teachers' fear is shared by learners (Monroe & Panchyshyn 2005:27). Negativity towards MWPs is even depicted in cartoons (that is, by Gary Larson of the USA), such as "Hell's Library", containing MWP-related books (Verschaffel, Greer, Van Dooren & Mukhopadhyay 2009:xvi).

The connection between *pure mathematics* and the opportunity to discover the complexity of mathematics by means of contextual (real-life) problems and MWPs is overlooked by teachers (Frankenstein 2009:111-113; Nickson 2000:123; Skovsmose 1994:78). Learners are therefore deprived of the opportunity to develop a more comprehensive understanding of mathematics, and an essential realisation of the purpose for doing mathematics (Fox & Surtees 2010:42; Swetz 2009:89; Wetzel 2008:1; Haylock & Cockburn 2008:6-7).

Teachers' pedagogical style influences learning opportunities for learners (Fleisch 2008:128). Fleisch refers especially to content coverage, content exposure, curriculum coherence, and curriculum pacing as contributing factors to the quality of learning opportunities. Content coverage includes cognitive demands, various levels of difficulty, and assorted topics. Content exposure refers to the time allocated to the subject. Curriculum coherence refers to the internal coherence in the sequence of curriculum content during implementation. Curriculum pacing refers to the pacing of exposure to new content within the classroom. Acknowledgement of learner diversity needs to be taken into consideration and needs to be connected to content coverage, content exposure, curriculum coherence, and curriculum pacing.

2.2.6 Language challenges and their connection to MWPs

Language is central to our lives and fulfils personal, communicative, emotional, aesthetic, cultural, political and critical purposes. It shapes our identity, knowledge, and understanding. The integration of knowledge, skills, and values occurs when we express ourselves by means of language. Some of the key features of the NCS are to develop the reading and writing abilities of South Africa learners to excel in learning, and to integrate and connect language skills across the curriculum, including with mathematics (DBE 2011b:4; DoE 2002b:5-6; DoE 2003a:47, 64).

MWPs are number problems embedded in wording, that is, mathematical language connected with widespread spoken language (Hansen 2005:65). Reading skills and mathematics performance are closely related. Language is needed to present MWPs. Problem solvers either listen to or read the MWP posed. Learners need language to interpret the MWP or reword it in a more meaningful, understandable and accessible format (Vilenius-Tuohimaa, Aunola & Nurmi 2008:409-410). Social interactions with MWP experiences, through discussion, negotiation, and sharing of meaning, occur by means of language (Nickson 2000:2, 145).

As mentioned, South Africa learners also experience low performance in literacy. The 2001/2002 national systemic research indicated average literacy scores of 54% for Grade 3, with average comprehension scores of only 39% (DoE 2003b:vii). Research data in 2007 reveals that Grade 3 learners obtained a score of only 36% for literacy (News24 2008b). This project revealed valuable data indicating the significant influence that language of instruction has on the performance of learners in relation to their home language. Where the language of instruction and the home language is the same, learners tend to score higher marks. Learners experiencing schooling through an additional language as the language of instruction are challenged with barriers to teaching and learning (Fin24 2010; News 2010a, 2009, 2008b). The Foundation Phase Teachers' Guide is quite clear that learners' lack of ability to read must not withhold teachers from exposing them to MWPs (DoE 2003a:64). The 2011 ANA average scores for foundation phase literacy in Grade 3 were even lower, namely an average of 35% nationally and 39% for the Eastern Cape (DBE 2011a:20).

Schooling needs to include and address the different kinds of language that learners will be confronted with at various levels in life. Three levels of life languages that require attention in classrooms are languages to interpret our working lives, languages to interpret our public lives towards citizenship, and languages to interpret our private lives or life worlds (NLG 1996:65-70). Often these languages include mathematical knowledge and information, which contributes to the complexity of interpreting and developing mathematical understanding.

2.3 CHALLENGES WITH REGARD TO THE LEARNING OF MWPs

Learners experience mathematics ubiquitously as various everyday activities involve mathematics, including problem solving (Jackman 2005:138). Mathematics can be fun, and problem solving can be intrinsically interesting and rewarding (Beesey & Davie 1991:17). The NCTM (2000:12) maintains this vision that problem solving is natural to young learners, as the world is new to them, and they can exhibit curiosity, intelligence, and flexibility while facing new situations. Then why are so many learners challenged with mathematics in general, and MWPs specifically, resulting in low scores?

2.3.1 School experiences and low scores

The deterioration of some learners' natural curiosity after entering schooling has been revealed. Research indicates that some learners experience school mathematics as boring, limited, and just about sums. Several learners question the purpose of learning mathematics (Adler 2008:2; Clemson & Clemson 1994:10).

Reddy (2006:95) suspects that the enjoyment claim by various South African learners, despite low mathematics and MWP scores in TIMSS, derives from a perceived need to give “socially desirable responses”. It is also noticeable that there was little difference in the mathematics performance of those who indicated that they enjoyed mathematics and those who indicated that they did not.

Several authors report on the excessive time that several learners (and teachers) experience in solving MWPs. The notion that MWPs are the most challenging problem type (Wetzel 2008:1; Monroe & Panchyshyn 2005:27; Hansen 2005:65; Van de Walle 2004:150; Nickson 2000:128) is often communicated to learners, resulting in mixed feelings and anxiety. Ultimately, many learners have strong negative feelings and expressions of hate for this subject (Noyes 2007:3-6).

2.3.2 Causes of unsuccessful learning

Various causes contribute to unsuccessful mathematics learning. Although this limited study focuses on several causes, those that have not been mentioned are not any less important. Mathematics failure can convert to anxiety towards the entire mathematics experience, or one aspect of the curriculum, such as solving MWPs.

Non-diverse teaching, the abstract nature of mathematics, poor understanding by learners, negative attitudes, continual underachievement (Chinn 2004:105-108), and inappropriate pacing (Hoadley 2003:265-274) negatively influence mathematics learning and MWP solving.

2.3.2.1 Insufficient classroom learning experiences

Learners often experience learning opportunities as sessions controlled by discipline and authority. Such an education situation often results in the smothering of individuality, which does not promote the learning of useful knowledge and skills (Cullingford 2010:ix). Mathematics teaching and learning is often neglected as a whole, or is based on number exercises, with none or little time invested in problem solving (Reddy 2006:103). The MWP teaching strategies that are implemented at times include the giving of prescriptions to learners on how to solve these problems. Such strategies include searching for word clues, and decision that certain words always imply a specific mathematical operation. In addition, there are negative beliefs regarding the solving of MWPs, which requires recognition. These include the belief that there is only one problem-solving strategy and solution per MWP. The idea that small differences between numbers reflected in MWPs are due for addition or subtraction, and that larger differences are due for multiplication or division, also contribute to learners' downfall (Chinn 2004:110).

Ignorance of learners' multiple and diverse learning styles, as manifested in teachers' depriving them from learning using concrete materials or manipulatives to develop knowledge and enhance understanding is another cause of insufficient classroom experiences (Riccomini & Witzel 2010:12; Rowland, Turner, Thwaites & Huckstep 2009:112-116; Haylock & Cockburn 2008:7-8; Chinn 2004:17).

2.3.2.2 Learner potential is lacking acknowledgement

Teachers need to avoid practices reflecting negative actions, such as the so-called PHD (pull him/her down) syndrome (Sunday Times[24] 1999). Learners often experience discriminatory behaviour, as not all teachers believe that all children can learn mathematics (Lee, Graham & Stevenson 1996:171). The mentioned global

[24] The title of the article read "Many children want to learn, but have to cope with PHD syndrome".

and domestic research (US; Kamii; among others) highlights a lack of MWP learning opportunities as a result of this lack of belief among some teachers.

2.3.2.3 Languages of mathematics

Learners are confronted with various words as mathematical vocabulary, and interpretation and comprehension of these words is needed to understand what the MWPs require of them (Chinn 2004:93). Mathematics is also a language of symbols and numbers, which are used to represent the solution to the MWP. The value of understanding mathematical vocabulary is underestimated. Mathematical vocabulary can have a positive or negative impact on learners' proficiency. Teachers need to devote instructional time to the teaching of mathematics vocabulary (Riccomini & Witzel 2010:115-116; Rowland et al. 2009:148-149).

Certain MWP types provide more information than what is needed, solving the requirement hidden in the question(s). Some learners struggle to differentiate between provided data, to select context-appropriate data, and to solve the MWP accordingly. By contrast, some learners attempt to use all the given data (Nickson 2000:145-146).

Some mathematical vocabulary has opposite meanings, depending on the structure of the MWP. One of several examples is the use of the word "more", meaning "more" or "plus (add)" in some contexts, and "less" or "subtract (minus)" in other contexts. Teachers who teach learners that "more" always means "add/plus" confuse learners, and if learners follow this rule without thinking and reasoning, they will solve an MWP where "more" means "less/subtract" incorrectly. For example:

Mark has 2 more toys than James. Mark has 10 toys. How many toys does James have? (Actually James has 2 toys fewer than Mark.)

In a research project with foundation phase learners, only 8% of the learners misinterpreted the word "more" when "more" meant "more", while 66% of the learners interpreted "more" incorrectly when "more" actually meant "less" (Ellerton & Clements 1991:12).

Conversely, some sets of words, although different in appearance, refer to the same basic operation. An example is the different conceptions of subtraction, including “difference”, “take away”, “how many more/less”, and “make less”, to name a few (Rowland et al. 2009:148).

To add to the challenge are MWPs which are worded differently, but when compared, one discovers that the same strategy can be used to solve them (Rowland et al. 2003:23; Haylock & Cockburn 2008:30). The “change” and the “compare” problem types are examples. Although both of these problem types might convey the same number sentence, the actual question which needs to be solved differs, which requires different kinds of thinking about the problem (Ellerton & Clements 1991:36). For example:

The MNP:	3 + 5 = 8:
Change-type MWP:	*Joe has 3 marbles. Tom gives him 5 more marbles. How many marbles does Joe have now?*
Compare-type MWP:	*Joe has 3 marbles. Tom has 5 marbles more than Joe. How many marbles does Tom have?*

2.3.2.4 Language and mathematics

Different kinds of language are used when engaging with MWPs, namely inner language, imaginary and verbal processes, identification of mathematical language, visualising a possible solution to the problem, and responding in a mathematical manner, by means of some kind of modelling, both visually and verbally (Riccomini & Witzel 2010:12; Ellerton & Clements 1991:36).

Ellerton and Clements (1991:38) are of the opinion that a key cause of difficulty with MWPs is the significant manner in which the language of mathematics and the language of common English usage (in the case of this study) frequently vary. If learners do not understand the language of instruction (English, in the case of this study), “they can’t learn what is being taught” (Riccomini & Witzel 2010:115).

2.3.2.5 Dyscalculia

Dyscalculia is a barrier to learning mathematics. Various causes can contribute to learners experiencing this condition. Some of the causes are poor (mathematical) memory, confusing symbols, and resistance towards solving MWPs, as the mathematical information incorporated among the words does not trigger understanding (Adler 2008:3; Chinn 2004:4,13).

2.3.2.6 Factors affecting the learning of mathematics and MWPs

Chinn's (2004:21-39) comprehensive selection of various factors that influence learners' aptitude to learn mathematics and solve MWPs requires acknowledgement by teachers. Manifestations of these factors are evident in various aspects of mathematics, but for the purposes of this study, the focus will be MWPs. These factors include short-term memory and recall, visual challenges, work speed, unrealistic expectations, inadequate or incomplete work attempts, incorrect recordings or writing errors, poor reading and comprehension skills, transferring skills during a variety of applications, no checking of answers, inability to recognise patterns, a lack of problem-solving opportunities, experiences of assessment ahead of content learning, exposure to negative comments and actions by teachers and peers which disqualify learners' mathematics learning abilities, inconsistencies in mathematics and related language, as well as conflict between teaching, learning and thinking styles.

2.3.3 Learners' needs

Learners need to be accepted as diverse individuals and to be educated accordingly. Furthermore, learners need open doors to and motivation to encounter, explore, and enhance knowledge and skills, as well as listening teachers, acting as listeners, and support materials (Cullingford 2010:ix; Christie 2008:41). The need for learners to be exposed to solve MWPs is critical if they are to develop a more comprehensive understanding of mathematics (Fox & Surtees 2010:42; Swetz 2009:89; Wetzel 2008:1). Learners need to experience success, and therefore continuous failure need not be a option (Blankstein 2010:xiii).

2.4 ADDRESSING THE TEACHING AND LEARNING CHALLENGES OF MWPs

Although the expectation persists that teachers are knowledgeable about their work, various research outputs have identified that one of the core requirements to develop and improve teaching is increasing teachers' knowledge about teaching and learning (Rowland, Turner, Thwaites & Huckstep 2009:13). Although the aforementioned authors' core focus is to enrich the teaching and learning of mathematics, the *generic knowledge* and the *content-specific knowledge* required needs to be recognised and taken into consideration for teaching to be improved. The mathematics and language connection, occurring in MWPs, increases the complexity and quantity of knowledge required.

Seven kinds of knowledge (representing both generic and content-specific knowledge) are essential for professional development and the improvement of teaching and learning (Shulman 1986, in Rowland et al. 2009:20). Addressing challenges with MWPs requires the scrutiny of these kinds of knowledge.

2.4.1 Generic knowledge

Generic knowledge is structured with general pedagogical knowledge, as well as knowledge of learners, knowledge of context, and knowledge of the purposes of teaching and learning. These knowledges assist teachers to interpret, understand, and improve teaching as a profession and as a practice. Although these knowledges filter through to specific subjects and concepts (that is, mathematics and MWPs), mentors more commonly provide generic comments than referring to the actual content taught (Rowland et al. 2009:12-20). The contributions of the four generic knowledges are vital and require more in-depth investigation.

2.4.1.1 General pedagogical knowledge

As there is no single "best"[25] practice for teaching mathematics, Ellerton and Clements (1995:57-58, 87) advise mathematics teachers to avoid an imbalanced "bandwagon" approach by promoting and implementing a specific isolated perspective. Instead, teachers need to devise sufficient principles and apply knowledge of various teaching theories or approaches. The contributing essentials of behaviourism, constructivism, connectivism, cognitivism, and humanism need to be identified, understood, and connections made, while ensuring a comprehensive *balance* in teaching mathematics. Cooper (2010:170) refers to "good practice" which needs to be worked towards.

The principles of **behaviourism** contribute positively towards rote learning and the acquisition of mathematical social knowledge (Feldman & McPhee 2008:42-43).

[25] "Best" is a term which cannot always be defined in a context such as this study; therefore I agree that there cannot be a "best" practice, but rather "good" practices.

However, the behaviouristic approach, also known as the “traditional approach” and the “tell-and-do approach”, can be a negative approach when implemented on its own. In the context of mathematics, social knowledge refers to mathematics vocabulary and the names of mathematics symbols. This knowledge requires the assistance of a more knowledgeable person. In the school context, the more knowledgeable persons are mainly the teachers.

