

**IMPROVING LEARNERS' MATHEMATICS PROBLEM SOLVING SKILLS AND
STRATEGIES IN THE INTERMEDIATE PHASE: A CASE STUDY OF A PRIMARY
SCHOOL IN LEBOPO CIRCUIT**

By

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DECLARATION

I declare that the **dissertation** hereby submitted to the University of Limpopo, for the degree of **Masters in Education in Mathematics Education** has not previously been submitted by me for a degree at this or any other university; that it is my work in design and in execution, and that all material contained herein has been duly acknowledge.

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ABSTRACT

The purpose of this study was to examine learners' mathematical word problem solving skills and strategies in Intermediate Phase. The study was prompted by Grade 6 learners' poor performance in the cognitive area, non-routine mathematical word problems, as revealed in Annual National Assessment reports of 2011, 2012, 2013 and 2014. The study followed action research collaborative method involving 26 Grade 6 learners and their mathematics educator. The school is a rural primary school categorised under quintile two. Problem solving theory by Polya (1957) guided the study in answering three research questions: What are the challenges faced by Grade 6 learners in solving word problems? What are Grade 6 learners' strategies in solving word problems? How can learners' problem solving skills and strategies focusing on word problems be improved?

Data were collected in a routine structured process: pre-intervention phase, intervention phase and post-intervention phase. Analysis was made through the development of a system of categorisation of learners' responses. The four principles of problem solving by Polya (1957) namely, the way learners understand the problem, how they devise the plan, how they carry out the plan and the manner in which they look back guided the analysis. The findings of the study revealed that the strategies introduced assisted learners in making sense of the word problems and finally proceeding towards an adequate solution. It was also found out that the learners lacked the ability to read with understanding; the problem being their lack of competence in the language of learning and teaching. The skills which learners also lacked when solving word problems were identified as arithmetic skills and reflective skills.

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CHAPTER 1: INTRODUCTION AND BACKGROUND TO THE STUDY

1.1. INTRODUCTION

This chapter presents the background, purpose, significance and the need for the study. Annual National Assessment (ANA) reports of 2011, 2012, 2013 and 2014 revealed that Grade 6 learners nationwide are unable to solve mathematical word problems. The purpose of the reports amongst others were for teachers to identify areas of learning where learners need extra help, and make some introspection which leads to reflective teaching to address areas of weaknesses. Additionally, ANA reports highlight and present to School Management Team (SMT) specific areas of mathematics knowledge and skills in which learners who participated showed low levels of competency. This present study responds to the said purpose of ANA reports, intending to examine and improve learners' mathematical word problem solving skills and strategies. The study is guided by three research questions: What are the challenges faced by Grade 6 learners in solving word problems? What are Grade 6 learners' strategies in solving word problems? How can learners' problem solving skills and strategies focusing on word problems be improved?

1.2. BACKGROUND OF THE STUDY

After South Africa became a democracy in 1994, the Department of Education in the country attempted to improve the quality of education by putting in place different strategies; such as the introduction of Curriculum 2005, National Curriculum Statement (NCS), Revised National Curriculum Statement (RNCS) and lately, Curriculum and Assessment Policy Statement (CAPS). Eventually the Department made a decisive contribution towards better learning in schools by introducing Annual National Assessment Examination. ANA was introduced after the survey findings of Systemic Evaluation that provided a valuable benchmark for monitoring progress in learning outcomes in the General Education and Training band (GET) (DBE, 2005). This imperative intervention forms one of the key strategies that the Department has put into place to annually measure progress on learner achievement towards the target of 60% achievement rate articulated in the Action Plan to 2014: Towards the Realisation of Schooling 2025 (DBE, 2010).

1.2.1. Purpose of ANA

As stated in DBE (2010), ANA was introduced to expose teachers to better assessment practices, make it easier for districts to identify schools in most need of assistance, encourage schools to celebrate outstanding performance and empower parents with important information about their children's performance. Furthermore, ANA provides the national baseline to benchmark annual targets and achievement towards realising the desired 60% threshold of learners mastering the minimum Literacy and Numeracy competencies by the end of Grade 3, 6 and 9 respectively.

ANA serves as an important indicator of the critical foundational skills that learners need in order to be able to learn. It is the tool that the Department of Education uses to ensure educational improvement of South Africa in the same way as the National Assessment of Educational Progress (NAEP) is used in the United States (Santapau, 2001). The issue of educational improvement is a global challenge. There are several International Association for the evaluation of Educational Achievement (IEA) studies which are conducted for a similar purpose of ensuring educational improvement of different countries such as Computers in Education Study (COMPED), Second Information Technology in Education Study (SITES), Pre-primary Project (PPP), International Civic and Citizenship Education Study (ICCES), Teacher Education and Development Study in Mathematics (TEDS-M), Civic Education Study (CIVED) and Language Education Study (Coughlan, 2013; Santapau, 2001). Amongst others, Systemic Evaluation, Programme for International Students Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), Progress in International Reading Literacy Study (PIRLS) and, Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) were also introduced to help countries to compare their educational achievement (Coughlan, 2013). The said teams exist to support research, bench marking and school improvement efforts (Coughlan, 2013) as ANA does.

The Department of Basic Education conducted ANA in February 2011, September 2012, 2013 and 2014 in literacy/language and numeracy/mathematics. The first set of tests was administered for learners who had completed Grades 1 - 6 in 2010. For the ones written in 2012 to 2014, they were administered for learners in their current

academic year grades, that is, from Grades 1 – 6. Unlike examinations that are designed to inform decisions on learner promotion and progression (summative evaluation), ANA data are meant to be used for both diagnostic purposes at individual learner level and decision making purposes at systemic level (DBE, 2011a). At individual learner level the assessment provides teachers with empirical evidence on what the learner can or cannot do at a particular grade. At the systemic level, ANA provides reliable data for decisions related to provision and support required at various levels of the systems.

The main purpose of the assessment is to make a decisive contribution towards better learning in schools (DBE, 2010). The purpose of the results thereof will be used to highlight and present to teachers and School Management Teams (SMT) specific areas of both language and mathematics knowledge and skills in which learners who participated showed low levels of competency (DBE, 2013). On that note teachers will be able to identify areas of learning where learners need extra help and make some introspection which leads to reflective teaching to address the weaknesses. Educators as ambassadors of learning will use those results to help in improving teaching and learning.

1.2.2. The overall results of ANA

Focusing on mathematics results, Table 1.1 below illustrates the national average pass percentage of learners from 2011 to 2014.

Table: 1.1: National average passes percentage

Grade	2011		2012		2013		2014	
	No. wrote	% pass	No. wrote	% pass	No. wrote	% pass	No. wrote	% pass
1	931489	63	1237492	68	1190280	60	1250791	66
2	885273	55	1080141	57	1079264	59	1153340	62
3	981309	32	974363	41	993750	53	1075326	56
4	888703	38	967983	27	931540	37	1037932	37
5	876549	37	935581	30	887963	33	925264	37
6	960081	31	944397	27	882863	39	896939	43

In the past four years (from 2011 to 2014) learners in Grade 1-6 performed as illustrated in Table 1.1 in Mathematics ANA examination. The pass percentages show improvement of learner performance in mathematics yearly. Looking at the 2011 and 2014 performance for Grade 6, the pass percentage improved from 31% to 43%. Besides, reports over the four years revealed numerous challenges that learners experienced in certain Mathematics topics (DBE, 2011a, 2012, 2013, 2014). The reports outlined that areas not showing improvement over the years are the inability to respond to non-routine mathematics word problems (DBE, 2010, 2015). Referring to the Grade 6 learners of Sedupe Primary (pseudonym), their performance in the non-routine problems included in the ANA examination from 2011 to 2014 are illustrated in Table 1.2 below.