The belief that learners best gain mathematical knowledge by inventing and constructing it for themselves underpins the **constructivist** approach. Piaget’s (1972:58) belief that “to understand is to discover, or [to] reconstruct by rediscovery” remains significant in this approach. Understanding mathematical knowledge depends on multiple quantities and the quality of connections that individuals forge between existing (prior) knowledge and new knowledge, while solving various (un)familiar MWPs (Van de Walle 2004:25-26; Hiebert & Carpenter 1992:74). Von Glasersfeld (1990:37) highlights constructivists’ multifaceted view that MWPs hold the possibility of numerous problem-solving strategies and/or solutions.

Active learning in a problem-enquiry and discovery-based constructivist classroom environment requires encouraging teachers and learners to think and explore. Although this is a formidable challenge, it remains a requirement to avoid perpetuating the prevailing behavioural approach (Feldman & McPhee 2008:61-62; Von Glasersfeld 1991:120; Brooks & Brooks 1993:30; Piaget 1972:61). Learners can be arranged in cooperative groups and can work as a class in workstations, or as individuals, with a class/group discussion to follow (Cobb 1990:8).

Communication will vary in a constructivist classroom. Teacher talk is not prohibited (Cobb 1990:8), but constructivist teachers will interact with learners through posing problems, creating two-way discussion opportunities, listening to learners and skilfully responding to their ideas, allowing learners to discover relationships or make connections, and using knowledge in various classroom and real-life contexts (Pelech & Pieper 2010:9; Van de Walle 2004:25-26). Communication-rich classrooms, which allow quality interactive discussions, are the heart of constructivist learning and have multiple virtues (Feldman & McPhee 2008:59; Ellerton & Clements 1991:87).

Constructivist teachers recognise the abilities and mathematical levels which learners have achieved, and design lessons accordingly, to allow for progressive learning and the scaffolding of support towards more independent performance. Such lessons include the five essential elements (5 Es), namely “engage, explore, explain, elaborate, and evaluate”, which are essential in the constructivist framework. The 5 Es need to occur in context-sensitive classrooms. Contexts have diverse meanings, that is, the context of learners, their needs and learning styles, and the context of the subject or concept (e.g. MWPs) (Feldman & McPhee 2008:62-63).

Connecting new information to prior knowledge occurs on three levels, namely the neural level, the conceptual level, and the external level. Such connections result in a more holistic idea and better understanding (Siemens & Tittenberger 2009:11-12). This **connectivist approach** to teaching and learning is multifaceted, as learners create internal connections (neural connections) within a specific conceptual framework such as mathematics and MWPs (conceptual connections) and communicate by displaying, exposing, and sharing the knowledge with other people (external connections). Haylock and Cockburn (2008:15-17, 74) emphasise the complexity of the network of connections which develops as learners continually engage with and do mathematics.

The **cognitive approach** displays sensitivity towards thinking and reasoning, application of conceptual and procedural knowledge, and problem solving. Although cognitivists have not reject behaviourists’ ideas out of hand, their focus has shifted more to the scope of learners’ cognitive abilities. The schema theory has been derived from cognitivism. This theory embraces learning through “mental maps of knowledge networks” (Feldman & McPhee 2008:46-48). The notion of the quality of prior knowledge influencing further learning and constructing connections, the value of verbal and visual stimulation to enhance memory and understanding, regular practice, and addressing misconceptions (often experienced in mathematics and MWPs) are recognised as valuable assets to enhance cognitive development (Haylock & Cockburn 2008:6-7, 226-227). Cognitivists view problem solving, learning, and understanding in terms of learners’ diverse abilities.

Several **humanist** qualities to enhance human freedom, dignity, potential, and self-fulfilment within the context of learning mathematics and solving MWPs need consideration. A holistic humanist-orientated approach requires attention to human cognition, learning abilities, thoughts, emotions, needs, motivations, values, and morals (Feldman & McPhee 2008:64). Such qualities promote the facilitation of the learning process, the process of lifelong learning, and development towards self-direction (Haylock & Cockburn 2008:6-7).

Classroom practices which are both learner- and teacher-centred (Ellerton & Clements 1991:87) are required for the integration of the positive qualities of the mentioned teaching theories to establish a *balance*. Both Ellerton and Clements (1991:87) and Steffe (1990:394) agree on the value of problem situations created by teachers and the provision of opportunities for learners to actively engage with mathematics.

2.4.1.2 Knowledge of learners and how they learn

Gagne's four levels of learning (that is, rote learning, concept learning, principle learning, and problem solving) embrace how children learn (Chinn 2004:91). Learners' uniqueness is evident in their diverse conduct towards mathematics (Jackman 2005:138). Enhancing learners' individual potential contributes towards the improvement of equality and meaningful learning (Cullingford 2010:x; Vosniadou 2001:25; Potter 1995:322).

Effective and motivated learning occurs in an environment which allows constructive active involvement, social interaction, meaningful activities, relating and connecting new information to restructure prior knowledge, being strategic, applying knowledge in diverse contexts, engaging in self-regulation, and being reflective. Learning takes time to develop through practice (Rowland et al. 2009:123; Vosniadou 2001:8-28). The pacing of learning among learners differs. Therefore learners need multiple learning opportunities where they can independently think rationally and critically, and interpret and solve MWPs while posing critical questions, discussing challenges, and proposing changes to community issues by means of realistic MWPs (De Klerk 2001:41; Vosniadou 2001:15). The success rates of such opportunities are determined by the pacing of teachers' teaching and learners' learning (Hoadley 2003:265-268). Learners furthermore need teachers to avoid teaching recipes to solve MWPs, to provide concrete manipulatives, to pose MWPs within real-life contexts, and to allow learners to make connections through observing and doing. Learners need to look for equivalences and transformations (Haylock & Cockburn 2008:6-7). Learners mainly display two kinds of thinking styles. One style reflects a more holistic thinking style where learners are more intuitive, are rigid in their thinking, and remain with one problem-solving strategy. The other style reflects a more formulaic, procedural, sequential and flexible thinking style with detailed recordings, using a range of problem-solving strategies (Chinn 2004:59-60).

Learners display diverse learning styles when solving MWPs, and teachers require the relevant knowledge. Visual and kinaesthetic learning styles are visible in the type of response to MWPs, where verbal learning styles are less identifiable during pen-and-paper tasks (Clausen-May 2005:5-6).

Piaget's and Vygotsky's timeless research contribute in-depth knowledge regarding learners' thinking (Jackman 2005:139; Bank Street 2002:1). The three knowledge types, according to Piaget, exhibit how learners construct mathematical knowledge and develop cognitively. These are physical mathematical knowledge[26], social mathematical knowledge[27], and logico-mathematical knowledge[28] (Charlesworth & Lind 2007:16-18; Jackman 2005:139; Chinn 2004:91). Physical mathematical knowledge-gaining develops ahead of the corresponding social mathematical knowledge, influencing the notion of conceptual development (e.g. the ability to solve an MWP), often occurring ahead of the attached language (e.g. the ability to explain MWP-solving strategies). Learners who demonstrate logico-mathematical thinking[29] often exhibit strong problem-solving and reasoning skills, as well as pose questions in a logical manner (Sheffield & Cruikshank 2005:22-23; Jackman 2005:139-140; Gardner 1991:9).

[26] Physical knowledge intails self-discovery and learning by playing or engaging with real or concrete manipulative.
[27] Social mathematical knowledge requires social interaction with more knowledgeable humans to learn mathematical language (words and symbols); this knowledge cannot be self-discovered.
[28] Logico-mathematical knowledge depends on unique individual constructions through creating and restoring relationships and connections while organising information uniquely to develop understanding of the mathematical world.
[29] Logico-mathematical thinking is one of Gardner's multiple intelligences.

Working in a progressive Piagetian sequence of concrete, semi-concrete[30], semi-abstract[31], and abstract[32] is a value-added approach to learning mathematics and solving MWPs (Haylock & Cockburn 2008:7-9; Sheffield & Cruikshank 2005:20; Van de Walle 2004:25; Ellerton & Clements 1991:88-89). Interpreting and developing understanding of solving MWPs from direct (pictorial) to mathematical (symbolic) modelling requires knowledge regarding mathematical vocabulary and the language (semantics) of mathematics, and the diverse meanings of the same words in different contexts (Chinn 2004:93-101). Multiple MWP-solving opportunities minimise challenges with the diverse meanings and uses of mathematical vocabulary. Writing mathematics and problem-solving strategies contributes positively to mathematics learning and understanding, providing the opportunity to visualise thinking and practise mathematical concepts in various formats (Ellerton & Clements 1991:118). The strong connection between language and mathematics has been emphasised.

Learners' cognitive development is continually modified and restructured during the learning process. The teacher's influence cannot be underestimated, through the creation of learning situations, the observation of learners' progress and the addressing of arising needs, the realisation of how learners think and reason, problem-solving abilities, communication about solutions and/or discoveries, and learning from mistakes (Cullingford 2010:ix; Jackman 2005:140; Piaget 1972:16).

2.4.1.3 Knowledge of context (including democracy in South Africa)

Context is a complex term that includes various meanings. It is changeable and has much influence and power. Both broad and immediate contexts deserve recognition when teaching and learning is under the spotlight. Human beings can experience various contexts at different times. A call for context-sensitivity is thus required to improve classroom practice (Feldman & McPhee 2008:60; Haylock & Cockburn 2008:6-7; Vandeyar 2008:693).

South African teachers have been challenged with a politically changed context since 1994. The Constitution provides the context for the curriculum (DoE 2003a:1;

[30] Semi-concrete is a pictorial representation of the concrete, or a picture replacing the concrete.
[31] Semi-abstract is a connection between either the concrete or semi-concrete and the abstract.
[32] Abstract is the symbolic presentation of a mathematical problem and solution.

DoE 2003b:1) to restore the divisions of the pre-1994 apartheid South Africa and to establish a society based on democratic values, social justice, and human rights, to improve the quality of life of all citizens and free the potential of each person, and to lay the foundations for a democratic and open society. The cornerstones of a democracy (that is, equality, freedom, responsible participation, and respect for authority) need to be visible in classroom practice to enhance the quality of education (De Klerk 2001:38-42; Steyn 2001:22-25).

Henderson and Kesson (2004:179-180) share an Australian perspective and significant contribution on promoting the development of problem solvers in a democratic context. Emphasis was placed on the increased role that education has to play in creating more socially productive individuals who can solve problems satisfactorily, lifelong and lifewide learning to stay in touch with the changing world and the needs of life, the investing of quality time in reconceptualising the three Rs of learning (that is, reading, writing, and arithmetic) for a comprehensive approach, the paying of attention to problem solving, collaborative learning, communication, discussion, flexibility, and creativity, as well as continual progressive learning, the continual professional development of teachers, and a policy focus change from public cost to public investment. The dual responsibility of value-adding to education should not be underestimated, and it is not just a school task.

2.4.1.4 Knowledge of the purposes of teaching and learning

Schools have been developed to educate the youth in a more formal or structured context. The purposes of schools are never unbiased. Therefore, the focus needs to be on *what* and *whose* purposes are being referred to. School environments need to promote the envisaged outcomes of national education, being one of the most important vehicles for teaching the societal (democratic) values and to develop and educate individuals and influence learners’ life opportunities (Cooper 2010:169; Christie 2008:21-22; NLG 1996:71-72). Although the particular identity and character of schools impedes how best to manage them (Coleman, Graham-Jolly & Middleton 2003:ix), “transformative leadership” is essential to achieve changes in education and schools (Graham-Jolly 2003:111-112; Fullan 1997:19).

Learners need to learn aspects of mathematics to organise their lives effectively (Fox & Surtees 2010:149-151; Rowland et al. 2009:161; Jackman 2005:141; Beesey

& Davie 1991:16). Access to mathematics learning is a human right, in itself, and needs to reflect everyday life needs (Jackman 2005:149; DoE 2002c:4). Furthermore, as learners do not experience their world in separate compartments, an integrated approach across the curriculum is essential (Fox & Surtees 2010:8; NAEYC & NCTM 2002:2).

Education has a dual emergence role and traditional role in society (Siemens & Tittenberger 2009:4). The emergence role includes, for example, emerging developments, changed ideas, and even (a) changed or adapted teacher's role(s). By contrast, the traditional role refers to the influencing and transforming of a society in search of "higher ideals" and a specific vision (for example, equality and democratic rights for all). When referring to tradition, one can include the views of educationists who have influenced education over a long period of time. Piaget, Vygotsky, Dewey, and Bruner are such educationists, to mention a few.

2.4.2 Content-specific knowledge

While generic knowledge influences education holistically, content-specific knowledge influences the subject (mathematics) and concepts (MWPs). Subject-matter knowledge, pedagogical content knowledge, and curriculum knowledge structure the content-specific knowledge (Rowland et al. 2009:20). In this study the focus emerges from the MWPs perspective.

Word problems originated thousands of years ago. The examples reflect everyday contexts (mainly agricultural) of the time. Swetz's (2009:87-88) learning from ancient literature indicates that MWPs "are composed to teach [even more complex] mathematics" progressively and to increase "an understanding of the development of mathematical ideas, their priorities and their interrelationship with the real world".

2.4.2.1 Subject-matter knowledge

Knowledgeable teachers are required to demonstrate mathematics and MWP subject-matter knowledge in practice. The envisaged outcome is optimising learning and success with solving MWPs at school and in everyday life. Educationists' research recommendations, both nationally and internationally, emphasise the continual need of teachers to (re)construct subject-matter knowledge (Christie

2008:184; Reddy 2006:78; Taylor 2006:2; Jackman 2005:146; Van de Walle 2004:99; Chinn 2004:2; Charlesworth & Lind 2003:9; Grouws & Cebulla 2000:15-16; Lee, Graham & Stevenson 1996:171-177). The need for a continual enhancement of the appropriate required subject-matter knowledge is evident in the call of national policy for lifelong learning as an essential teacher role (DoE 2002c:3; Brunton 2003:A-47-A-53). Teachers need sufficient knowledge for the phase they teach, including an understanding of the connections and progressions between mathematical concepts, as well as the substantive and syntactic aspects of subject-matter knowledge (Rowland et al. 2009:23; Askew, Brown, Rhodes, Johnson & Williams 2006:1).

Three of the six NCTM (2000:16) principles motivate teachers to focus on teaching (mathematical subject knowledge), learning (recognition of prior mathematical knowledge), and assessment (identification of deficient mathematical knowledge). As effective teaching nearly entirely depends on the experiences that teachers provide every day in the classroom, the need exists to focus on teachers' subject knowledge and deep understanding of the mathematics that they need to teach (Van de Walle 2004:3).

Because of the ever-present connection between mathematics and language, teachers also require literacy subject-matter knowledge (Ellerton & Clements 1991:7). Chinn (2004:3,99-101, 135) reminds of the various levels of language-rich representation that teachers can utilise to pose problems and that learners can apply when responding to questions. Therefore, the tendicy to generalise a specific word with a specific meaning at all times, is irresponsible.

Reading challenges need to be recognised, and an empathic response by teachers is needed to prevent learners from feeling intimidated by the subject of mathematics (Chinn 2004:135).

Some learners experience textbook problems as meaningless and abstract. To address this problem, teachers need to use real-life contexts to improve learners' responses and understanding of MWPs, and they need to ensure that their interactions are relevant, genuine and of practical use, and that the outcome is real (Chinn 2004:56; Grouws & Cebulla 2000:11).

2.4.2.2 Pedagogical content knowledge

The development of effective mathematics teaching styles requires subject-matter knowledge (the *what*), together with appropriate pedagogical content knowledge (the *how*) (Rowland et al. 2009:23). The subject of mathematics can be viewed from a developmental perspective, as the development of facts, concepts, and procedures, as well as from a preventative perspective, as misconceptions about the different mathematical concepts need to be minimised (Chinn 2004:92; Hansen 2005:65).

Different kinds of pedagogical content knowledge are essential to improve teachers' actions, while encouraging learners to think, to question, to solve problems, and to discuss their ideas, strategies, and solutions (a teacher principle in the NCTM 2000:18). The latter links up with the equity principle, which includes beliefs of "high expectations and strong support for all learners … regardless of personal characteristics, backgrounds, or physical challenges" (NCTM 2000:12), while striving for excellence in mathematics education during multiple opportunities and adequate support (Van de Walle 2004:3). As learners do not learn all subjects in the same way, various solutions to address the factors which influence the learning of mathematics are a necessity (Riccomini & Witzel 2010:12; Chinn 2004:21).

Mathematical pedagogical content knowledge, while including generic pedagogical content knowledge drawn from multiple education theories, is specifically concerned with how teachers transfer their own subject-matter knowledge to their learners, how resources and representations are used, and how teachers analyse ideas and explain concepts (Rowland et al. 2009:21).

The process of learning mathematics and solving MWPs (Charlesworth & Lind 2007:16; Jackman 2005:138-139; Geist 2003:10-12) displays various essential characteristics and involves various progressive developmental stages. Geist and Jackman stress the importance of repeating activities, which leads to meaningful learning, as learners are able to continually connect new concepts and skills to their existing knowledge, while rethinking and practising engaging with similar problem-solving activities. Charlesworth and Lind refer to the necessity to improve conceptual development from a young age, by constructing "building blocks of knowledge" for application to new real-life problems.

2.4.2.3 Curriculum knowledge

A problem-solving-orientated mathematics curriculum is essential to improve the solving of MWPs (Jackman 2005:140). A curriculum is more than a collection of activities. It needs to be coherent, focused on important mathematics and MWPs, and well articulated across the grades (a curriculum principle in the NCTM 2000:14). Learners need teacher assistance to make the connections between concepts and develop progressively (Cullingford 2010:ix-xi; Van de Walle 2004:3).

The various influences pressing for curriculum change are found in national (i.e. central government, ministers), provincial, local (municipal), institutional (i.e. schools, teachers, learners), and individual (teachers in the classroom) domains (Jansen & Middlewood 2003:54-56). Jansen and Middlewood are especially concerned about the critical influence of curriculum management at school level and the quality of actual student learning, specifically in a democratic society. Teachers potentially have the most significant influence, because of their direct impact on learners. Teacher factors that contribute to classroom practices that the above authors refer to are teacher motivation and attitudes, teacher knowledge, and teacher mastery of teaching.

Implementing a curriculum in a democratic manner is a challenge (Noyes 2009:286; Henderson & Kesson 2004:12; Hoffert 2001:39). In the mathematics classroom, the curriculum needs to be implemented in such a way that the teachers acknowledge that although not all learners will achieve the highest level, teachers need to provide an environment where all learners "learn to use *their* mathematics", that is, a curriculum for all, and not just for the *elite*. Teachers need to develop an understanding and the required wisdom to make decisions regarding the implementation procedure in a specific classroom setting. Curriculum wisdom consists of three components, namely practical enquiries, critical enquiries, and visionary enquiries (Henderson & Kesson 2004:8).

The connection between the curriculum, pedagogy, and assessment cannot be ignored (Christie 2008:184-185). The CAPS document (DBE 2010a:10-12) is one attempt to address this lack of guidance, by providing more explicit content detail and progressive structured time allocations, although only the weekly breakdown indicates MWPs explicitly (DBE 2010a:24, 26, 27). Teachers were trained during the last few months of 2011.

2.5 CONCLUDING COMMENTS

The contribution that literature can make to develop an informed teacher to include MWPs effectively in practice requires that a balance be established between knowledges concerning subject-matter and those concerning pedagogical content. Such knowledge will support the teacher to create “people-centred practices” where learners will be actively involved in the learning process, developing their own knowledge and skills within a socially just classroom environment, with a supportive teacher striving towards “good practice” (Cooper 2010:170). In Chapter 4, the results of the gathered data reveal practice as is within a sample of foundation phase classrooms, with the intention to identify factors which influence “good practice” from the perspective of the phenomenon of the MWP.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter aims to explain the research tradition and/or paradigms in which this study is located. In addition, the chapter gives an account of the data gathering strategies employed, the data analysis process, and the justification for it.

Various views about paradigms have emerged and developed over time. Paradigms represent “a distillation of what we think about the world, but cannot prove” (Lincoln & Guba 1985:15). Paradigms are viewed by Guba (1990:17) as basic beliefs guiding action, while Clare (2003:19-20) describes them as a set of assumptions that provide the researcher with philosophical and conceptual guidelines for the disciplined investigation of natural and social phenomena. The notion of paradigms incorporates epistemology (how we know the world), ontology (posing questions about the nature of reality), and methodology (how to obtain knowledge about the world in a sequential manner) (Cohen, Manion & Morrison 2007:5; Denzin & Lincoln 2003:3).

Positivism (objectivity) and interpretivism (subjectivity) are concerned with order. One of the criticisms against positivism is that the approach is unable to answer many interesting and important questions about life. Unsuccessful application of positivism is evident in the school and classroom context, with the challenges and problems of teaching, learning, and human interaction. The complexity and tangible quality of social phenomena compare notably with the order and regularity of the world (Cohen et al. 2007:11, 18).

3.2 PHENOMENOLOGY

Phenomenology, as a qualitative research method, attempts to understand how human beings experience a particular phenomenon. With this method researchers attempt to determine the perspective of participants concerning a particular phenomenon (Johnson & Christensen 2008:48; Creswell 1998:51). Through participant observation and reflection (Schwandt 2007:96) this study attempted to elicit the factors influencing the implementation of the phenomenon of the MWP, and the related interactions between foundation phase teachers and their learners.

Phenomenologists believe that reality is socially constructed. Human beings are “active agents in the creation of reality” as they interpret their world, and they “act uniquely on these interpretations” (Goodman 1992:119). There are three approaches in phenomenology. The first describes an experience as it is observed. The second interprets an experience in relation to relevant features of context. The third scrutinises whether the type of experience is contributing to the world in which it exists (Le Roux 2006:38). All three approaches are discussed in Chapter 4 of my study.

The nature of this study necessitated the use of a qualitative approach. The research traditions explored were the interpretive tradition and critical theory. The relevance of these research traditions to this study is explained in the following section.

3.3 RESEARCH TRADITIONS RELEVANT TO THIS STUDY

3.3.1 The interpretive tradition

This paradigm encompasses different approaches (for example, phenomenology) in the human sciences, focusing on studying, interpreting, and understanding societal life (Schwandt 2007:160; Ritchie & Lewis 2003:7; Denzin & Lincoln 2003:33; McFarlane 2000:23; Burrell & Morgan 1979:28). The interpretive paradigm promotes the investigation of complex issues and understanding of the totality of a situation.

Taylor (1985:45) emphasises the main qualities of this paradigm as being its ability to make the researcher “aware of the existence and dimensions of problems, to reveal their interconnections, to rule out some of the more obvious ‘solutions’, [and] to add to and refine the concepts we employ to describe and evaluate phenomena”. At the same time, this paradigm sensitises the researcher to “what otherwise might be ignored, misunderstood or acted upon in blind faith”. In addition, Coleman (2003b:153) explains that to study a phenomenon is an attempt to understand “what is happening” with regard to the phenomenon and to observe the phenomenon within a more holistic situation.

Interpretivists believe that the goal of science is to persistently grapple with phenomena, with the intention of “getting it right about reality or multiple realities”, even if we cannot completely achieve this intention. Diverse viewpoints, by means of various processes of observation, construct our interpretation of the world. An individual researcher cannot capture the world, but rather contributes towards multiple perspectives and realities of the world. Due to this limitation of scientific methods, interpretivism can provide only an approximation of the truth (Cohen et al. 2007:21; Henning 2004:20; Coleman 2003b:152). Researchers need to enter the society of individuals under investigation, in order to convey the reality experienced by the research participants (Schwandt 2003:297; Burrell & Morgan 1979:253).

The interpretive paradigm usually explores qualitative methods that enable the researcher to gain a descriptive understanding of the participants’ interaction with the phenomenon in its particular context (Le Roux 2006:38; Henning 2004:19; Coleman 2003b:152; Ritchie & Lewis 2003:23). Thus, it involves an investigation of the social phenomenon as observed through the eyes of the participants, rather than through the researcher’s eyes.

Different research tools provide “multiple perspectives and multiple truths” (Patton 1987:166). Thus, in order to understand a phenomenon, various different sources of data need to be obtained. A range of participants, situated in a social context, informs the collective process (Schwandt 2007:96). As human behaviour is too diverse and complex to be described through generalisations and theories, reporting on small samples, researched in depth and/or over time, is more suitable. Interpretive researchers are dependent on the realities constructed by participants’ actions and interactions with people and their world (Le Roux 2006:38; Golafshani 2003:597; Coleman 2003b:153; Fien & Hillcoat 1996:27).

Interpretive knowledge is constructed from more than observable phenomena. It is also influenced by factors such as one’s intentions, values, and beliefs, how one adds meaning to situations, and one’s self-understanding (Henning 2004:20; Coleman 2003b:152; Ritchie & Lewis 2003:17). Consequently, interpretive researchers view knowledge as constructed rather than found; this is also referred to as “constructivism”. Constructivism is typically associated with a qualitative research design. It is described as contextual, inclusive, and involved (Mertens 2005:12, 444).

Specific emphasis on the psychological processes of interpretation, influenced by and interrelated with social contexts, assists with understanding phenomena and events. Interpretive researchers are extremely sensitive to the role of the context(s) and its/their connections and influences on the participants’ lives. Interpretive inquiry methodologies, such as unstructured observations and interviews, are ways to collect significant situational data and to acquire “insider knowledge” in natural settings (Henning 2004:20).

3.3.2 The interpretive tradition in this study

Phenomenology, as philosophical base for the interpretivist stance, is explored in my study. I have attempted in this study to understand, interpret, appreciate, and reveal the participants’ engagements with the phenomenon and practices of the MWP. Attempts have also been made to avoid being judgemental. I have made every effort to consciously avoid analysing the multifaceted data according to my own philosophy about MWPs.

The methodological implications of the interpretive tradition (Schwandt 2007:96; Henning 2004:20) guided the selection of data-gathering and data-analysis strategies. Unstructured observations and open-ended reflections were explored. The qualitative data analysis complemented this study, in order to gain insider knowledge with regard to the implementation of MWPs in foundation phase classrooms.

3.3.3 Critical theory

This research study expected to find sufficient good practice to develop a better understanding of how adequate classroom settings function, and to make recommendations to contribute towards improving the teaching and learning of MWPs. Hence, to be able to suggest changes for improvement also requires an exploration of the critical theory paradigm (Henning 2004:16).

Critical theory seeks to reveal the interests at work in difficult situations and to interrogate the legitimacy of those interests. This theory aims to identify the extent to which people are legitimate in their service of equality and democracy. The intention of critical theory reflects transformative qualities, such as to transform society and individuals towards social democracy. It also pursues equality issues, such as ideology and participation. Critical theory, and critical educational research, in particular, is concerned with the relationship between schooling, education, culture, society, economy, and governance (Popkewitz & Fendler 1999:xiii), with a specific interest in the reduction of inequalities, the social construction of knowledge and curricula, and to what extent the acknowledgement of diversity is visible in education. This theory is unambiguously rigid and normative, involving an outlook of what actions in a social democracy ought to entail. It furthermore seeks "to unite the disempowered, to redress inequalities, and to promote individual freedoms within a democratic society" (Cohen et al. 2007:26-27; Toni 2009:28). It also provides equal opportunity to question real needs, to explore possible solutions, and to solve problems (Fleming & Murphy 2010:6-7). Fleming and Murphy (2010:202) acknowledge the potential of critical theory to assist in the striving for a "more just social form of life".

Pedagogical practices are related to social practices, and that it is the task of the critical researcher to identify and address injustices in these practices (Popkewitz & Fendler 1999:xiii). The critical educational research approach furthermore attempts to address educational issues such as daily classroom practices, problems and/or challenges, and what is taught in the classroom setting and how it is taught (Gibson 1986:2). Fleming and Murphy (2010:202) question social interactions with the intention of determining why people say and/or do certain things. As critical educational research is grounded on a vision of social change and democratic values, it seeks to empower teachers and learners to participate in programmes of research (Fien & Hillcoat 1996:29).

Critical theory differs from the interpretivist paradigm. Interpretivists describe the situation as it is/was observed from multiple perspectives, not questioning it or attempting to transform it. A critical theorist, on the other hand, "questions the political nature of that very process, maintaining that some relationships in the world are more powerful than others" (Cohen et al. 2007:27; Henning 2004:23).

Interpretivism, constructivism, and critical theory, all divisions of qualitative research, acknowledge that reality is practical and is formed by various forces (Lichtman 2006:16; Fien & Hillcoat 1996:28). The relationship between interpretivism and critical theory in qualitative research is of great value in identifying, observing, describing, and critiqueing discourses in reality, as well as how these discourses manifest in and shape people's lives. Critical researchers also focus on active experiences, and the social relations that structure these experiences. The data obtained from practice and social relations cannot be isolated from the value domain or be separated from the ideological message (Henning 2004:23).

3.3.4 Critical theory in this study

The research questions triggered a progression from the interpretive paradigm to critical theory. This progression was inspired by the belief of Babbie and Mouton (2001:34) that critical theory aims to change society for the better, and not (just) to interpret it.

This study aims to contribute to the pedagogy of personal and classroom-based social transformation (Creswell 1998:82). I realise that I need to avoid sounding too hopeful and determined. Therefore, the recommendations that emanate from the data of this empirical study, although not changing or reconstructing the world (Henning 2004:23) and schooling, could add value to the process of educating student teachers at Nelson Mandela Metropolotan University (NMMU).

During data analysis I did not only want to reveal advantages and disadvantages in society (as well as in classroom practice) which are often taken for granted. I was particularly looking for strategies to address inequalities brought about by diverse classroom practices.

My study is sensitive to the democratically developing South Africa and its education system. The critical framework thus provides opportunities to critique on the social injustices of a particular society (in the case of this study, foundation phase classrooms). This study focuses on the phenomenon of the MWP and the practice of the teaching of this phenomenon in the classroom setting. The social relationships and interactions between participating teachers and learners in the small sample, within democratic South Africa and all its educational changes, all need to be taken into account when practice is described and critique is formulated.