Table 1.2: Average passes percentage of Grade 6 learners of Sedupe Primary on non-routine problems

Year	Number of learners wrote	Percentage pass
2011	39	3%
2012	32	5%
2013	28	4%
2014	36	8%

The Grade 6 class of 2011 had 39 learners and only 3% did well on non-routine problems. In 2012, 2013 and 2014 there were 32, 28 and 36 learners respectively

where 5%, 4% and 8% did well. As it could be deduced from Table 1.2, the performance is drastically poor on non-routine problems.

DBE (2012, 2013 & 2014) indicated that it is difficult to compare performance from year to year because different tests are administered and are likely to yield different results. Reflecting on DBE (2012, 2013 & 2014)'s indication, I noticed that some of the questions posed on word problems were not aligned to CAPS. Word problems not involving decimal fraction and measurement context as DBE (2011b) dictate that they should feature in ANA examination papers, but were not included. Nonetheless, illustration of Table 1.2 confirms how poorly my learners performed in word problems.

Analysis of ANA results provides evidence to inform and direct appropriate interventions for teaching and learning. The intervention is further directed to curriculum implementation management by School Management Teams (SMTs), curriculum and management support at district level, resource provision and, monitoring at provincial and national levels. This confirms the disparities in a number of schools in the country which must be addressed, using ANA results.

The DBE singled out Grades 3 and 6 as centres of attraction considering that the government and the society placed more emphasis on monitoring learner performance at the lower grades, in particular within the Foundation and Intermediate Phases. As an Intermediate Phase mathematics teacher, I put a great deal of interest on the results of Grade 6 Mathematics. The overall performance of learners considering competency in mathematics basic skills, showed that learners were not able to translate word problems into mathematical expression in order to solve them using relevant mathematical techniques (DBE, 2011a, 2013). For example, there was a general inability to calculate the amount of change a shopper would receive from a specified amount tendered after paying for a number of items whose individual prices were given (DBE, 2011a).

1.2.3. Concerns deduced from ANA results

As part of the ordinary public schools, Sedupe Primary School (pseudonym), where I am presently employed, also took part in ANA. Learners at the school performed poorly on the assessment over the past four years. The pass percentage for the school in mathematics was 22%, 35%, 30% and 38% in 2011, 2012, 2013 and 2014 respectively. Most learners performed poorly mainly on the cognitive area, non-routine mathematics word problems (DBE, 2010), that is, cognitive level: complex procedure (DBE, 2011b, p.296) as the topic is revealed as one of the most challenging to learners (DBE, 2014a). From the analysis of learners' scripts it was deduced that learners were unable to translate problem texts to mathematical expressions (DBE, 2011a, 2013, 2014). It has been further shown that they were unable to interpret word problems correctly and to use given information correctly.

Although different tests are administered every year (DBE, 2012, 2013 and 2014), questions set in the assessment are developed from CAPS. The ANA report highlights one important aspect, which is that there is a need to improve Grade 6 learners' problem solving skills and strategies. In a way, learners need to be engaged fully in the cognitive area non-routine mathematics word problem as part of their curriculum content.

1.2.4. Grade 6 Curriculum

According to DBE (2011b, p.15), in South Africa one of the specifications of content for Grade 6 in mathematics is solving problems that involve whole numbers and decimal fractions including financial and measurement context. The said content is categorised as cognitive level: complex procedures not problem solving. For example, the following word problems were given to learners to solve:

- Mr Msebenzi buys 480 sweets for R30, 00. He repacks the sweets into packets of 24 each. He sells the packets for R2, 50 each. How much profit will he make if he sells all the sweets?
- A car travels at 100 km per hour. How far will it travel in 45 minutes?
- Tamara invited 37 friends to her party. Each friend may drink 2 glasses of cool drink. If each glass holds 200 ml, how many 2-litre bottles of cool drink should her mother buy?

- Miriam left Durban at 21:45 and arrived in Johannesburg at 04:30 the next day. How long did her journey take?

To solve the above set of questions, learners are expected to demonstrate skills of complex calculations and high order reasoning, describe rules and relationships as there are no obvious routes to the solutions (DBE 2011b, p.296). These skills require learners to identify patterns and find “functions” that link several entities, e.g. what “function” links the unit price to the number of items that one can purchase in a shop? According to Subject Assessment Guidelines for Mathematics (SAGM) taxonomy (DoE, 2008a), NAEP taxonomy, Stein taxonomy and Porter’s taxonomy (Berger, Bowie & Nyaumwe, 2010), the said skills are categorised under moderate complexity, procedure with connections, solving non-routine problems and complex procedures respectively. Berger et al. (2010) elaborate that the methods of solution are not directly given in moderate complexity and learners need to decide on how to approach the problem by bringing together concepts and processes from various domains. They further show that procedures with connections demand learners to engage with concepts and stimulate them to make powerful connections to meaning or relevant mathematical ideas. Solving non-routine problems require learners to apply and adapt a variety of appropriate strategies and mathematics in context outside of mathematics. DoE (2008b) highlights that complex procedures are mainly unfamiliar and involve integration of different learning outcomes and require learners to use higher level calculation skills and reasoning to solve problems as they do not have a direct route to the solution. The skills mentioned above are problematic to learners.

1.2.5. Reflections on learners’ word problems solving

Grade 6 learners at my school were unable to break complicated descriptions to small parts, to understand those parts and to see the relationship between them. They were not familiar with the skill of interrogating a word problem for understanding. Lacking this skill leads them to be unable to translate the word problems into mathematics expressions. The following are examples of how they responded to word problems:

- Mr Msebenzi buys 480 sweets for R30, 00. He repacks the sweets into packets of 24 each. He sells the packets for R2, 50 each. How much profit will he make if he sells all the sweets?

Answer by learner:

$$\begin{array}{r} 30.00 \\ + \quad 24 \\ \hline 250 \\ \hline 32.74 \end{array}$$

- Miriam left Durban at 21:45 and arrived in Johannesburg at 04:30 the next day? How long did her journey take?

Answer by learner:

$$\begin{array}{r} 21:45 \\ +04:30 \\ \hline = 12:00 \end{array}$$

Learners happened to copy figures appearing on the word problem and used any operation that came to their minds not knowing what was really required of them. As seen by Barwell (2011) learners combined the numbers in problems in apparently non-sensible ways and gave unrealistic solutions when solving word problems. What had been said above including the intervention suggested by DBE (2013), that the skills that deal with word problems should be taught, prompted the present researcher to pursue this study.

1.3. PURPOSE OF THE STUDY

The purpose of this study was to examine and suggest ways to improve Grade 6 learners' problem solving skills and strategies focusing on solving mathematical word problems. The following research questions guided the study:

- What are challenges faced by Grade 6 learners in solving word problems?
- What are Grade 6 learners' strategies in solving word problems?
- How can learners' problem solving skills and strategies focusing on word problems be improved?