Ideology is explored in this study by means of a description of the best practice observed, keeping in mind democratic requirements and values for equality.

3.4 RESEARCH DESIGN

A research design is an action plan that researchers implement in an attempt to respond to the research question(s) as accurately and unambiguously as possible (Denzin & Lincoln 2003:57-58; Mouton 2002:55-57; De Vaus 2001:9). The qualitative research approach was selected, as this study is aimed at eliciting the factors that influence the implementation of the phenomenon of the MWP in natural foundation phase classroom settings.

The qualitative research approach is described in different ways by several researchers. The views of some qualitative researchers are incorporated with the 10 critical elements (in italics below), as proposed by Lichtman (2006:8-15), for creating a qualitative research agenda.

As qualitative research is about human beings, the main purpose of a qualitative research project is to provide an *in-depth description*, comprehension and *understanding* of the human experience, an *interpretation* of the human phenomenon, the social (human) interactions within the situations, as well as the human discussions (Henning 2004:3; Schurink 1998:240). Miles and Huberman (1994:10) state that these actions carry intentions, meanings, and consequences. *Inductive thinking* is required to interpret concrete phenomena in connection with abstract interactions.

Qualitative researchers collect data about observable phenomena in their naturally occurring settings and contexts (Angrosino 2008:4; Schwandt 2007:206; Miles & Huberman 1994:10). This ensures authenticity in the collection of data when the qualitative research approach is used in the social sciences.

The progression of a research project can impact on the *dynamics* of the research, which will then require changed and/or additional research methods. The diversity of human beings and human situations effectively means that life consists of multiple realities (Miles & Huberman 1994:10), and that there is thus *no single* *way of doing something*. Therefore, a *variety of data* is required to reveal the complexity of the diverse human factors. Such a variety should ensure a richness of data. One particular option in qualitative research is to conduct an in-depth study with a smaller focus. Isolating a smaller focus from a more *holistic* truth needs to be avoided, and therefore investigation of a phenomenon (e.g. the MWP) requires recognition of a holistic reality (e.g. mathematics).

The researcher has a fundamental *role* to gather, analyse, and interpret data as it is found. The experience, knowledge, skills, and background of a researcher could influence the research outcome. This can lead to a biased interpretation of the data. The researcher needs to realise the dangers of being biased. As there is no one right response, the researcher has the responsibility to carefully interpret what has been seen and heard in an attempt to be unbiased and to display objectivity, reflecting the interpretations by both the insiders (that is, the participants) and the outsider(s) (that is, the researcher(s)).

A qualitative research study presents data in words rather than numbers (Fraenkel & Wallen 1990:368). It uses direct quotes to emphasise certain points and applies a writing style which is often more personal (less formal). The worded interpretation is *non-linear*, as it can reflect various entry points to the study (for example, a comment made about something observed and/or read). A two-way flow between the gathering and the analysis of the data is needed in order to reveal the outcome of the observations and interviews related to the research questions.

The qualitative research journey of inquiry usually commences with a vaguely formulated idea, developing through progress. An open mind and a willingness to explore new ideas and follow the research design that emerges is recommended (Burns & Grove 1993:64; McMillan & Schumacher 1993:15). Such a design implies continual adaptation to data-gathering strategies. In addition, Hatch (2002:41-43) refers to an open-ended approach, while exploring the research settings within the framework of research questions for more specific direction.

My journey of inquiry was inspired by the yearly reflections by the foundation phase student teachers at NMMU, which I analysed as lecturer. These reflections revealed concerns with the featuring and implementation of MWPs in foundation phase classrooms. As the MWP is a phenomenon of interest to me and a core mathematics concept in the modules that I teach, this research project became necessary. Three clearly formulated research questions, as explained in Chapter 1, initiated the actual journey. In order to display open-mindedness, I opted for a more flexible approach that was informed by the mentioned reflections, the literature study, and my own observations.

The need to find alternative approaches to ensure rich data was kept in mind. Therefore, unstructured interviews with the teachers were included at the end of a classroom observation. During such interviews, I had to avoid imposing my own preconceived ideas on the teachers and let them participate freely.

The data-collection process for this study adhered to the requirements for authentic data collection, as referred to above. I observed teachers and their learners in their classrooms. The student teachers reflected on their own experiences in foundation phase classrooms and what they had observed concerning the teachers' and learners' interactions and actions. I strived to provide an in-depth description and interpretation of data gathered from a small sample.

As MWPs are one aspect of the broader spectrum of mathematics teaching and learning, a need for acknowledging a more *holistic* description (that is, international and national views, policies, and the curriculum, as well as implementation documents) could not be excluded in a study of this nature. As Lichtman (2006:16) asserts, interpretivism, constructivism, and critical theory accept that reality is practical and is shaped by various influences. He adds that "findings are value-laden rather than value-free".

3.5 SAMPLING

The sample for data gathering has a critical impact on the analysis and interpretation of data aimed at acceptable recommendations. Certain settings consist of subsettings, such as classrooms in schools (Miles & Huberman 1994:27). One needs to take into consideration that not all classrooms in a particular school will be observed or reflected on.

At the schools where I observed, I observed one class each of Grades 1, 2 and 3, although there might be more classes per grade in each school. These classes were allocated to me by the school principals, depending on the teachers' willingness to participate in the research project. A selection of the subsettings in each school was observed and included in this study.

In the case of the student teachers, they were granted access to foundation phase classrooms as per availability and preference of the school principal, foundation phase head of department, or the school staff member responsible for student teaching practice matters.

The selection of qualitative research samples displays a purposive tendency, that is, it is not random (Strydom & De Vos 1998:198). Time constraints and location availability also influence the sample selection (Miles & Huberman 1994:27). Availability constraints created time constraints. A combination of these mentioned constraints, which influenced this study, were especially the availability of the independent observer. As far as locations are concerned, these were only available during two consecutive months.

Various schools are observed by student teachers every year. Student teachers did not attend the same school during every teaching practice opportunity. Therefore the sample expanded over time. For my classroom observations I selected three schools from the sample that the student teachers utilised. Specific research sites are selected according to their particular location as it is convenient to the researcher (Walford 2001:14). Another two schools, which never before had NMMU students visiting them, were also selected for validity reasons as to ensure that not known schools were included in the sample.

Multiple case sampling contributes confidence to the results by strengthening the accuracy, the validity, and the stability of the results. Multiple case sampling requires an explicit sampling frame. Such a sampling frame is guided by the research questions (Miles & Huberman 1994:29). Observations and reflections, as well as unstructured interviews, depending on need, made up the majority of the research methods employed.

Based on the ideas of Miles and Huberman (1994:27), sample selection for this study was informative, based on some prior research. As a set of observations for data gathering can lead to comparisons, where similarities and differences are identified, thereby enriching understanding, classroom observations (inspired by the student teachers' reflections) were conducted. What was learned in one observation after the analysis could lead to the selection of the next sample. This is evident in this study, as the analysis of the student teachers' reflections progressed to the classroom observations and the accompanying unstructured interviews.

Accessing the research setting required appropriate communication prior to the actual observations, in order to arrange for set times when the observations would take place (Walford 2001:51-52). Ethical agreements accompanied these arrangements in order to develop the required trust between the researcher and the participants.

3.6 PROCEDURES FOR ENHANCING RELIABILITY AND VALIDITY

Researchers need to select research instruments that will provide the best and most accurate data in order to respond to the research questions (Johnson & Christensen 2008:143). Reliability and validity are vital matters which need to be considered.

3.6.1 Reliability

Reliability refers to the consistency of the data (Johnson & Christensen 2008:143-144). During the data-analysis process similarities are repeatedly identified. This enhances the quality and the consistency of the phenomenon of MWPs. Results are deemed reliable when they are repeated by means of diverse research techniques (Babbie 2005:144). Various terms have been used to describe reliability and validity, such as "trustworthiness", "credibility", "dependability", and "confirmability" (Kvale 2002:301).

Repeated emphasis of the use of the phenomenon of the MWP in the student teachers' reflections inspired me to undertake this research project. I witnessed similar trends during classroom observations in the same social settings (that is, foundation phase classrooms), but also at some alternative classrooms, used to ensure reliability. To enhance the reliability of the data even further, an independent researcher was employed.

3.6.2 Validity

Validity refers to the accuracy of the interpretations of the data (Johnson & Christensen 2008:144). Validity depends on the quality of the continual checking (looking for bias, negligence, or lack of precision), questioning (with reference to all the procedures and decisions) and theoretical interpretation of an investigation (Henning 2004:148; Kvale 2002:309). Verification of the research data is essential for the trustworthiness of one's reporting on one's research (Miles & Huberman 1994:11). Therefore I used the assistance of an independent observer for the classroom observation which I conducted.

As lecturer of Foundation Phase mathematics and methodology, who emphasises the inclusion of MWPs in classroom practice, I constantly had to withhold myself from contributing my own views to the interpretation of data. Excluding biases requires a technique called bracketing (Poggenpoel 1998:337, based on the ideas of Burns & Grove 1987). Bracketing is a conscious action of the researcher to ignore what is known about the practice being studied. Consequently, it involves excluding preconceived ideas and views, and revealing the data as observed (Laverty 2003:6).

3.6.3 Independent observer

Trustworthiness needs to be promoted in the observation process. Therefore an independent observer accompanied me to all the classroom observations. We recorded our own data separately from each other. The data gathered by the independent observer was analysed in the same manner as all the other data. The two sets of classroom observations were compared. The use of an independent observer satisfies the requirements of an external audit, to ensure quality and verification, as suggested by Creswell (1998:203).

3.6.4 Triangulation

It is the task of the researcher to ensure that data used in the research project is valid and reliable. Triangulation fulfils the purpose of supporting results by means of multiple data samples (Miles & Huberman 1994:267-268; Fraenkel & Wallen 1990:380). These measures to ensure the correctness of the results contribute to the quality of the results (Miles & Huberman 1994:294).

I tried to use various measures to enhance the reliability and validity of the data used. Therefore, as mentioned, I did my own investigation to verify the reflections by the student teachers. Furthermore, I observed classroom practice in the same schools as well as alternative schools. I also used the assistance of an independent researcher.

In addition to the above-mentioned data-gathering strategies, unstructured interviews with classroom teachers were conducted to enrich the observed data, and for purposes of elucidation.

3.7 METHODS FOR DATA GATHERING

3.7.1 Student teachers' reflections

Student teachers have reflected yearly on practice-based mathematics and MWP-specific experiences. The data gathered from these reflections indicated several factors influencing the implementation of MWPs in Foundation Phase classrooms. Some concerns were raised.

I was interested in these respondents' "thoughts, beliefs, knowledge, reasoning, motivations and feelings about the topic" (Johnson & Christensen 2008:207). Diverse reflections were gathered which contributed to the richness of the data. During teaching practice, student teachers connected their mathematics subject-matter knowledge and mathematics pedagogical content knowledge with their experiences in practice and their own developing teaching philosophy. I do not prescribe specific teaching methodologies, but rather allow students the freedom to explore various teaching strategies (such as those discussed during lectures, their own ideas, and/or the ideas of their teaching practice teachers), taking into account learner diversity. The student teachers responded to an open-ended question related to their own practical classroom experiences, connected with their university-gained theoretical knowledge, some self-study, and their own beliefs. Their reflections therefore displayed the connections between their different types of knowledge and the application of their abilities.

Another component of their reflections was based on the classroom teachers and the learners. Student teachers reflected on what they had observed, with specific reference to actions and interactions between the teachers and their learners with MWPs during the mathematics/numeracy lesson times. Some student teachers critiqued the classroom practices, provided recommendations, and shared their own feelings about these practices.

Patton (1987:11) is in favour of open-ended, qualitative responses, as these "responses are longer, more detailed, and variable in content". These open-ended responses allow one to understand the world as perceived by the respondent.

These reflections were written in words. These provided the opportunity for respondents to participate freely. I could also avoid directing their responses with oral discussions or interrupting their responses. Such a qualitative research strategy is supported by McMillan and Schumacher (1993:483).

Although rich data was obtained from the student teachers' reflections, my personal involvement was needed. I felt uncomfortable not exploring the classroom settings personally to witness the mentioned emerging concerns. Classroom observations were thus decided upon.

3.7.2 Classroom observations

Observation is one of the qualitative data-collection strategies (Henning 2004:5). Silverman (2006:68) advises that a researcher needs to participate to experience the world, and not just to observe the world from a distance. Instead, as complete observer (Johnson & Christensen 2008:214), or non-participant observer (Cohen et al. 2007:325), I opted for classroom observation as an outsider. I wanted to observe what occurred in classroom settings during mathematics lessons, without any interference by me or the independent observer. Such first-hand data was collected to determine the reliability of the data and to support and strengthen the data obtained from the student teachers' reflections. I hoped for minimal reactivity from the teachers and the learners. Reactivity refers to a change in behaviour of people because they know they are being observed (Johnson & Christensen 2008:214-215). The classroom observations were "snapshots" (Miles & Huberman 1994:10) of reality, due to their once-off occurrence.

Qualitative studies place researchers in social settings, with the intention of making sense of these settings. The data-collection tools for this fieldwork research method are direct observation recordings in field notes, as well as interviewing. Such observation studies are usually characterised by a smaller amount of time spent in the field, where the researcher often enters the field with specific interests and/or specific questions (Hatch 2002:22). In this study this is demonstrated by the few classroom observations and the immediate follow-up unstructured interviews.

Classroom observations were unstructured in order to enter practice open-minded and unbiased. The phenomenon that was being researched was kept in mind. Consequently, the observations focused on MWPs during mathematics/numeracy lessons. The teachers as prime participants were observed. Due to the social interaction between the teachers and the learners, the learners' responses to the situation were also observed. I recorded the actions, conversations, and engagements of the teachers and learners as field notes during each observation. In order to avoid my own bias, to ensure an authentic and accurate recording of the classroom observations, an independent non-participant observer accompanied me to each classroom visit.

Thirty to fourty-five minutes were allocated for each classroom visit. Participating teachers were requested to teach as they would usually teach, and not to teach in a contrived manner for the sake of the research project. The everyday interactions were essential for obtaining reliable data. The main purpose of these classroom observations was to witness the everyday teaching and learning of mathematics (in the numeracy learning programme), with particular emphasis on the teaching of MWPs. The focus was on *how* and *when* MWPs feature during teaching time, as well as the teachers' and the learners' involvement. These aspects were mainly focused on as a pre-design, inspired by the student teachers' reflections, but, as mentioned, I attempted to stay “open-minded” regarding any aspects that might not have been mentioned that might be observed during the actual observations.

During the observations, field notes were recorded in writing, to capture the essence of what took place in the real-life classrooms (Miles & Huberman 1994:9). The recording of observations requires prompt writing and discipline to record only what actually happened (Cohen et al. 2007:260). Field notes were recorded from an interpretivist perspective. I decided to make notes as the observations took place, especially when observations took place consecutively. All observations were transcribed in detail shortly after the observation.

Observations are to some extent selective, as the researcher as observer selects which information to record as field notes. Reporting on observations requires a disciplined approach. Wariness of tunnel vision, bias, and self-delusion is required (Miles & Huberman 1994:56).

3.7.3 Interviews

Short interviews with the classroom teachers were conducted where time allowed and if teachers were willing to respond. The need for these interviews was determined during the observation, for reasons such as MWPs not being included, or if any other interesting incident of value to this study was noticed. In particular, teachers whose teaching practice was more satisfactory were interviewed. I was interested in gaining understanding of the participants’ perspective on the topic of MWPs (Johnson & Christensen 2008:207; Patton 1987:11).

The teachers responded verbally to open-ended questions, supported by qualitative researchers (Johnson & Christensen 2008:207; Schurink, Schurink & Poggenpoel 1998:314; Patton 1987:11).

Focused and careful listening is required during interviews (Johnson & Christensen 2008:206). Data gathered in this manner were written as field notes immediately after each interview to avoid data loss, and the notes were placed with the matching observation. Interactions between the observer and the participants enrich the understanding of the realities experienced (Laverty 2003:26). Interviews, as interaction, contribute to a better understanding and alternative perspectives on realities (Toni 2009:51).

3.8 ETHICAL MEASURES

Researchers conducting research in the field of the social sciences need to be aware of ethical issues. Researchers enter the private lives of participants. All participants need to be treated with respect and dignity (Berg 2001:39). The privacy and rights of all participants need to be ensured (Kumar 1999:191). Researchers need to recognise proper and improper conduct in data gathering (Babbie 2005:62).

Revealing the views of the participants is crucial. The privacy and confidentiality of the participants need to be protected and ensured. These ethical needs remain a necessity.

I adhered to ethical issues when I conducted my research. The identities of the student teachers, the teachers, and their learners, as well as the independent observer, were not mentioned. The names of the schools were not revealed.

The ethical requirements from the university were adhered to, and procedural requirements were followed. Permission from school principals and the DoE was obtained. The participating teachers indicated their availability in writing. Ethical issues were also reflected in the reliability and validity issues.

3.9 DATA ANALYSIS

Data analysis is the process of ordering, structuring, and creating meaning from a variety of collected data (Johnson & Christensen 2008:531; De Vos 2002:339). Due to the non-linear tendency of qualitative research, data analysis is a time-consuming and ambiguous process, but also creative and fascinating (De Vos 2002:340). Qualitative research aims to discover patterns, themes, and holistic features while analysing the data (Johnson & Christensen 2008:531). It is a mammoth task for qualitative researchers to look for themes in the data (De Vos 2002:340; Creswell 1998:139).

The value of qualitative research is to collect multiple data over a period of time, with data analysis commencing early in the study. Data analysis can occur concurrently with data gathering (Johnson & Christensen 2008:531; McMillan & Schumacher 1993:480). This results in a cyclical process of data collecting and the analysis of data, repeated a few times as needed. This cyclical process is called "interim analysis" (Johnson & Christensen 2008:531; Miles & Huberman 1994:428). Creswell (1998:142-165), cited by De Vos (2002:340), refers to a spiral of data analysis and explains that a procedure of analytical circles is preferable to a linear approach. Interim analysis supports the researcher to refine his or her developing theories (Johnson & Christensen 2008:531).

The mentioned cyclical processes emerged as my study progressed. The yearly student teacher reflections, collected over time, were analysed. These reflections were completed by student teachers in written format (thus already a transcript). The generated themes inspired the classroom observations conducted by me. Reliability and validity considerations created the need for more field notes to be collected by an independent observer. Clarity issues resulted in unstructured interviews being conducted with participating classroom teachers immediately after each completed observation.

According to Wolcott (2009:86-87), the researcher needs to satisfy readers with sufficient detail about *how the data was obtained that the researcher actually used*, despite recognition that the researcher is the "best source of information about the confirmability of what has been reported". Special attention was paid to explaining in as much detail as possible how the data was obtained for this study.

3.9.1 Student teachers' reflections

Theory guided the inquiry (Wolcott 2009:71) of the student teachers during their teaching practice in the Foundation Phase classrooms. Their reflections are therefore their views of how they observed classroom teachers and how they experienced implementing their theoretical knowledge in practice.

The student teachers' reflections were analysed systematically and precisely to communicate what was determined. Inductive analysis was used to look for emerging themes (or categories) and patterns (Wolcott 2009:29; Miles & Huberman 1994:9; McMillan & Schumacher 1993:480). Inductive analysis creates opportunities for multiple realities, since pre-imposed ideas were not selected before the data-gathering process commenced (Potter 1996:156). This analysis approach also ensures an enhanced description of the context. Miles and Huberman (1994:69) also refer to pattern coding, which is a process to identify emerging themes. The purpose of this analysis method is to divide the data into more workable chunks, to develop a cognitive view of the phenomenon, and to create a more focused approach towards later fieldwork.

During the analysis process, I had to apply the rule to exclude or separate emerging interpretations from descriptive data. Interpretations and opinions by the student teachers were placed in square brackets (McMillan & Schumacher 1993:485). Open coding was conducted for the descriptive data. De Vos (2002:345) describes open coding as “the process of breaking down, comparing, conceptualising and categorising data”.

The most commonly used format for displaying data in qualitative research is extended text (Miles & Huberman 1994:11). It is human nature to experience cognitive challenges when larger quantities of data need to be analysed and processed. The complexity of the situations observed might not be captured in the written text.

3.9.2 Classroom observations

The participating teachers were requested to continue with everyday mathematics classroom practice. As a result, rich data were collected during the classroom observations. Data reduction was needed to focus on the research questions. A data-reduction process was incorporated in the analysis process (Miles & Huberman 1994:10-11).

The themes which emerged from the student teachers’ reflections were used to guide the classroom observations. Hence, an open mind was kept to remain unbiased and to record the reality of the specific setting. For this reason, I opted for the research method of discovery analysis. Discovery analysis occurred as interim ideas emerged during the data gathering, while I was making field notes during the data-gathering process (McMillan & Schumacher 1993:480).

Transcription of data is the process of capturing the field notes from interviews as typed text (Johnson & Christensen 2008:534). Once the observational field notes were transcribed, open coding was used. The existing themes from the student teachers’ reflections were retained, connected with what was observed, and used for confirmation during the interpretation process. Differences were identified and revealed.

While conducting the analysis process, the data was categorised into three broader categories guided by the three research sub-questions (See section 1.5 for more detail). The categories focusing on the first two research questions were analysed in depth for emerging themes. This data was interpreted to reveal the observed factors influencing the teaching and learning of MWPs. The analysis of the third category was inspired by questions such as the following: What is different in some classroom practices which inspire learners to work more independently? How are the teacher interactions different? What do the teachers and learners need to know (individually and collectively) in order to do what they are doing?[33] These analysis questions guided my thinking while engaging with the data, in order to address my concerns with the phenomenon of the MWP. The analysis questions (implemented to sort the data) were interpreted from the perspective of the classroom observations and were expanded by the student teachers' reflections on each research question.

3.9.3 Unstructured interviews

During the unstructured interviews, I posed questions to the participating teachers to clarify certain observations. My main interest related to why MWPs were implemented, or not implemented, in classroom practice. Field notes were taken after each interview.

The interviews were transcribed soon after the observations and the interviews had been completed. This was done as a time delay could have resulted in some data getting lost (Miles & Huberman 1994:66). Open coding was used once again.

3.9.4 Coherence of the data

Analysis of the multiple data required coherence for a *holistic*[34] view. The three methods of coding mentioned by De Vos (2002:345-346) were implemented. As mentioned, open coding was used for each category of data gathered. Axial coding

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[33] This question and the analysis ideas are inspired by Wolcott (2009:37).
[34] This relates to the views of Lichtman (2006:8-15) and Coleman (2003:153) regarding a holistic, connected view of the phenomenon being investigated.

followed. Axial coding is a process of connecting the themes which have emerged in each data category, to create a more holistic message. The rich data revealed several themes and emerging concerns regarding the phenomenon of the MWP. As this study is limited, selective coding was employed to reveal the core themes which most suitably validated and addressed the three research questions.

To avoid tunnel vision when writing up my own observations (Wolcott 2009:72), the student teachers' reflections were used to support statements and/or to elaborate with a larger data spectrum, in order to determine a clear perspective. Comparisons between various field settings (that is, the various classrooms observed) and the multiple samples enrich interpretation possibilities (Miles & Huberman 1994:245). Large differences further contribute to the richness of the interpretations (Miles & Huberman 1994:245).

I am convinced that the process of data analysis, although complex, reveals the embedded data as observed and transcribed. The participants' views were kept unchanged. I will present and interpret the collected data in the following chapter.

CHAPTER 4

RESULTS

4.1 INTRODUCTION

This chapter seeks to discuss what was revealed by the data-gathering process. The main research question *Which factors influence the implementation of mathematical word problems in Foundation Phase classrooms?* was kept in mind at all times during the process of scrutinising the results. The data addressing each research sub-question is dealt with separately. These sub-questions are *What challenges, if any, are encountered in the teaching or implemention of mathematical word problems? What challenges, if any, accompany the learning of how to solve these problems?* and *How can these identified challenges, if any, be addressed*?

The qualitative data gathered by means of student teacher reflections, my own classroom observations, and the unstructured interviews were analysed according to emerging themes within the framework of the reviewed literature. The data provided by the independent observer was also taken into account.

Interpretation is the human activity of making sense of the gathered data (Wolcott 2009:30). Interpretations and critique need to arise from the data (Laverty 2003:24, 31). In order to avoid including personal bias, the reporting requires a disciplined approach. The research issues need to be reported on in their complex state, and not revealed in an oversimplified manner (Wolcott 2009:32). It is by no means my intention to point fingers or to blame any teachers for what they are doing or not doing during numeracy/mathematics teaching and learning time. Rather, it is my objective to determine current practice in the selected sample of classrooms, in order to determine the factors that influence the implementation of MWPs in foundation phase classrooms and that cause learning challenges, as well as to reveal more effective classroom practices. My aim is thus to strive towards "good practice" (Cooper 2010:170), specifically with regard to more effective learner performance in MWPs.

As mentioned in Chapter 1 of this study, Jansen (2011:19) questions the purpose of repeatedly identifying negative performance of teachers and learners in mathematics. Such an awareness of influential factors leads to supportive qualities to assist teachers and student teachers in their lesson planning and implementation.

4.2 RESEARCH QUESTION

The research question of this study is *Which factors influence the implementation of mathematical word problems in Foundation Phase classrooms?* With the aim of respond to this research question, three sub-questions were identified. (See 1.5). These three sub-questions provide a multiple focus on the main research question and attempts to pay attention to the factors influencing the most important humans involved (thus the teachers and learners) with the implementation of a specific phenomenon (MWPs) in mathematics teaching and learning, in a specific context (the foundation phase classroom).

4.3 RESEARCH SUB-QUESTION 1:

What challenges, if any, are encountered in the teaching or implemention of mathematical word problems?

Several themes emerged from the observations and interviews. The most commonly occurring factors were selected. These themes were connected to the student teachers' reflections. The data will now be discussed according to these themes and with relevance to the three research questions.

4.3.1 The featuring of MWPs in mathematics teaching

Various approaches to include MWPs in everyday teaching were observed in the 14 Foundation Phase classrooms in which observations were conducted. Most of the teachers[35] who participated in this study used MWPs as an application of basic mathematics knowledge at the end of the observed lessons. Four teachers used

[35] There were eight teachers in total, namely one Grade 1 teacher, four Grade 2 teachers, and three Grade 3 teachers.

alternative approaches. One teacher used storytelling with MWPs embedded throughout the story and which contributed to the detail of the story. Another teacher used progression from the direct modelling approach to the mathematical modelling approach. Yet another teacher spent the entire lesson engaging with learners while they solved a worksheet on MWPs in pairs. Still another teacher used a problem-centred approach with one MWP featuring for the duration of the lesson. These alternative approaches are discussed under Research Sub-Question 3 (see section 4.5).

Two teachers did not include any MWPs in the lessons observed. These teachers revealed in their responses in a short interview after their lessons that they only include MWPs when time allows. They shared beliefs that their core responsibility is to ensure that “their learners can do basic mathematics”. The Grade 1 teacher considered MWPs as too advanced for Grade 1 learners. The Grade 2 teacher mentioned that she only includes MWPs when these mathematics problems appear on an assessment task or on a worksheet.

During the interviews, a number of teachers mentioned that a large amount of time is spent on assessment. They felt that little time was available for “extras” such as MWPs, and that basic mathematics knowledge therefore had to remain a priority. A few teachers added that Foundation Phase learners had to be more equipped with basic mathematics knowledge before they could be allowed to attempt MWPs.

The student teachers’ reflections revealed a wide range of implementation models by the teachers that they visited for teaching practice, from no MWPs embedded in everyday teaching (due to similar beliefs to those mentioned above), to actively engaging learners in multiple opportunities to solve MWPs. These reflections also confirm that teaching focused mainly on solving number problems (MNPs), and not contextually based problems or MWPs. These reflections confirm the trend to use MWPs for the application of basic mathematical knowledge at the end of a lesson, if time allows. In some classrooms, only fast-working learners were provided with MWPs to solve, as they had to be kept busy, while slower-working learners were simply left with number problem activities to complete. Thus, as one student teacher noted, “no equal opportunity for all learners occurred”.

One particular Foundation Phase class, which solved MWPs only as homework, was observed by a student teacher. These learners were instructed in advance how to solve this type of problem. They had to write their solutions in a particular way, as prescribed by the teacher.

As mentioned, I was made aware by one teacher that MWPs were only used for assessment. This trend was experienced and confirmed by some student teachers. Although the teaching and learning of MWPs did not take place in mathematics lessons, the learners were assessed on these problem types.

4.3.2 Types of MWPs

Various typical routine MWPs were posed. Only three teachers (one Grade 2 teacher, and two Grade 3 teachers) attempted to expose learners to more real-world MWPs. The majority of MWPs provided straightforward information which exposed the operation fairly clearly. Intensive thinking and reasoning was not necessarily required with the typical routine MWPs used. The real-world MWPs used in the Grade 3 classes were more challenging and more non-routine MWP types for Foundation Phase learners. The contexts used were *pouring tea* and *pizza problems*. (See section 4.5 for more detail.)

The prevalence of implementing mainly routine MWPs was confirmed by the student teachers' reflections. The MWPs consisted of short statements and an accompanying question. Furthermore, most of the MWPs were single-step problems, meaning that only one step was required to solve them. The more sophisticated contexts utilised were money, eating, and birds. Examples of these MWP contexts are:

- Money MWPs, including MWPs about buying, selling, paying, calculating totals, and determining change.
- Eating MWPs, e.g. Valmarie eats 3 sweets and Henru eats 4 sweets. How many sweets have they eaten altogether?
- Bird MWPs, e.g. There are 6 birds sitting on the wall, and then 3 fly away. How many birds are left on the wall?