1.4. SIGNIFICANCE OF THE STUDY

It is important that learners possess strategies and skills that they can use in solving mathematical word problems. These skills assist learners not only in solving simple mathematical problems, but they help them with real life problem-solving skills. In other words, mathematical word problem solving skills would equip learners with critical thinking, allowing them to be cognitively versatile in a number of ways. At a personal level, teaching mathematical word problem solving strategies and skills would provide me with the opportunity to contribute towards improving mathematics results of the school where I teach. It would assist in terms of giving me prospects to support mathematics educators at my school with ease. The present study would provide a panorama for educators to teach new strategies and approaches to deal with mathematical word problems. Educators may perhaps be encouraged to become reflective practitioners, thus performing their work in a more solid and effective manner. Learners as well might develop a greater understanding of mathematical word problem solving strategies and could also learn to solve non-routine problems in varying degrees and contexts.

1.5. OVERVIEW OF THE CHAPTER

The purpose of this study was to improve learner's mathematical problem solving skills and strategies in Intermediate Phase. To report on the results and findings of this study, I organised the write up into six chapters. In chapter one I introduced the study by establishing the purpose, significance and need for the study. I also provide the context of the study.

Chapter two provides a review of the literature relevant to mathematical word problem solving. I outlined what problem solving is and conclude by outlining the theoretical framework that guided the study. Chapter three covers a detailed description of research methodology and design that guided the study. Chapter four captures research findings and discussions of emerging key ideas guided by the theoretical frame work. Chapter five responds to the research questions. Chapter six presents the implications and recommendations of the study. A list of references and appendices also form part of the closing sections of this study.

1.6. CONCLUSION

This chapter provided the background to the study. It outlined what prompted this study, purpose and significance. It was pointed out in this chapter that Annual National Assessment (ANA) was introduced to make a decisive contribution towards better learning in schools geared to assist learners improve mathematical word problem solving skills and strategies. The next chapter reviews the literature pertaining to mathematical word problem solving. Secondary sources such as articles from scientific journals and academic books are used.

CHAPTER TWO: LITERATURE REVIEW

2.1. INTRODUCTION

Presented in this chapter is a synthesis of research that supports the improvement of learners' mathematical word problem solving skills and strategies. Included in the chapter is problem solving in mathematics, collaborative teaching, efforts for educational improvements and achievements and theoretical framework that guided the study. This study was centred on mathematics problem solving as a complex process which requires an individual who is engaged in a mathematical task to coordinate and manage domain-specific and domain-general pieces of knowledge. The process is from a given state to a goal state with no obvious way or method for getting the solution.

In this chapter, the importance and challenges of collaborative teaching are outlined. Collaborative teaching as driven by the needs of the teachers engaged in providing perspective, diversity and space for teachers to consider questions about learner learning that can provide new insight unavailable in inquiry. It opens learners' eyes to accepting more than one opinion and to act more cooperatively with others. In contrast, collaborative teaching tends to expose each partner's professional and personal points of view; therefore it is a challenge to work with someone whose teaching style is different from one's own. It is therefore important to turn the challenge into a constructive learning situation in which the differences between the partners can be used to reach the goals set.

The issue of educational improvement is a global challenge. International Association for the evaluation of Educational Achievement (IEA) exists in order to improve learning and teaching in a number of countries. The main focus of the introduction of ANA was to improve the educational achievement of South African learners. The theoretical framework that guided the present study is the problem solving theory by Polya (1957).

2.2. PROBLEM SOLVING IN MATHEMATICS

2.2.1. What is problem solving?

There are great statements of intent for defining problem solving in mathematics education (Krulik and Rudnick, 1987; Charles, Manson, Nofsinger and White, 1985; Stigler and Hiebert, 2004; Giganti, 2007; National Centre for Education Evaluation and Regional Assistance (NCEE), 2012). In mathematics education, problem solving is defined as the process from a given state to a goal state with no obvious way or method for getting the solution (Charles, Manson, Nofsinger and White, 1985; Stigler and Hiebert, 2004; NCEE, 2012). This definition emphasises the non-routine nature of problem solving process and the fact that it is not the execution of memorised rules or shortcuts, such as using key words to solve mathematics word problems (Cai and Lester, 2010). Giganti (2007) shows that problem solving is knowing what to do when you do not immediately know what to do. Stigler and Hiebert (2004) define problem solving as the resolution of any task for which the learners do not have an immediate method available. For Krulik and Rudnick (1980) problem solving is the means by which an individual uses previously acquired knowledge, skills and understanding to satisfy the demands of an unfamiliar situation. Giganti (2007) explains problem-solving as the ability to apply the mathematics we know in different situations. Reflecting on these definitions it appears that for one to solve a problem, he/she is required to have acquired some mathematical knowledge that needs to be applied.

Problem solving is further referred to as the mathematical process that has the potential to provide the intellectual challenges for enhancing learners' mathematical understanding and development (Cai and Lester, 2010). NCEE (2012) concurs with Lajoie (1995) and Anderson (2009) by recognising problem solving as an important life skill involving a range of processes including analysing, interpreting and reasoning, predicting, evaluating and reflecting, argument construction, and the development of innovative strategies. Reflecting on the definitions above, the understanding about problem solving is that learners must draw on their knowledge and through this process, they will often develop new mathematical understandings. Problem solving could be viewed as the opportunity to engage in mathematics and derive a reasonable way or ways to solve problems.

2.2.2. Mathematical word problems in problem solving

One of the main topics in the mathematics curriculum is the solution of word problems (Ferrucci, Yeap and Carter, 2003; Hegarty, Mayer and Monk, 1995). In many countries, both textbooks and state assessments require students to solve word problems (Jitendra, Sczesniak and Buchman, 2005). Swee Fong and Lee (2009) indicate that solving arithmetic and algebraic word problems is a key component of elementary mathematics curriculum. Mathematics word problems have received a lot of attention in the educational literature, mainly because this topic is considered to be one of the more difficult topics in mathematics classes (Ferrucci, Yeap and Carter, 2003; Hegarty, Mayer and Monk, 1995).

Word problem is referred to by Boonen, Schoot, Wesel, Vries and Jolles (2013) as any mathematics exercise where significant background information on the problem is presented as text rather than in mathematical notation. The definition brings in an argument whether mathematical word problems should be regarded as problems when attempted by learners or should be regarded as exercises. Cai and Lester (2010) argue that some word problems are not problematic enough for learners and should only be considered as exercises for learners to perform. McIntosh and Jarrett (2000) and NCEE (2012) instead show that considering learners' previous experience with problem solving, a mathematical problem to one learner might be an exercise to another. Stigler and Hiebert (2004) concur and indicate that depending on the experience and mathematical knowledge of individual learners, the same problem may represent different challenges for each individual learner.

Solving word problems involves reading and understanding the problem, formulating a strategy, applying the strategy to produce a solution, and then reflecting on the solution to ensure that it produced an appropriate result (Bodner, 1987). Given that word problem requires learners to draw on their knowledge and through the process, they develop new mathematical understanding.

Taconis, Ferguson-Hessler and Broekkamp (2001) categorised mathematical word problems into four areas: exercise, generic well-structured problem, harder well-structured problem and Ill-structured problem. They explain the problems as follows:

- With exercise, learners can immediately recall an algorithm for solution and apply the recalled algorithm.

- Generic well-structured problem has the problem and goal clearly stated and familiar to learners. Learners here have to understand the problem, recall an algorithm, apply it to the problem, and reflect on the solution.
- Harder well-structured problem also has the problem and goal clearly stated but unfamiliar to learners. Learners also have to understand the problem, formulate or recall an algorithm, apply it to the problem, and reflect on the solution
- Ill-structured problem is a mathematical word problem which has the problem and goal unclear; information is missing and learners have to determine the goal, formulate an algorithm and apply it to the problem.