A few teachers mentioned during the interviews that for them the main purpose of MWPs is for Foundation Phase learners to find the "hidden number sentence in the wording". Some teachers expected learners to interpret the keyword in the question of the MWP to identify the required calculation. An example of such a word is "altogether", which always requires addition, according to some teachers.

4.3.3 The posing of MWPs

Several realities regarding the posing of MWPs were revealed during classroom observations.

MWPs were posed verbally to Grade 1 and 2 learners, but often in writing to Grade 3's. Grade 1 and 2 teachers who were interviewed about this matter mentioned that they felt that their learners would either not be able to read the MWP, or would take too long to read it and would not know afterwards what they had read. Some teachers felt that their learners would lack the ability to read independently.

In most instances, the teachers initially read the MWPs to the Grade 3 learners. Thereafter, learners could refer to the written MWP as needed, while they attempted to determine the solution. During the interviews, the teachers expressed their learners' inability to comprehend an MWP by reading it themselves, and therefore they did the reading on behalf of their learners.

Only two of the Foundation Phase teachers posed the MWPs and allowed learners to attempt the problem independently, before they engaged with the learners. Most participating teachers all immediately reverted to explaining what the MWP required after posing it, highlighting some words as operation indicators, or they were prescriptive and told learners exactly how to solve the MWP, or a combination of these actions. When interviewed, teachers responded that that there was insufficient time for the quantity of work that they had to complete, and that therefore they did not have time to wait for learners to struggle to read these problems. They also shared their belief that learners were unable to do MWPs, and that they therefore were not keen to invest too much time in this aspect of the curriculum. One teacher explicitly mentioned that her learners' reading was so poor that she knew they would not be able to identify all the words, and that they therefore would not be able to comprehend what they had attempted to read.

The student teachers' reflections confirmed this notion. The student teachers expanded the data with reflections that most MWPs were posed verbally to learners (with either the whole class, or to small groups), and that student teachers almost never viewed the MWPs in writing while the learners were facilitated by the classroom teachers. Hence, when working independently, the learners received the MWPs in writing. Expectations were that learners had to use auditory perceptual skills and interpretation skills while engaging with MWPs in the presence of the teachers, but had to rely on visual perceptual (that is, reading) skills and interpretation skills when working independently. Several learners experienced difficulty in making connections between the auditory and visual requirements.

4.3.4 The teachers' interactions with and support to learners

Teachers' interactions with and support to learners varied widely. Support seemed to be provided at times before an actual need was displayed by learners. Several teachers tended to prescribe MWP-solving strategies to learners or would focus learners' attention on certain vocabulary as so-called "clues" connected to certain mathematical operations.

During the observations, one teacher became quite upset with her Grade 2 learners when they were unable to provide the solution to the MWP immediately after it was posed to them. These learners had to apply mental calculations. They were shouted at for being so slow and told that they were embarrassing her and themselves in front of the visitors (that is, the independent observer and myself). Eventually one learner responded. The response was incorrect. The teacher quickly corrected the learner and continued with another mathematics number activity. After the lesson, before I could ask any questions, she apologised that her learners had not been able to do the MWP. When I questioned her why writing materials and concrete support materials were not available, she responded that the learners need to be able to respond quickly to MWPs, as they cannot "sit on it the whole day". She also mentioned that she did not like to teach MWPs and did not often use these problem types in mathematics lessons.

The support that several teachers provided can be viewed from an educational perspective as wasted thinking and reasoning opportunities for learners, as well as a rejection of learners' diverse individual MWP-solving approaches and strategies. This was evident in the prescriptive manner that learners were told which strategy to use. It was also evident when some teachers hammered into their learners certain keywords which, in the teachers' opinion, indicate mathematical operations (that is, addition, subtraction, multiplication, and division). In the case of the latter, learners had to immediately respond with the appropriate operation according to the preference of the teacher, which did not always correspond with the thinking of the learner. For example, in one lesson a multiplication MWP was posed, and some learners wanted to initiate their problem solving with counting in multiples and/or repeated addition. Only one learner progressed immediately to multiplication after a picture was drawn. The teacher reminded the learners that she wanted multiplication only. This progression can occur only when learners are familiar with multiplication, can see and understand the connection between addition and multiplication, and feel confident to use multiplication. The teacher's comment during the interview was that she had taught them multiplication the previous day and expected them to apply this operation in a MWP on the day of the observation.

Some teachers revealed in the interviews that time constraints encourage them to speed up the learning process and use keywords related to mathematical operations, as a quick way of "making progress". As one teacher said, "I need to ensure that I provide the learners with these shortcuts". The response to my question "What do you do when not all learners understand how to use these shortcuts?" was that this was knowledge that the learners "simply need to learn and remember".

The student teachers contributed to the different interactions between teachers and learners. They expressed the view that some learners had to solve MWPs mentally and respond verbally most of the time, that learners were often instructed which problem-solving strategies to use, that learners were often not allowed to use their own thinking and reasoning strategies, and that in some classrooms learners were only allowed to use an abstract response to MWPs. A few student teachers witnessed teachers who would pose an MWP and immediately graphically represent the MWP as a drawing on the chalkboard, to indicate the meaning of the MWP.

The teachers did most of the talking during the teaching and learning of MWPs. In several classrooms learners were granted little, if any, opportunity to discuss the problem and interact with their peers to determine problem-solving strategies and solutions. Most teachers were only interested in hearing the final answer, as quickly as possible.

Both the student teachers and I observed that teachers rush learners to obtain solutions to MWPs. Neglect to discuss MWPs in depth and to correct errors in solving MWPs independently (that is, not paying attention to learners' errors) and reluctance to offer in-depth learner support were noted.

4.3.5 Manipulative support materials

There was often a discrepancy between the needs of learners and the use of manipulative support materials. Opportunities for learners to manipulate concrete materials while graphically representing the problem-solving strategy and understanding the MWP were often not allowed by teachers for a long enough duration, or at times not at all.

The student teachers' reflections confirmed the different experiences that Foundation Phase learners were exposed to. In some Foundation Phase classrooms, learners were allowed to support their thinking and reasoning through graphic representation, while learners in another class were instructed to provide the abstract number equation first and then explain their thoughts by means of support materials. There were even some Foundation Phase learners who were allowed to function only on the abstract level. As one student teacher mentioned,

> My teacher said to the Grade 2 learners that concrete manipulatives are only for Grade 1's.

This was evident in the classroom observations as well. Very few teachers allowed learners to use manipulative support materials. When questioned during the interviews, the response was that learners had to learn how to solve MWPs mentally, or on the abstract level. One teacher mentioned that it was too time-consuming to unpack teaching and learning support materials every day. Another teacher felt that learners needed to "outgrow" concrete manipulatives when they enter Grade 3. One teacher reminded me during the interview of the outcome that her learners had achieved, namely to provide and/or write a number sentence with a final answer relevant to the MWP.

Two teachers that I observed expected learners to first produce the abstract solution to the MWP and then demonstrate the problem-solving strategy with concrete teaching materials and then with a drawing. When interviewed, one of these two teachers responded that she wanted learners to first do mental calculations until she agreed that they had the correct solution, and then learners had to display the solution to her with manipulative materials. The second teacher expected learners to check their responses by using manipulative materials, without her prior confirmation of their solution.

I observed a Grade 1 teacher who expected her learners to solve an MWP on the abstract level, as she requested them to "write the sum". When the learners did not respond accordingly, she started to draw a picture on the chalkboard to represent the MWP. Once she had completed the picture, she instructed the learners to use her picture to write the number sentence. When most of the learners were still unable to carry out her instruction, she asked them "Can't you see it?" She was not willing to be interviewed after the lesson.

4.3.6 The teachers' beliefs and expectations

Different expectations from the same age group of learners were noted. Although the same curriculum (the RNCS) was implemented in all the classrooms, the methodologies used by the teachers varied. Teachers expected their learners to apply mathematics knowledge that they had not yet grasped and could not yet apply with confidence. The evidence to support these observations has already been mentioned among the previous factors discussed.

Teachers' beliefs about the abilities of their learners also varied. Some teachers believed that their learners were unable to think and reason about MWPs, and they consequently prescribed problem-solving strategies to them. They underestimated the abilities of their learners, as a few student teachers reflected that when they implemented MWPs, the so-called "unable[36]" learners did manage to solve the

[36] The teacher used the word "un-able" and is therefore quoted directly.

MWPs, although not all of these learners managed to use sophisticated abstract strategies.

Some teachers did not want to attempt teaching MWPs in their lessons, despite the fact that these problem types are embedded in the mathematics curriculum. These teachers believed that their learners were unable to solve any MWPs.

Several teachers prefer learners to first obtain basic mathematical knowledge (such as counting, basic operations/calculations, fractions, halving, and doubling), and then apply this knowledge in solving MWPs.

Not all teachers enjoy solving MWPs. This reality was confirmed by a teacher that I observed (see section 4.3.4). Another teacher was quoted by a student teacher as saying that she hated MWPs as her learners never understand these problem types", and for this reason never include MWPs in everyday teaching and learning of mathematics.

4.3.7 Teachers allowing for learner creativity

Learners seemed to enjoy designing their own MWPs when given the opportunity. In my limited time during classroom observations I witnessed one such an opportunity. Unfortunately the teacher constantly interrupted the learners while they were verbally sharing their MWPs. The interruptions were to make corrections to learners' use of language. Because of these interruptions, one learner said that she could not remember what she wanted to say, and consequently did not complete her MWP. The teacher did not pay attention to this learner.

Student teachers mentioned that although there were just a few opportunities created by teachers for such creativity from learners, the learners were nevertheless keen to participate. When the student teachers attempted such an activity with the learners, the learners had "great fun" in designing and solving one another's MWPs.

4.4 RESEARCH SUB-QUESTION 2:

What challenges, if any, accompany the learning of how to solve these problems?

The first research sub-question examined factors that influence MWPs from the perspective of the teachers. This second research sub-question will focus on the learners and how they experienced MWPs in various ways.

4.4.1 How learners experienced MWPs

Although all the Foundation Phase learners observed were in Foundation Phase classrooms in the same metropole, their experiences of MWPs varied considerably. In most classrooms where MWPs were implemented, the learners were required to listen to the verbally posed MWP, try to remember what was heard, internalise and understand the MWP, and immediately respond with the solution. In some classrooms, the learners did not attempt to respond, as they were waiting passively for the teacher to do the explanation and instruct them on which strategy to implement towards the solution. Learners asked a student teacher to inform them which problem-solving strategy to use, because they said that “our teacher always tells us what to do”.

During the observations, after posing the MWPs, several teachers immediately instructed the learners as to which problem-solving strategy they were to use. The teachers revealed during the interviews that they were aware of the inability of their learners to solve MWPs, and that they therefore viewed it as their responsibility to support their learners and instruct them on what to do.

In a few classrooms, learners were allowed to use manipulative materials for a direct modelling approach (that is, drawing a picture, or displaying their understanding by means of concrete materials), but they also had to provide the mathematical modelling (that is, the abstract number sentence). Some teachers expected all learners to provide the mathematically modelled solution, without their being given the opportunity to graphically represent their thinking and reasoning. Not all learners displayed the required readiness to provide a number sentence orally and/or in writing.

In some classrooms, the learners were confronted with frustration from their teachers, as they were rushed to provide the answer and even shouted at if they could not solve the problem. One teacher even mentioned to the learners that they were "silly[37]", and then she provided the solution by making a drawing on the chalkboard and instructed the learners to show by means of concrete manipulative materials what she had drawn. Then she wrote the number sentence on the chalkboard, and the learners had to copy her drawing and number sentence onto paper. After this activity in a small group, the learners were instructed to solve another MWP in their seats and do what they had done in the small group, but this time they had to draw and write in their workbooks. The learners could not all do what was required of them. The teacher was quite frustrated and told the learners that they would continue with the activity the following day.

The student teachers revealed similar experiences to those mentioned above. High levels of frustration occurred in some classrooms, and some learners did not grasp MWPs, as their teachers believed that their learners did not grasp the mathematics concepts to be able to solve MWPs at the teachers' required pace.

Several student teachers and I witnessed learners being prescribed how to solve MWPs. This resulted at times in the development of some dependent behaviour, as learners did not develop confidence in tackling MWPs. Furthermore, learners did not explore or value their own different thinking and reasoning styles as relevant or acceptable, as the teacher would direct them to her own prescribed style, which they did not understand.

My observations also revealed inequalities in learner opportunities and experiences. Most learners were deprived of the opportunity to think and reason according to their own learning style and had to deal with prescriptive instructions which they had to follow. The learners' participation was often passive and more teacher-centred. This was evident, as the teachers did most of the talking in the MWP-solving sessions. Some learners even had to listen to the thinking of the teacher and then had to copy the teacher's strategy and solution from the chalkboard. The interviews confirmed teachers' beliefs about learner inabilities.

[37] The word "silly" is a direct quote of the word used by the teacher. The teacher might also meant that the learners were "stupid".

In the classrooms where learners were allowed to experience MWPs in a less restricted and prescribed manner, the learners eagerly engaged with the MWPs and sought solutions. These learners manipulated support materials with confidence. It was evident in the observations that these learners were frequently exposed to MWPs. Although not all learners solved MWPs on the same mathematical level, the teachers accepted their efforts and supported them so that they progressed from their current level of achievement. Leading questions were posed, rather than answers being revealed. Learner contributions were valued and used for further knowledge development and progression. Cooperative learning from peers was encouraged. The details of these observations are explained in section 4.5 of this chapter.

4.4.2 Language issues and MWP experiences

In the classrooms where observations took place, the language of instruction was not the same as the learners' home language. As language was an issue in these classrooms, the teacher would first speak the home language of the learners and allow them to solve the MWP in this language, before the learners were instructed to repeat their feedback in the language of instruction. This was confusing for some learners, as they did not know which vocabulary to use.

Listening to an MWP, internalising its meaning, and attempting to solve it is a process. Some learners were not allowed the time to experience this process, as they had to rapidly produce a solution. Some learners were confronted with a teacher who would pose the MWP and immediately provide a drawing to graphically represent the MWP on the behalf of the learners, or would orally explain the MWP to them. The learners' right to follow the mentioned process was not satisfied.

In some classrooms, the teachers highlighted some keywords and asked the learners to mention which basic mathematical calculation they needed to do when they heard certain words. The context of the MWP was not discussed.

The student teachers experienced similar mathematics situations. Several student teachers satisfied learners' needs by means of reading assistance when the learners were handed a worksheet with MWPs to solve. Some learners concentrated on word recognition, and therefore missed out on the meaning of the MWP.

4.4.3 Learner diversity

Learners are diverse and do not all internalise experiences with MWPs in the same way. This is evident in their behaviour and work etiquette when embarking on solving MWPs.

Some teachers in my research sample had set ways of dealing with MWPs, and the different needs of the learners were not taken into consideration. All the learners were expected to follow the same strategy. Consequently, learners' needs were not necessarily addressed by means of alternative teaching methods, neither were the learners allowed to express their own ideas.