Boonen and Jolles (2015) in contrast classified mathematical word problems into three categories, that is, combine word problems, change word problems and compare word problems. They summarised that in combine word problems a subset or superset must be computed given the information about two other sets. It involves understanding part-whole relationships and knowing that the whole is equal to the sum of its parts. They further explain that change word problems are word problems in which a starting set undergoes a transfer-in or transfer-out of items, and the cardinality of a start set, transfer set, or a result set must be computed given information about two of the sets. Lastly in compare word problems, the cardinality of one set must be computed by comparing the information given about relative sizes of the other set sizes; one set serves as the comparison set and the other as the referent set.

It implies that beside the type of mathematical word problem posed, it is important that tasks should be given according to the goals set which can be characterised by promoting learners' conceptual understanding, fostering their ability to reason and communicating mathematically, and capturing their interest and curiosity (McIntosh and Jarrett, 2000; Cai and Lester, 2010). The problem should be non-routine, in that the learner perceives the problem as challenging and unfamiliar, yet not insurmountable (Becker and Shimada, 1997). Learners should by themselves decide which method, or procedure, to undertake to solve the problem (McIntosh and Jarett, 2000).

2.2.3. Why teach problem solving in mathematics?

Anderson (2009) points out that learning problem solving in mathematics helps learners to acquire ways of thinking, habits of persistence and curiosity, and confidence in unfamiliar situations that will serve them well outside the mathematics classroom as problem solvers. Concurring with Giganti (2007), Anderson (2009) also regards problem solving as an important mathematical process because it requires learners to combine skills and concepts in order to deal with specific mathematical situations. It is important to teach learners problem solving as they will develop problem solving habits of mind when working with the content areas which prepare them for real problems' situations requiring efforts and thoughts (NTCM, 1989).

Learners who develop proficiency in mathematical problem solving early are better prepared for advanced mathematics and other complex problem-solving tasks (Giganti, 2007). NCEE (2012) notes that problem solving abilities are used not only in advanced mathematics topics such as algebra, geometry and calculus, but also throughout the entire mathematics curriculum. NCEE (2012) further pronounces that problem solving is an integral part of all mathematics learning and it should not be an isolated part of the mathematics program. It should involve all five content areas: Number and operations, algebra, geometry, measurement, and data analysis and probability.

Problem solving prepares learners not only to think mathematically, but to approach life's challenges with confidence in their problem-solving ability (Moyer, Cai and Grampp, 1997). The skills acquired from mathematical problem solving processes transfer to other areas of life such as the ability to reason. The active and varied nature of problem solving helps learners with diverse learning styles to develop and demonstrate mathematical understanding.

Stigler and Hiebert (2004) report that problem-solving can also be used effectively as a vehicle for introducing new mathematical knowledge to learners by creating a need for that knowledge. Carson (2007) indicates that problem solving connects theory and practice as it specifically relates to applying abstract school knowledge to concrete real world experiences. Hains-Wesson (2013) also shows that not only are problem-solving skills useful in a scholarly context, but they can help learners understand and

develop solutions when coping with many of life's problems or challenges within a varied and problematic environment.

Rigelman (2007) characterises mathematical problem solvers as flexible and fluent thinkers, those having confidence in their use of knowledge and processes. Mathematical problem solvers are further characterised by their willingness to take on a challenge and persevere in their quest to make sense of a situation and solve a problem. Lastly mathematical problem solvers are seen as persons who are curious, seek patterns and connections, and are reflective in their thinking. Furthermore, Rigelman (2007) states that being a good problem solver can lead to great advantages in everyday life beside the classroom.

Problem solving reported in this study involves problem solving by learners in the lower grades which could involve making significant connections between different representations, which requires learners to show their conceptual understanding (DBE, 2011b: 296). These are the problems involving complex calculations and higher order reasoning under the cognitive level complex procedures. It is clear that engaging learners in problem solving can help them develop reasoning skills. Teachers should see to it that learners are encouraged to reason through their mathematical activities including word problems. To inculcate a culture where learners learn to reason and to improve their problem solving skills and strategies collaborative teaching as a teaching strategy can be used.

2.3. MATHEMATICAL PROBLEM SOLVING SKILLS AND STRATEGIES FOCUSING ON WORD OR STORY PROBLEMS

Several studies attempting to improve learners' mathematical problem solving skills focusing on word problems have been conducted worldwide (Langeness, 2011; Rockwell, Griffin and Jones, 2011; DBE, 2011a; Verzosa and Mulligan, 2013; Sepeng and Webb, 2012; Taber, 2013; DBE, 2013; Maluleka 2013; DBE, 2014; Sepeng and Madzorera, 2014; Reynders, 2014; Boonen and Jolles, 2015; Loc and Phuong, 2015). Some such studies focused on reading comprehension as part of mathematical problem solving (Schwanebeck, 2008; Hite, 2009; Langeness, 2011; Limond, 2012; Verzosa and Mulligan, 2013; Sepeng and Madzorera, 2014). Some of the studies

focused on improving achievement and abilities to solve word problems (Pantziara, Gagatsis and Elia, 2009; Csikos, Szitanyi and Kelemen, 2011; Sepeng and Webb, 2012; Van Klinken, 2012; Fajemidagba, Salman and Ayinla, 2012; Jan and Rodrigues, 2012; Maluleka 2013; Taber, 2013; Murtini, 2013; Kavkler, Magajna and Košak , 2014) and others explored the difficulties faced by learners in solving word problems (Yeo, 2009; Reynders, 2014; Boonen and Jolles, 2015; Loc and Phuong, 2015). DBE (2011a), DBE (2012), DBE (2013) and DBE (2014) equally sight-saw the impediments faced by learners in solving word problems.

Csikos et al. (2012), Van Klinken (2012), Kavkler et al. (2014) and Boonen and Jolles, (2015) focused their studies in the Foundation Phase (South African context) working with the Grade 3 (Csikos et al., 2012; Van Klinken, 2012; Kavkler et al., 2014) and Grade 2 (Boonen and Jolles, 2015) learners as their participants. Schwanebeck (2008), Pantziara et al. (2009), Gooding (2009), Rockwell et al. (2011), Langeness (2011), Reynders (2014), Taber (2013) and Kavkler et al. (2014) examined the Intermediate Phase. Rockwell et al. (2011), Langeness (2011) and Reynders (2014) singled out Grade 4 learners, whereas Taber (2013), Gooding (2009) and Kavkler et al., (2014) singled out Grade 5 and only Schwanebeck (2008) and Pantziara et al. (2009) focused on Grade 6 learners. Alternatively, Sepeng and Webb (2012), Fajemidagba et al. (2012), Maluleka (2013) and Sepeng and Madzorera (2014) studied the Senior Phase learners in Grade 9 and Grade 11 respectively. Jan and Rodrigues (2012) considered both Grade 8 learners and their teachers, while Loc and Phuong (2015) examined only teachers in the elementary schools.

Comparable to my study, only Schwanebeck (2008) and Pantziara et al. (2009) used Grade 6 learners as participants. The intention of Schwanebeck (2008) was to investigate learners' ability to solve problems instructions and practice using a specific word problem summarisation worksheet. Pantziara et al. (2009) intended to investigate the effects of different types of diagrams in non-routine mathematical problem solving by constructing learners' ability to solve problems with and without the presence of diagrams. Both studies did not intend to improve learners' problem solving skills and strategies as my study does.

Schwanebeck (2008) focused mainly on helping learners to comprehend by breaking down word problems. The findings revealed that restating a word problem in a different way can lead learners to understand the word problem. The findings further showed that using a learner's name or sibling's name can also bring understanding to a troubling word problem; this leads to the learner owning the problem. Instead, Limond (2012) looked at the use of reading strategies in the mathematics classroom as a means to improve mathematical comprehension incorporating graphic organisers (four corners and a diamond organiser) using 50 seventh grade learners. The study discovered that the four corners and a diamond organiser proved to be an excellent instructional method for preparing learners to justify their answers for story problems and also provided the learners with the skills for writing proofs as they advance through their mathematics learning requirements.

According to Hite (2009), reading accuracy and comprehension played an important role in learners' mathematical thinking on problem solving. It further showed that there is a great relationship between reading skills and problem solving. Concurring with Hite (2009) is Langeness (2011) who proved that for learners to write their own mathematics word problems, it requires them to go beyond the mere reading and solving of word problems. It is further presented by Langeness (2011) that the dissection and reconstruction of problems that learners needed to do to change an existing problem lead them to comprehend those problems more deeply. Sepeng and Madzorera (2014) on the other hand also showed that mathematics language appears to influence learners' comprehension when solving word problems. As much as one cannot divorce the issue of language from mathematics word problem solving, Sepeng and Madzorera (2014) further highlight that knowledge of vocabulary influence success in word problem solving. On the other hand, Reynders (2014) revealed that even if learners were presented with word problems in a language other than their mother tongue, they preferred to discuss the content of the word problems in their mother tongue. In addition, Boonen and Jolles (2015) also found out that the core problem which the learners experience might be associated with the fact that they have difficulty in general with processing relational terms like 'more than' and 'less than'.

Schwanebeck (2008), Hite (2009), Langeness (2011), Limond (2012) and Boonen and Jolles (2015) bring to light that a major component of successfully solving a word problem is by comprehending or understanding what is being asked of the problem solver within the wording. That brings the issue of language as a barrier to mathematics word problem solving (Reynders, 2014). Cartert and Dean (2006), Hyde (2006) and Franz and Hopper (2007) as cited by Limond (2012) show that integrating reading skills into a mathematics classroom is vital as mathematical comprehension improves when reading strategies are incorporated into mathematical instructions. The present study reports how learners were able to understand what was required of them and be able to proceed to the next step.

Van Klinken (2012) reports that a schematic approach to teaching word problems can help learners to conceptualise word problems in a schematic way, thereby leading to deeper understanding as well as greater flexibility and accuracy when solving word problems. It is further shown that the approach gave teachers an alternative and successful path to approach difficult curriculum topics and also provided numerous opportunities to link real life with classroom mathematics. Pantziara et al. (2009) investigate the effects of different types of diagrams in non-routine mathematical problem solving by constructing learners' ability to solve problems with and without the presence of diagrams.

Pantziara et al. (2009), Van Klinken (2012) and Taber (2013) show that, strategies for solving mathematical word problems needed to be taught to learners. Learners need to be exposed to those strategies so that when they translate the text to mathematical expressions they know how to tackle the problem. According to Yeo (2005) different strategies can be used to solve one arithmetic word problem and those can be taught to learners, bearing in mind that learning occurs only when learners process new information or knowledge in such a way that it makes sense to them in their own frames of reference (Hull, 1999). This means that mathematics word problems as non-routine problems require learners to solve them the way they understand those problems.

Individually, Verzosa and Mulligan (2013), Maluleka (2013) and Loc and Phuong (2015) on their research questions wanted to find out the challenges encountered by

learners that impede their strategies of solving word problems. Besides, Maluleka (2013) also intended to know how to improve learners' mathematical process of solving word problems. Kavkler et al. (2014) instead aimed to know the strategies learners use in solving mathematics word problems. Maluleka (2013) reports that learners attempt solving word problems with no understanding. This was supported by the findings of Kavkler et al. (2014) that learners show less flexible use of arithmetic skills, as well as qualitatively different mathematics word problem solving, which is also related to their lower non-verbal reasoning. The findings of Maluleka (2013) are also backed by Loc and Phuong (2015) who point out that, learners often have difficulties in finding out the strategies for solving word problems and that they also often commit errors in the process of problem solving. On the other hand, Verzosa and Mulligan (2012) identify socially and culturally driven barriers to learning mathematics problem solving as superficial strategies, children's engagement, and learning in an urban poor context.

Parallel to this study, the research questions by Verzosa and Mulligan (2012), Maluleka (2013) and Loc and Phuong (2015) are analogous to the ones that guided this study. Verzosa and Mulligan (2012) and Maluleka (2013) focused on Grade 9 and second grade learners respectively. Loc and Phuong (2015) concentrated on both teachers and learners of primary school from Grade 1 to Grade 5, and Kavkler et al. (2014) gave attention to both teachers and learners of Grade 5. In the present study the research questions addressed the challenges encountered by Grade 6 learners and also intended to know their strategies of solving mathematics word problems. This study further intended to find out how to improve learners' problem solving skills and strategies in Grade 6 through collaborative action research.

Jan and Rodrigues (2012) and Murtini (2013) in their studies tried to improve learners' ability in solving mathematics word problems. Murtini (2013) envisioned to identify the role of the scheme method, whereas Jan and Rodrigues (2012) explored and improved teaching and learning practices in the area of mathematical word problems. On the contrary, Taber (2013) used mathematics word problems strategies to improve achievements of learners. Murtini (2013) revealed that scheme learning method increased learners' ability to solve mathematical word problems. Jan and Rodrigues (2012) alternatively showed that learners seemed to encounter challenges in

comprehending word problem statements which resulted in ineffective teaching and learning practices. Taber (2013) showed that learners were able to use the strategy independently to accurately solve word problems using division or multiplication.

Equal to this study, Jan and Rodrigues (2012) used action research in their study using Grade 8 learners and their teacher. However, in my case, Grade 6 learners and their teacher were employed as participants. They further focused specifically on difficulties faced by learners in comprehending mathematics word problems, whereas I focused on the general difficulties faced by learners in solving word problems. With Murtini (2013), quasi experimental and Anova mixed design was used in contrast to the action research method used in this study.

Fajemidagba et al. (2012) and Sepeng and Webb (2012) conducted their studies whose purpose was to examine the effect of instructional strategy pattern on the performance of learners, provide preliminary results on the use of schema-based strategy instruction, and explored the question of whether discussion as a teaching strategy could improve learners' problem solving performance in mathematics word problems respectively. Fajemidagba et al. (2012) discovered that the experimental group exposed to instructional strategy pattern performed significantly better in Mathematics word problems-solving involving simultaneous equations than their counterparts in the control group. Sepeng and Webb (2012) revealed that in classrooms of experimental schools in which discussion technique was successfully implemented, there was a statistically significant improvement in the learners' competence in solving word problems.

Rockwell et al. (2011) and Verzosa and Mulligan (2012) conducted studies looking at the teaching of addition and subtraction of word problems. Rockwell et al. (2011) found that participant's ability to solve all types of one-step addition and subtraction word problems improved following instruction. On the other hand, Verzosa and Mulligan (2012) identified social and cultural barriers to learning such as superficial strategies, children's engagement and learning in an urban poor context. Csikos et al. (2011) point out at the possibility, feasibility and importance of learners learning about visual representation in mathematical word problem solving as early as in Grade 3. This was investigated during the development of learners' knowledge about word problem

solving strategies with an emphasis on the role of visual representations in mathematical modelling.