Previously (see above), several observations about learner diversity being neglected were mentioned. This ignorance was observed by the independent observer and me in most classrooms, and was also reflected on by the student teachers. Only in four classrooms were the learners allowed to apply their own strategies and engage with the MWPs from different entry points. These learners were more eager to solve MWPs and were keen to keep on trying in their search for the solution. In one classroom, I observed learners supporting each other to make sense of the posed problem. It was clear that these learners frequently solved MWPs. They took responsibility to solve the MWPs in groups, but still worked independently, and only involved the teacher when needed. Their requests to this teacher were for guidance and reassurance, and they never asked what they had to do.

When comparing the ability of all the learners from the various classrooms observed, it was noticeable how different these learners were in their ability. They ranged from very confident problem solvers to very dependent learners.

4.5 RESEARCH SUB-QUESTION 3:

How can the discovered challenges, if any, be addressed?

Various factors influencing the implementation of MWPs from both a teaching and a learning perspective were identified in the data. These factors include mathematics, language, educational and human (both teacher and learner) concerns. The mathematics concerns included in this study are the featuring of MWPs as an integral part of mathematics teaching and learning. The roles of language in and for mathematics learning, and specifically to understand and solve MWPs, were identified. The need to read and interpret an MWP holistically, and not just isolate keywords for the sake of a basic mathematics operation, was identified as a factor influencing learners. The educational value of MWPs to enhance thinking, reasoning and problem-solving skills within the context of the subject mathematics requires attention as another influencing factor. Human interactions, especially interactions of teachers with learners, were another factor of concern.

Four Foundation Phase classroom observations were rewarding in the sense that learners seemed to enjoy the mathematical experiences in solving MWPs, but these learners also displayed qualities of (some kind of) independence in their approach to MWPs. These four experiences were selected as examples of classroom experiences of “good practice”. Each of these four experiences elicited educational qualities which both the independent observer and I valued as examples of “good practice”. These experiences are the narrative (storytelling) approach, the direct-modelling-to-mathematical-modelling approach, the worksheet approach, and the problem-centred approach. These approach explanations are accompanied by the interview disclosure. The “good practice” descriptions are revealed as part of the conclusion in Chapter 5.

4.5.1 The storytelling approach

One group of learners from the Grade 1 class in which this approach was applied sat with their teacher. The rest of the class were involved in independent mathematical written activities in their seats. The group with the teacher listened to a story that they were familiar with. Integrated in this story were several MWPs which required solving. Each time the teacher mentioned an MWP in the story, she stopped, and only continued the storytelling once the MWP was solved. Learners took turns to dramatise the MWP, using several real objects. Then the rest of the group solved the MWP in whichever manner they preferred. They had writing materials and concrete manipulative materials that they could use.

The learners enjoyed this experience, and one learner even expressed her disappointment when they reached the end of the story, as she wanted it to continue.

The interview

The teacher revealed in the interview that she often used storytelling and/or role play when teaching MWPs. She expressed her view that this approach is successful with young learners, because they enjoy stories. She also shared that she uses pictures and props with the storytelling, to enhance visualisation and learner interest. This teacher also stated her preference to work in small groups, rather than with the whole class, when solving MWPs. She stated that she prefers the more one-on-one contact that she has with the learners when working in small groups. She said that she then has the opportunity to get to know the learners' learning, understanding and problem-solving style, as well as determine their needs.

4.5.2 The direct-modelling-to-mathematical-modelling approach: the baking tray MWP experience

In the Grade 2 class with whom this approach was applied, the teacher likewise worked with one small group at a time, while the rest of the class completed a mathematics worksheet independently in their seats. The small group with the teacher had to solve a baking tray MWP, namely the following:

> There are 3 gingerbread men in a row and 3 rows on the baking tray. How many gingerbread men can be baked at a time?

The teacher was somewhat prescriptive, in that she instructed the learners to first draw their understanding of the MWP. Once they had discussed the drawings, they were allowed to convert their direct modelling to mathematical modelling. It was interesting to observe how one learner first wrote the multiplication number sentence with the answer on the reverse side of the paper provided, and then only made the required drawing. Although the teacher noticed this learner's sequence of actions, she did not make any comment. Once all the learners had completed the mathematical modelling, the various strategies were discussed and compared. Learners had the opportunity to explain their strategy. The differences and similarities were noted. Special attention was paid to the fact that although the learners used different strategies, they all came up with the same solution. The strategies used were mainly repeated addition (3 + 3 + 3 = 9), and counting in multiples of three (3; 6; 9). Only one learner used multiplication (3 x 3 = 9).

The learners then had the opportunity to solve another MWP. They had to determine how many gingerbread men would be on three of these trays. They were instructed to first use direct modelling before they did mathematical modelling. The teacher encouraged them to use either their own strategy, or to try one of the strategies of their peers that had been discussed. Most of the learners used their own strategy again, but after counting in multiples of either 3 or 9, they wrote either the repeated addition number sentence, or the multiplication number sentence. Only the one learner who preferred to reverse the two kinds of modelling (mentioned in the previous paragraph) again wrote the multiplication number sentence on the reverse side, and then made the required drawing.

The learners were confident in their approach to the MWP. They were keen to participate in solving the MWP, and to share their strategy with their peers. Appropriate mathematical vocabulary was used by the teacher and the learners. There was no emphasis on keywords as operation indicators. Learners had the freedom to explore, discover, and discuss, but within the prescribed direct-modelling-to-mathematical-modelling approach.

The interview

During the interview this teacher expressed her belief that learner differences need to be acknowledged, and need to be accommodated as much as possible. She also approved of the use of cooperative learning between learners. Her response concerning her preference of using direct modelling before mathematical modelling was that this preference was based on her several years of teaching experience. She stated that "this approach works for me and the Foundation Phase learners”. She confirmed her flexibility when I enquired about the one learner who reversed the modelling sequence.

4.5.3 The worksheet approach: pizza MWPs

The Grade 3 learners to whom this approach was applied were seated at their double desks. This created the opportunity for them to work in pairs. They shared a worksheet with a few MWPs on it, and they had to solve the MWPs. The teacher started the lesson by relating a real-life pizza story to the class. She had a pizza box from a popular pizza company as real object to maintain the learners’ attention. This strategy worked. The procedure was that the learners read the MWP aloud as a class, the teacher then asked the learners to explain the MWP to her, and the learners were then allowed to solve the MWP in pairs in their desks. No specific problem-solving strategy was suggested. Learners had writing materials with them, but no manipulative support materials. Once a pair thought they had the solution, one learner had to write the solution on the chalkboard. A discussion followed. Within the allocated time for this lesson, the first three MWPs were dealt with at a relaxed pace. Solving MWPs by using this approach is time-consuming but appropriate, as the learners were eager to participate in all aspects of the approach used.

Towards the end of the allocated time, the teacher realised that they would not be able to finish all the MWPs in time. However, instead of postponing the remaining MWPs on the worksheet to the following lesson, she started rushing the learners. This created anxiety among some learners, who could not handle the increased pace, and eventually some learners stopped attempting to solve the problems. What initially was a worthwhile experience was thus unfortunately not maintained. It was interesting to observe how the changed behaviour of the teacher triggered different kinds of behaviour among the learners. A few fast-working learners did manage to increase their pace and still managed to provide solutions. In summary, a learning situation which at first exhibited equality changed to an experience of inequality when the teacher’s behaviour changed.

The interview

The teacher felt frustrated about the lack of time in the day to spend on teaching and learning activities. When I enquired about the possibility of reducing the number of MWPs per mathematics lesson, she did not support the idea. Her feeling was that learners need to learn to handle pressure and complete what they have been assigned to do.

4.5.4 The problem-centred approach

In the class with whom this approach was applied, the desks were grouped together to accommodate six Grade 3 learners per group. The teacher presented the class with the hypothetical scenario that they had to make tea for 100 parents who were attending a meeting in the school hall. The teacher then posed a non-routine MWP with a real-life context to the entire class. At first she posed the MWP orally, but then also provided the MWP to the learners in writing on small pieces of paper. The MWP was as follows:

> I can pour 13 cups from 1 teapot. How many teapots do I need to make tea for 100 people?

The learners read the MWP aloud as a class. Then the groupwork activity commenced. Each group member was assigned a role (that is, scribe, drawing artist, organiser to ensure that everybody was provided with the opportunity to participate actively, and discusser during feedback), and each group member also attempted to solve the problem. The teacher acted as facilitator while the groups were working on the MWP. She only engaged with learners when they requested assistance. She did not provide any answers or clues which would give away the solution, but posed leading questions to enable the learners to discover the solution themselves. Once she had granted the learners ample time to solve the MWP, she requested each group to provide feedback, by explaining their thinking and reasoning strategies and their proposed solution. Although not all the groups managed to provide the correct solution, the teacher allowed the groups to complete their feedback, while the other learners listened attentively. Once all the groups had explained their ideas, the class decided which solution, in their opinion, was the most appropriate. Then each group had to compare the result of their attempt with the actual solution. The groups then had to relate to the teacher what they had learned from the situation.

The teacher then posed a similar MWP to the learners. She encouraged the learners to attempt to use an alternative problem-solving strategy to the one that they used with the previous MWP, or to improve on their previous strategy. The learners were keen to take on this new challenge. One group decided to use the same strategy as before, as they had not managed to come up with the correct answer in the previous MWP, and they were keen to improve on their problem-solving skills. The leader of this group of learners related this to the teacher. The teacher was eager to motivate the learners to do what they felt was needed for them to improve their knowledge.

It was interesting to observe how this class overcame their potential language barriers. The teacher's home language was the language of instruction, while for all the learners this language of learning was their first additional language. The learners seemed confident, and although one group did revert to using their home language when giving feedback (which was allowed by the teacher), all the other groups used the language of instruction when giving feedback. I had the impression that these learners managed to handle this well-structured situation with confidence. The independent observer agreed.

The interview

During the interview the teacher was keen to reveal how she exposed her learners to similar MWP lessons at least once a week. Her weekly lesson planning made provision for MWP and MNP engagements. However, she did not follow any particular sequence. She said that "one situation just led to the next". She believed in a balanced, integrated approach which allows learners to solve problems every day. Her practice of allowing the learners freedom to explore is precious to her. She said that it demands time and space to develop a mathematical mind, and it was her intention to do just that for her learners, that is, to provide them with sufficient time and space. She shared her strategy of identifying, with the support of the learners, which mathematics knowledge the learners require to solve an MWP more easily. Such mathematics concepts would then be included in her mathematics lessons. She would then provide MWPs for the learners to solve. Her learners then had to decide which mathematics knowledge they would apply, as she would refuse to tell them. She preferred to ask leading questions, guiding the learners to self-discovery.

She expressed her belief that this approach is very successful and that she would not like to change her approach. She specifically mentioned that she had used this approach while implementing several mathematics curricula. She was convinced of the educational value of this approach.

4.5.5 Student teacher reflections

Some encouraging evidence was revealed by the reflections of the student teachers. One student teacher had the pleasing experience of witnessing a balanced approach being used, between the teaching of basic mathematics and the solving of MWPs. In the classroom in question, the teacher made sure that the learners were exposed to mathematical vocabulary, and that they were also given the opportunity to use it. Learners were allowed to first think about the problem before they attempted to solve it, they were allowed to use any method they felt comfortable with, and they were given the opportunity to explain their thinking and reasoning. The student teacher also noticed that these learners were much more advanced in their handling of mathematics in general, and MWPs in particular, than the learners in other classes of the same grade which she had observed. Although her views may be regarded as subjective, they do carry merit when compared to data obtained from the other student teachers who had observed classes in this particular grade.

Evidence revealed that some teachers would pose MWPs orally and expect learners to respond in abstract mode, and if that failed, the learners were allowed to use manipulative materials, or the teacher would demonstrate, so as to improve learners' understanding. The student teachers revealed similar experiences, with positive results.

The teaching of basic addition and subtraction by means of MWPs was observed in a few classrooms by the student teachers. Their reflections indicated how the learners seemed to grasp the concepts of addition and subtraction with more ease than was usually the case when these concepts were taught according to traditional methods. Student teachers that had attempted to introduce concepts through MWPs gave the same positive feedback.

The student teachers were generally convinced that the inclusion of MWPs in basic mathematics teaching and learning is valuable and cannot be overlooked. Especially those student teachers who attempted to include MWPs in their mathematics teaching and who experienced success are adamant about a basic mathematics-MWP balanced approach. As one student teacher wrote in her reflection,

> I think that this lack of word problems is the major cause of the learners' struggling with Numeracy. A word problem helps learners to put mathematical concepts in a real-life situation and thus gain a real understanding. I feel the importance of word problems has been completely overlooked.

4.6 CONCLUSION

In this chapter, various factors that create challenges with regard to the teaching and learning of MWPs were identified from the data gathered by means of classroom observations and obtained from the analysis of the student teachers' reflections. Furthermore, some *good practice* was discovered from the two methods of data collection.

In Chapter 5 I draw from both the literature and the data gathered by the empirical study, to offer some suggestions that should make a positive impact on the teaching and learning of MWPs in Foundation Phase classrooms.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The literature and the data gathered by the empirical study reveal factors that contribute to the complexity of the implementation of the phenomenon of the MWP, embedded in the subject of mathematics in Foundation Phase classrooms. The interpretations in Chapter 4 mirror the complexity of the reality observed (Wolcott 2009:70).

Teachers in South Africa are still in the process of adapting to the school curriculum, which has changed much since 1994, in the quest towards equality in education. The implementation of one particular mathematics phenomenon is part of this continual work in progress, in the search for a coherent South African mathematics curriculum and implementation strategy that will provide the desired education outcome in South Africa.

In this chapter I discuss insights gained from this study. This chapter also reviews "good practice" (Cooper 2010:170) strategies discovered from the classroom observations and interviews. These insights contribute to the intention to improve training (Jansen 2011:19) and support to (student) teachers, striving to emphasise hope for teachers when implementing MWPs in Foundation Phase classrooms.

Jansen's thoughts regarding the need to "overcome knowledge deficits in mathematics" tie in with my concerns on the subject of school mathematics, as mentioned in Chapter 1. The various types of knowledge described in the literature, as discussed in Chapter 2, connect with the thoughts of Jansen. Some "good practices" discovered during the observations correspond to "good practices" mentioned in the reviewed literature.

Several ideas from the literature are incorporated in the recommendations in this chapter. I cannot emphasise enough that although insights, conclusions, and recommendations are made, these are all relevant to this particular study, and cannot necessarily be transferred as they are to another context. What one learns from one study can be applied (and adapted, if necessary) in another context.

5.2 INSIGHTS BASED ON THE DISCOVERIES OF THIS STUDY

I accumulated various insights during this qualitative journey of enquiry. These insights have both some negative and some positive dimensions. The insights are only based on findings from the classrooms which were included in this study, and therefore generalisation of the insights to other classrooms is not necessarily possible.