Yeo (2009) notes that learners cannot obtain word problem solutions because of lack of comprehension of the problem, lack of strategy knowledge, not being able to translate the problem into mathematics form, not being able to use correct mathematics and because of inappropriate strategy use. Furthermore, learners lack flexibility in seeking to solve the problem using more than one attribute. This was revealed on the study that sought to explore difficulties faced by learners when solving problems. The results (Yeo, 2009) were disclosed before some studies on improving mathematics problem solving skills were conducted (Limond, 2012; Van Klinken, 2012) but still the challenge remains (DBE, 2011a, 2012, 2013, 2014).

It has been reported yearly over the past four years by the Department of Basic Education that learners are not doing well in the cognitive level complex procedures (DBE, 2011a, 2012, 2013E, 2014). According to these reports, learners showed incompetency in solving word problems by being unable to translate problem text to mathematical expression and write correct mathematics sentence (DBE, 2011a, 2013), unable to apply knowledge in a given context (DBE, 2012) and generally the inability to respond to non-routine word problems (DBE, 2014). The report was prepared each year from 2011 to 2014 after learners had written the ANA Examination whose purpose was to make a decisive contribution towards better learning in schools (DBE, 2010). The ANA report highlights specific areas of Mathematics knowledge and skills in which learners who participated showed low levels of competency (DBE, 2013). In addition to that, the report also provides SMTs with objective evidence to identify areas where individual teachers need specific support in terms of both content knowledge and various methods of facilitating learning.

The ANA report (DBE, 2010) states that mathematics question paper covered three cognitive areas: basic mathematical concepts (20%), application of concepts (60%) and non-routine problem solving (20%). This is also supported by Curriculum and Assessment Policy Statement which outlines that Grade 6 learners in South Africa are supposed to be assessed based on the four cognitive levels DBE (2011b, p.296), which the ANA report DBE (2010) refers to them as cognitive areas, that is, knowledge,

route procedures, complex procedures and problem solving. The cognitive level, complex procedures, comprises of word problems which are contextualised (based on real life) and the report showed that specific skills/knowledge/competencies assessed testing whether learners are able to solve such problems, only 17% of the entire group of learners who wrote the exam in 2011 showed competence (DBE, 2011a, p.29). The report further showed that solving word problems was the most difficult skill experienced by learners (DBE, 2014). The reasons for word problems to be difficult for learners are highlighted by Murray (2012) that learners cannot read with understanding and therefore do not know what is required of them. She further shows that for learners to learn their mathematics with understanding, they should be able to relate to it, and try to make personal and collective sense of what they are learning. This can only happen when the mathematical ideas which teachers want to develop are embedded in situations that provide the possibilities of making connections to previous experiences, knowledge, and needs.

The report (DBE, 2014) brings to light that educators can use it to make some improvements in teaching and learning potential of pupils. It further shows that the evidence of the ANA report must build into normal teaching programmes and also be used to inform specific interventions to improve the levels and qualities of learner performance in schools (DBE, 2013). This means that through introspection which leads to reflective teaching, educators will help to improve teaching and learning. Analysis of the knowledge and skills that learners were able or not able to demonstrate in the assessment shows that, while there has been an appreciable improvement in performance in the basic skills in Mathematics, a significant proportion of learners still experience challenges in providing responses to questions that require high order cognitive skills (DBE, 2014). All the concerns above are attempts to improve the education of learners which, in the main, is a global challenge.

2.4. EFFORTS FOR EDUCATIONAL IMPROVEMENTS AND ACHIEVEMENTS

This study is influenced by the results of ANA, which has been introduced as part of the Foundation for Learning Campaign to generate standardised evidence for monitoring the progress in the DBE's programme which purports to lay a solid foundation for learning. The main focus of the introduction of ANA is to improve the

educational achievement of the country, South Africa (DBE, 2010). The results thereof serve as a commission for the quality of education at the General Education and Training (GET) Band in South Africa (DBE, 2014). Studies comparing educational achievements between countries are conducted worldwide such as Language Education Study, CIVED, TEDS-M, ICCS, PPP, SITES, COMPED, NAEP, PISA, TIMSS, PIRLS and Systemic Evaluation.

Some studies are conducted in Africa like SACMEQ and in individual countries such as Systemic Evaluation and NAEP. Other studies are conducted internationally where interested countries participate. These are CIVED, TEDS-M, ICCS, PPP, SITES, COMPED, PISA, TIMSS and PIRLS. South Africa participated only in studies such as Language Education Study, SITES and SACMEQ (Dickson and Cumming 1996; Plomp, Anderson, Law and Quale, 2003; Spaul, 2012). Some of the studies such as CIVED, TEDS-M, ICCS, PPP, SITES, COMPED, PISA, TIMSS and PIRLS are led by International Association for the Evaluation of Educational Achievement (IEA).

Systemic Evaluation, which is conducted in South Africa, like ANA, has been led by the Quality Assurance Chief Directorate of the Department of Education. The main objective of Systemic Evaluation is to assess the effectiveness of the entire education system of South Africa and the extent to which the vision and the goals of the education transformation process are being achieved by the system (DoE, 2005). The evaluation is to serve three purposes: first, to determine the level of achievement of learners within the system; second, to highlight specific areas/issues within the system that require further attention/investigation; and, third, to serve as a base line for comparison against future systemic evaluation studies. The report provides a snapshot of the gains made and the challenges that remain in ensuring that learners meet national standards in reading, listening, writing, numeracy and life skills. In addition to reporting on learner performance, the report examines the context in which learners' experience learning and teaching, and attempts to link the academic performance of learners to their learning context. In so doing, it aspires to promote and ensure accountability and thus gain the confidence of the public in education (DoE, 2005). The end goal of Systemic Evaluation is to improve education delivery and its outcomes. It is the aim of the Department of Education that all stakeholders will interrogate the information provided by the study for this purpose.

The Southern and Eastern African Consortium for Monitoring Educational Quality (SACMEQ) is a consortium of education ministries, policy-makers and researchers who, in conjunction with UNESCO's International Institute for Educational Planning (IIEP), aims to improve the research capacity and technical skills of educational planners (Hungu, Makuwa, Ross, Saito, Dolata and van Copelle, 2010). To date, SACMEQ has conducted three nationally representative school surveys in participating countries in 1996, 2000 and 2007 as SACMEQ I, SACMEQ II and SACMEQ III respectively. These surveys collected extensive background information on the schooling and home environments of learners, and in addition, test learners and teachers in both numeracy and literacy (Spaull, 2012).

On the other hand, COMPED aimed to describe and analyse various aspects of the introduction and use of computers in participating countries (Pelgrum and Plomp, 1991; Pelgrum, Reinen and Plomp, 1993). The focus was on how computers were used, the extent and availability of computers in schools, the nature of instruction about computers, and estimates of the effects that computers had on learners, the curriculum, and the school as an institution. Pelgrum and Plomp (1993) showed that the study was designed as a two-stage survey where Stage 1 of the study was a descriptive survey that investigated computer use at the elementary, lower secondary, and upper secondary levels. Stage 2 of the study consisted of the first part which was a follow up of Stage 1 and studied changes over time. They further showed that the second part involved assessing the effects of schools, teachers, and classroom practices on learner outcomes in the domain of computer usage in schools (functional computer knowledge, skills, and attitudes).