As mentioned in Chapter 4, several insights from a teacher perspective were discovered. These are the inadequate featuring of MWPs in most Foundation Phase classrooms. The types of MWPs are limited and not always challenging to enhance thinking and reasoning, but very amenable to application. Shortcomings in some teachers' posing of MWPs to learners were underestimating learners' ability and/or not attempting to improve learners' language and mathematical abilities. The teachers' interactions with and support to learners deprived them from doing, discussing, and discovering while constructing and connecting knowledge via MWPs. Support was often given ahead of the desired need, which denied learners the opportunity to learn from their mistakes and to determine what they really know or do not know. Teachers also displayed different ideas with regard to the use and availability of manipulative support materials. The teachers' beliefs about and expectations of their learners were not always learner-friendly and often denied learners the creativity to develop and/or expand.

Chapter 4 also revealed that several insights from a learner perspective were discovered. The experiences of the learners differed considerably, highlighting the disparities in classroom practice. Teachers' anxiety, frustrations, diverse beliefs, and inappropriate expectations contributed to learners' unrewarding experiences with MWPs. Language issues that were experienced were not always addressed, and therefore contributed to learners' inability to achieve success with MWPs. Although learners in South Africa are currently living in a democratic society, the learners' classroom experiences did not reflect observance of their rights, as learner differences were not always taken into consideration during teaching and learning opportunities.

Insights gained from the various “good practices” discussed in Chapter 4 were pleasing. It was quite clear what can be achieved with Foundation Phase learners when the mentioned concerns are addressed. These discovered “good practices” tie in with the thoughts of Cooper (2010:170) and Jansen (2011:19).

5.3 CONCLUSIONS BASED ON THE DISCOVERIES OF THIS STUDY

Wolcott (2009:113) states that qualitative research does not provide conclusions or generalisations as final answers. Rather, a qualitative study reports on what was discovered from the sample of reality researched. In this study, interpretations and critique were made on the classroom practices observed and the reflections studied. Factors that negatively affect the teaching and learning of MWPs were identified. In addition, classroom practices were noted where positive teaching and learning had occurred, and they were presented as possible alternative teaching practices to enhance learning.

Guided by the three research sub-questions, the conclusions are presented according to the primary perspectives studied, namely

- The teacher perspective: Which challenges are teachers experiencing, and how do they impact on the implementation of MWPs in Foundation Phase classrooms?
- The learner perspective: Which challenges are learners experiencing, and how do they impact on learners’ learning to solve MWPs?
- The “good practice” perspective: What can be done about addressing the situation and enhancing teaching and learning about and by means of MWPs?

The data obtained from the classroom observations and interviews were confirmed by the independent observer and the student teachers’ reflections. Although there are a vast number of conclusions that can be made, I selected the most important factors to base conclusions on. The recommendations made will be based on the same factors. As a treatise, my study has limitations to the number of conclusions that can be presented.

A bullet format is used to list the conclusions. The rational for writing the conclusions as bullets, is to put emphasis on the different ideas. The bullets are also used to highlight each selected factor influencing the implementation of MWPs in foundation phase classrooms.

Despite the fact that words such as "some" or "several" have not been used, these conclusions are nevertheless not generalisations, and are not true of all teachers and learners.

5.3.1 Conclusions from the teacher perspective

- The featuring of MWPs is not explicit in all Foundation Phase classrooms, despite the NCS (both the RNCS and CAPS) requirement that learners need to become problem solvers. Not all learners are granted the opportunity to engage with MWPs. These disparities lead to a failure to observe the human right of all learners to be educated in mathematics. Not all teachers realise or believe that MWPs are embedded in mathematics education.

- Teachers did not always manage to make time to teach MWPs. Evidence obtained from the problem-centred classroom that was observed shows that it is possible to implement a balanced approach for mathematics teaching and learning, that is, an approach which makes provision for the use of MNPs and MWPs.

- Number stories provide an alternative dimension to the MWP situation. These creative opportunities are not utilised to enhance learners' thinking and reasoning.

- MWP types are mainly routine problems, which provide insufficient challenges. As learners are confronted with simple MWPs for the application of basic mathematics, thinking and reasoning opportunities are inadequate.

- The posing of MWPs could be more conducive to learning. Teachers' actions create little opportunity for independent engagement with MWPs. Teachers should avoid the sequence of first posing a MWP and then immediately explaining the MWP to learners. Over-hasty support explains the conclusion of teachers' notion of avoiding possible learner failure.

- Some teachers created the impression that they wanted to compensate for learners possibly failing to solve MWPs. Consequently, the teachers were prescriptive in explaining the MWP and instructing learners as to which problem-solving strategy to implement.
- The educational value of manipulating support materials is underestimated by most teachers. Grade 2's and 3's are often deprived of the opportunity to demonstrate their ability to solve MWPs in diverse ways.
- The evidence gave the impression that several teachers view their role from a traditional perspective, where the teacher is seen as the provider of knowledge, and not as an initiator and facilitator of learning. The notion of first prescribing to learners, rather than promoting thinking and reasoning, is an example of this.

5.3.2 Conclusions from the learner perspective

- Learners need to master basic mathematics conceptual knowledge before teachers will allow learners to apply their knowledge to a contextual problem or an MWP. The connection between MWPs and basic mathematical knowledge was observed as one-sided.
- Such experiences with MWPs are inadequate to develop learners as independent problem solvers who will be able to extend their problem-solving knowledge to real-life situations.
- Prescriptivism was often experienced when it came to the question of which problem-solving strategy learners were to use. Learners were often told what to do by their teachers. Consequently, learners were not able to use problem-solving strategies that they preferred or related to more positively. In short, learners were deprived of opportunities to develop and progress as active, responsible learners.
- The use of manipulative support materials was at times forbidden, or the materials were not readily available. Learners thus had no opportunity to concretely represent and visualise MWPs through a hands-on approach. Instead, learners had to produce solutions using mental calculations or abstract representations. Learner differences were consequently ignored or not taken into

consideration. Such undemocratic behaviour by teachers deprived learners of their right to develop individually and independently.

- Learners had to tolerate teachers' frustration, anxiety and, in some cases, unprofessional behaviour during MWP-solving opportunities. Verbal abuse occurred, causing learners to withdraw from active participation. Teachers' fear of possible learner failure was evident in their lack of faith in and underestimation of learners' ability. In addition, learners were disadvantaged, as they were not allowed to develop at their own pace.

- Insufficient language development occurred in the handling of MWPs. Teachers read the MWP on behalf of the learners, which conveyed the message of lack of faith in learners' ability to learn how to read themselves. Learners were told what to do by teachers, rather than being allowed to develop their thinking and reasoning skills. Learners were often given shortcuts to solving the problem, by being presented with keywords. The message conveyed by this strategy is an ignorance of the context of the MWP as a whole, as well as a belief in half-truths, as words in MWPs at times have opposite or alternative meanings when read and interpreted in the context of the MWP as a whole.

The above conclusions from the teacher and learner perspectives sound very negative. This is not my intention. I am simply drawing conclusions from what I observed and what I perceived during the interviews. The following conclusions, also selected from the observations and interviews, have a more positive flavour, as they reflect "good practice".

5.3.3 Conclusions from the "good practice" perspective

- Alternative approaches to handle MWPs in Foundation Phase classrooms exist and can be implemented successfully by teachers to enhance learner potential to develop as active problem solvers.

- A balanced approach between MWPs and MNPs is achievable.

- Teachers can develop various roles in the teaching and learning process. Teachers do not always have to have absolute control, but by acting the role of facilitator, they allow learners to take control of their learning. Teachers simply need to be available to oversee the learning situation, to provide support as needed, and to maintain a positive learning environment that is conducive to learning.

- Teacher behaviour influences learner behaviour and related performance in the teaching and learning situation.
- Foundation Phase learners have the ability to solve MWPs when allowed to develop their knowledge and problem-solving skills through their own strategies and at their own pace.
- Learners need teachers to unlock their potential in a democratic, value-laden environment, acknowledging their potential and creating opportunities for their needs.

5.4 RECOMMENDATIONS

In qualitative research, recommendations based on the sample of reality which was studied need to be offered. Drawing attention to implications can also be value-adding, as it allows the researcher to be more distant and contemplative from a broader perspective (Wolcott 2009:118).

The recommendations are a connection between the insights and conclusions of the study and the reviewed literature. Again, only a selection of the most important recommendations is included in this study.

The intention behind the recommendations given is multifaceted and is guided by the three research sub-questions. Therefore the three main focuses of this study, namely teachers, learners, and “good practice”, in relation to the phenomenon of the MWP are integrated for a more holistic and coherent understanding. Although several of the factors influence the implementation of MWPs negatively, I view these negative factors as challenges or problems that need to be addressed in the search for *good practices*.

5.4.1 Recommendations for teachers

Jansen's (2011:19) recommendation that teachers need to overcome knowledge deficits (see section 1.1) corresponds with the various types of knowledge described in Chapter 2 (see section 2.4). These knowledges need to be implemented in practice in order to create the changes required.

Teachers need to acknowledge that MWPs are embedded in mathematics education, they are related to real life, and they open doors to opportunities to learn how to handle the real world. Teaching *by means of* and *for* MWP solving generates opportunities to develop and enhance learners' content knowledge and their cognitive domain. Such an approach creates opportunities for a balanced approach between MWPs and MNPs. MWPs and MNPs are connected in various ways. Following a more traditional approach of first teaching basic mathematics and then applying such knowledge when solving MWPs requires an awareness of the possibilities of the problem-centred approach.

Teachers need to develop sensitivity towards pacing their teaching. Provision needs to be made for learner development and the needs of learners to progressively develop their problem-solving skills. Learning to solve MWPs successfully is a journey of inquiry which takes time and requires multiple opportunities. The ideas of Piaget to work from the concrete, allowing for visualisation (for example, real objects and drawings) to the abstract (thus from direct modelling to mathematical modelling) requires focused lesson and time management planning. I suggest that teachers take note of Japanese successes, by focusing more on the process of problem solving than on the final solution. Japanese learners of mathematics explore the journey of problem solving, enjoying opportunities for doing, discovering and discussing their thinking and reasoning thoughts, while searching for the solution.

Feldman and McPhee's (2008:93) quote "How can we do new math with old math minds?" and the thoughts of Jansen (2011:19) to avoid perpetuating the negative mathematics performance of Foundation Phase learners and teachers inspire change. Obama (2009:3) reminds us of the unavoidable need to change and encourages us that "we can do it". Therefore, teachers need to carefully rethink their own practices and decide whether they are honestly creating a "good practice" for all learners in classrooms in South Africa. Teachers in South Africa are dealing with diverse contexts and diverse learners, all contributing towards the complexity of the situation. But, despite the latter, teachers can still attempt to make a difference, but it will require a change of mindset and exploring more than the *knowledge in the blood*. Teachers in South Africa also need to bring democratic values into the classroom, for a socially just mini-society to occur in each classroom. Each learner's right to be taught and to have the opportunity to learn requires recognition. Lessons need to be planned and implemented accordingly to adhere to the values of South Africa's democracy. Issues in classrooms which have an impact on MWP solving are ignorance of equality, freedom, responsible participation and respect for authority. In a classroom, the authority is the teacher. Teachers need to earn respect through the way they practise their teaching, and through professional behaviour, taking into account that learners are human beings and require appropriate and humane treatment.

A large number of research projects has been conducted over the last three decades which have expressed various ideas to improve learner success and MPW-solving abilities. Murray, Olivier and Human (1980s, South Africa) and Kamii (1990s/ 2000s), to name just two authors, indicated the MWP-solving abilities of Foundation Phase learners. This study, although small in scale, indicates that the ideas of these authors are still valid, and that Foundation Phase learners can indeed solve MWPs. They just need the opportunity to do so regularly and in all schools.

Teachers need to adhere to their role as lifelong learners and ensure that they continue to study the latest concerns and possibilities, by doing more reading and attending professional development sessions. Only if the work of researchers is read, acknowledged, learned from, and implemented where applicable, can a collective strive to improve the teaching profession be possible. Research focusing on a particular phenomenon, as is the case in this study, or phenomena if it is a larger study, is a positive step in the direction towards change for the better.

Teachers in South Africa are still in the process of implementing curriculum changes and constantly need to adapt their planning and implementation. This creates the opportunity to also change the implementation of a phenomenon, especially if such a change can improve the school lives for both teachers and learners. Wisdom in implementing the curriculum needs to develop among teachers (see section 2.4.2.3).

Teachers need to and can develop good problem solvers, by learning from Sheffield and Cruikshank (2005:83). Their recommendation includes knowing basic mathematical knowledge, developing the ability to visualise the problem, being able to think and reason, developing a strong understanding of concepts and mathematical vocabulary, becoming a confident reflector on the problem-solving strategies used, becoming a manipulator of various problem-solving strategies, being able to solve MWPs with confidence, and reducing anxiety. Van de Walle (2004:37-38) shares similar ideas with regard to MWP solving and becoming efficient at solving them. Two of his ideas that are worth mentioning are his view concerning the reduction of discipline problems, when he states that "a problem-centred approach engages [learners] so that there are fewer discipline problems", and especially his idea that solving MWPs is "a lot of fun".

5.4.2 Recommendations for learners

Learners are all different and possess different needs. The needs of learners, as was discovered in this study, can be addressed by teachers and their practices. Therefore, I will refrain from offering recommendations in this regard, but rather focus on what teachers can do to "make hard things easy" (Feldman & McPhee, 2008:46) (see also section 1.2.1).

5.4.3 Recommendations for *good practice*

I perceived Jansen's (2011:19) quest for *hope* in the four "good practice" observations that were discussed in Chapter 4. I was amazed to observe what really was possible when committed teachers provide socially just classroom environments where learners can become good problem solvers, as conceived in the literature by Sheffield and Cruikshank (2005:83). It was also pleasing to note how the four teachers in question had developed the "art of teaching"[38], as recommended by Cullingford (2010:viii-13).

[38] Cullingford, C. 2010. *The art of teaching*. New York: Routledge. This is a book worth learning from.

These four *good practices* are examples of what is possible, which one can learn from to overcome the challenges of teaching and learning. As Cullingford (2010:2) states, “The heart of the tensions teachers experience is the tension between learning and teaching”.

5.5 PERSONAL REFLECTION

This study was a very interesting and personally rewarding journey of inquiry. I have by no means completed the journey. I have (rather) paused for a while to share what I have learned.

Currently there are still important issues in the teaching and learning of and by means of MWPs that perplex me as an academic. Future studies are therefore a possibility.

What excites me the most is to have discovered the hidden potential that young Foundation Phase learners have.

As a teacher, I would like to say that these young learners which we as teachers need to cherish for the year that they spend with us in our classrooms believe in us and hope that we will accept them for who they are and grant them learning opportunities to develop themselves. The question remains: What do we do as teachers to maintain their hope?

As a lecturer, I would like to say that the student teachers in this study, who so passionately reflected on their experiences in various Foundation Phase classrooms, especially from the perspective of the phenomenon of the MWP, inspired me to embark on my journey of inquiry. I hope that I will be able to maintain their hopes in making them the inspiring teachers that we together hope they will be.

May we together keep on trying to teach and learn *by means of* and *for* MWPs in improving mathematics education in Foundation Phase classrooms, and in so doing, improve learners’ ability to cope in school, and in real life.

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