SITES as a qualitative study of innovative pedagogical practices using information and communication technology (ICT) (Kozma, 2003), aimed at identifying and describing innovations that were considered valuable by each country and that might be considered for large scale implementation in schools in other countries (Plomp et al., 2003). It further identified factors contributing to the successful use of innovative technology based on pedagogical practices and provides teachers and practitioners with new ideas about using ICT in the classroom. The case selection and the collection of data were conducted in all participating countries in 2001.

PPP is a longitudinal study designed to explore the quality of life of preschool children in the various care and educational environments provided for them (such as preschools, child care centres, or family day care centres). It also assesses how these environments affected their development (Montie, Xiang and Schweinhart, 2007). The study was conducted in three phases involving children at the age of four. ICCS reported on learner achievement in a test of knowledge and conceptual understanding, as well as learner dispositions and attitudes relating to civics and citizenship. For countries that participated in the 1999 data collection (14 year olds), the study also measured overtime changes in civic content knowledge (Schulz, Ainley, Fraillon, Kerr and Losito, 2010; Schulz, Ainley and Fraillon, 2011). ICCS assessed learners enrolled in the eighth grade.

TEDS-M is an international comparative study of primary and secondary mathematics teacher education. TEDS-M examined how different countries have prepared their teachers to teach mathematics in primary and lower-secondary school (Ingvarson, Schwille, Tatto, Rowley, Peck and Senk, 2013; Schwille, Ingvarson and Holdgreve-Resendez, 2013). TEDS-M surveyed teacher education institutions, educators of future teachers, and future teachers at primary and secondary level. Language Education Study aimed to describe the policies and curricula for language education and assess learner achievement in language learning (Dickson and Cumming, 1996). The study focused on providing "national profiles" of language education in participating countries, including language policies, curricula, opportunities for language use and learning outside of school, and characteristics of teachers. In 1995, data were collected on four languages commonly taught as a school subject: English, French, German, and Spanish (Dickson and Cumming, 1996).

NAEP, PISA, TIMSS and PIRLS respectively, their purpose is to show where countries stand, and motivate policymakers to identify shortcomings and challenges facing their education systems, and remedy them with proper reforms (Spaull, 2012). NAEP on the other hand measures fourth-, eighth-, and twelfth-grade learners' performance, most frequently in reading, mathematics and science. The assessments designed specifically for national and state information needs, United States Department of Education (2002). PISA has been introduced in the year 2000 and it is administered

by Organization for Economic Cooperation and Development (OECD) in the United States of America. TIMSS was introduced in 1995 and reports on international trends in mathematics and science achievements at the fourth and eighth grades. The major purpose of TIMSS is to provide important background information that can be used to improve teaching and learning in mathematics and science. PIRLS on the other hand is an international assessment administered every five years that measures trends in learners' reading literacy achievement and policy and practices related to literacy. This study is also carried out under the auspices of the IEA, a consortium of research institutions in 60 countries (Spaull, 2012).

Even though drawing conclusion from the said researches above is hard for many countries, their report help to improve the education of different education systems. These studies also provide countries with a comprehensive picture of their mathematics and science education across primary, middle, and upper secondary schools. High quality, internationally comparative data about learner achievement in mathematics and science are important for monitoring and improving the health of a country's education system. Evidence of underperforming areas often stimulates education reform, with subsequent assessments being effective monitors of changes in the educational system. Santapau (2001) indicates that even high performers are prone to jitters where by countries like Japan enforce their education by introducing Saturday schooling to improve their education. In South Africa ANA was introduced for this purpose.

Based on what has been reported above, it shows that there is a need to improve the education of our learners. On that, educators as ambassadors of educational achievements can use existing theories in their practice to help improve the education of our learners. Based on this study, the practices may have to be carefully examined and mathematics teachers specifically be made aware of how they can successfully implement mathematical problem solving in the classroom (Yeo, 2009). Given that context, I was then motivated to pursue the present study based on the following theory of learning.

2.5. THEORETICAL FRAMEWORK

Learning theories have been developed over the past decades by theorists such as Polya (1957), Mathematical Problem Solving Theory, Bruner (1966), Constructivists theory, Newell and Simon (1972), General Problem Solver Theory and Schoenfeld (1985), Mathematical Problem Solving Theory. Bruner (1966) maintains that learning is an active process in which learners construct new ideas or concepts based upon their current or past knowledge. The belief is that learners select and transform information, construct hypotheses, and make decisions, relying on a cognitive structure to do so. The theory illustrates that whatever learners do is influenced by their past knowledge or experience of the environment they find themselves in. For learners to solve mathematical word problems, they need past knowledge or experience to construct new ideas or to respond to the problem given.

Newell and Simon (1972) on their General Problem Solver (GPS) theory articulate that critical step in solving a problem with GPS is the definition of the problem space in terms of the goal to be achieved and the transformation rules. The basic solution rules are identified as transforming one object into another, reducing the difference between two objects, and applying an operator to an object. On the other hand Mathematical Problem Solving theory of Schoenfeld (1985) emphasise that understanding and teaching mathematics should be approached as a problem-solving domain and categorise knowledge/skills that are needed to be successful in mathematics into resources, heuristics, control and beliefs. With the said theories it appears to me that in any given circumstance when solving a problem there is a way to solve that problem, either following a rule or categorise the skills available to successfully solve that problem. Mathematics problems often require established procedures and knowing what and when to apply those (Gagnon and Maccini, 2008).

Polya (1957) in his book *How to Solve It* presented four strategies that can be used to help learners solve mathematical word problems. The theory states the four principles that form the basis for problem solving as:

- Understanding the problem.
- Devising a plan.
- Carrying out the plan.
- Looking back.

On that note trying to simplify strategies by Polya (1957), Krulik and Rudnick (1987), Snyder (1988), Maccini and Gagnon (2006), Hains-Wesson (2013) and Faucette and Pittman (2015) came up with their strategies. Krulik and Rudnick (1987) like Polya (1957) introduced four strategies to solve problems, Snyder (1988) introduced STAR strategies whereas Maccini and Gagnon (2006) talked of RIDGES and Hains-Wesson (2013) introduced common foundational steps in order to solve problems. Faucette and Pittman (2015) illustrated two strategies of which the first one: K.N.W.S has four steps and a six step strategy: SQRQSQ. According to Faucette and Pittman (2015) these strategies are designed to help learners read and learn mathematics focusing primarily on word problems and also help teachers to evaluate learners' understanding and any possible misconceptions they may have about a particular word problem.

Krulik and Rudnick (1987) stated their strategies as:

- Explore
- Select a strategy
- Solve the problem
- Review and extend.

With Snyder (1988), RIDGES stands for:

- R - Read the problem,
- I - I know statement,
- D- Draw a picture,
- G - Goal statement, and
- E - Equation development and
- S - Solve the equation.

For Maccini and Gagnon's (2006) STAR stands for:

- S - search the word problem
- T - translate the problem
- A - answer the problem
- R - review the solution.

Hains-Wesson (2013) on the development of the problem solving teaching resource introduced the problem solving process as indicated in the figure below:



Figure 1: problem solving process

Beside, Faucette and Pittman (2015)'s two strategies KNWS and SQRQSQ means:

KNWS

- K – What facts they KNOW
- N – What information is NOT relevant
- W – WHAT the problem wants them to find out
- S – What STRATEGY can be used to solve the problem

SQRQSQ

- Survey – skim the problem to get an idea of the nature of the problem.
- Question – ask what the problem is about, what information does it requires or restate the problem.
- Read – read carefully to identify important information, facts, relationships and details needed to solve the problem. Highlight important information.
- Question – for this step one ask what must be done to solve the problem, what information is provided, what strategies are needed? What is not given or unknown? What operation(s) should be used with what number and in what order?

- Compute (or construct) – here the computation is done to solve the problem or construct a solution by drawing a diagram or by making a table or by setting up and solving an equation.
- Question – as the last question one should ask if the solution seems to be correct and whether the answer is reasonable. Also it is checked on this step whether the calculations were done correctly, facts provided in the problem were used correctly, solution makes sense and the answer is in the correct units.

Looking at the strategies (Krulik and Rudnick, 1987; Snyder, 1988; Maccini and Gagnon, 2006; Hains-Wesson, 2013; Faucette and Pittman, 2015) above they all play around Polya's (1957) four principles. However, Snyder (1988) and Faucette and Pittman (2015) have six stages and Hains-Wesson (2013) has seven stage process. Krulik and Rudnick's (1987) four steps is also a duplicate of those of Polya (1957).

Expanding the strategies of Polya (1957) by means of understanding the problem, learners must read between lines and understand what they are expected to do mathematically (Barwell, 2011). The idea is to read the problem carefully and write what is known and what is unknown (what need to be solved or found). All the information should be listed, relevant or not (Snyder, 1988). The problem can also be expressed in own words to show understanding. The learner should not only understand the problem, but should also desire its solution (Polya, 1957) as Moursund and Albrecht (2011) note that a personal commitment to solving the problem is needed in this stage of problem solving.

Stigler and Hiebert (2004) highlight that in many instances of general practice the stages involving understanding of the problem process tend to be weak. Then again, the Florida Department of Education (2010) point to this step as the most overlooked step in the problem-solving process whereas it is essentially a higher form of step one in which learners identify what the problem is and represents it in a way that is easier to understand (Krulik and Rudnick, 1987). Moursund and Albrecht (2011) approve that an initial understanding of the givens, resources and goal are needed in this step.

The Florida Department of Education (2010) once again emphasises the strategies that teachers can use to support learners through this first step of problem-solving as:

- Survey, Question, Read (SQR): The 'S' is for reading the problem rapidly, skimming to determine its nature. The 'Q' is for deciding what is being asked; in other words, ask "what is the problem?" The R is for reading for details and interrelationships.
- Frayer Vocabulary Model: The Frayer model is a concept map which enables learners to make relational connections with vocabulary words
- Mnemonic Devices: are strategies that learners and teachers can create to help learners remember content. They are memory aids in which specific words are used to remember a concept or a list.
- Graphic Organisers: Graphic organisers are diagrammatic illustrations designed to assist learners in representing patterns, interpreting data, and analysing information relevant to problem-solving
- Paraphrase: this strategy is designed to help learners restate mathematics problem in their own words, therefore strengthening their comprehension of the problem.
- Visualise: learners here visualise and then draw the problem, allowing them to obtain a clearer understanding of what the problem is asking, in a way learners would be practicing to create pictorial representations of mathematical problems.

It is further recommended by the Florida Department of Education (2010) that teachers should decide which strategies to use based on learners' difficulty in understanding the problem and help them to make this strategy part of their repertoire of high-road strategies (Moursund & Albrecht, 2011).

After understanding the problem, the next step is to draw a conclusion or make a hypothesis about how to solve the problem based on what has been found in step one (Krulik and Rudnick, 1987). The equation can then be developed from the translation of the problem through different designs e.g. translating a problem into picture form and from that the equation can then be developed (Snyder, 1988; Florida Department of Education, 2010). The plan is available when one knows which calculations, computations or constructions have to be performed in order to obtain

the unknown (Polya, 1957). The Florida Department of Education (2010) indicates that learners should find the connection between the data and the variable before deciding on the plan. This can only be successful if the idea is based on past experience and formally acquired knowledge (Carson, 2007). In this stage of devising the plan, Polya (1957) listed some partial strategies that can help planning to solve the problem, that is, guess and check, draw a picture or diagram, look for a pattern, make a table, use a variable, make an organized list, eliminate possibilities, use logical reasoning, work backwards and etc.

The given information can now be plugged into the equation to answer the problem by solving the unknown. The learner should be the one who constructs the idea based on previous knowledge (NTCM, 2000; Bruner, 1966) so that the idea is not lost as the danger is that the learner can forget the plan if the learner received the plan from the teacher (Polya, 1957). Re-reading of the word problem should be done and check the reasonableness of the answer. By so doing the learners will be reconsidering and re-examining the results and the path that led to the answer or solution (Polya, 1957). Furthermore, they could consolidate their knowledge and develop their ability to solve problems.

The skill of problem solving could and should be taught in the classroom and it is not something that one can be born with (Polya, 1957). The Florida Department of Education (2010) further expresses that learners should be encouraged to develop and discover their own problem-solving strategies and become adept at using them for problem-solving. Additionally this will help them with their confidence in tackling problem-solving tasks in any situation, and enhance their reasoning skills in a way developing flexibility to choose from the variety of strategies they have learned. For teachers to develop learners' ability to solve problems they must instil interest for problems into learners' minds and give them plenty of opportunity for imitation and practice (NCTM, 2000). This study followed Mathematical Problem Solving theory by Polya (1957) on helping learners to solve word problems. As indicated earlier on, all the strategies introduced (Krulik and Rudnick, 1987; Snyder, 1988; Maccini and Gagnon, 2006; Hains-Wesson, 2013; Faucette and Pittman, 2015) portray the four problem solving principles by Polya (1957).

2.6. CONCLUSION

It has been shown in this chapter that problem solving is a means by which an individual uses previously acquired mathematical knowledge, skills and understanding to solve a problem. It is also noted from the literature that mathematics problem solving tasks have the potential to provide the intellectual challenges for enhancing learners' mathematical understanding and development. Above and beyond what problem solving denotes, it is important that mathematical problem solving tasks be given according to the goals set which can be characterised by promoting learners' conceptual understanding, fostering their ability to reason and communicate mathematically, and capture their interest and curiosity. It is also important to teach learners problem solving as it prepares them not only to think mathematically, but also to approach life's challenges with confidence in their problem-solving ability.

The skills and strategies of problem solving can be taught through collaborative teaching. It has been learned from this chapter that collaborative teaching provides teachers with opportunities to be engaged in more philosophical discussions and to learn from each other's experiences and teaching styles. Even though collaborative teaching as a teaching strategy has its downfalls, expose each partner's professional and personal points of view more than the traditional one-teacher-per-classroom setting, it allows engaged teachers to blend their teaching styles and expertise so that they can overcome the challenges they face in teaching problem solving in particular.

The chapter showed that a great deal of research has been conducted in the field of mathematical word problem solving. Literature revealed that some such studies focused on reading comprehension as part of mathematical problem solving while others attempted to improve achievement and abilities of learners to solve word problems. Several of the investigations explored the difficulties faced by learners in solving word problems and certain sight-saw the impediments faced by learners in solving word problems. It has been shown from the said reports that a significant proportion of learners still experience challenges in providing responses to questions that require high order cognitive skills the non- routine problems which the present study focused on.

For the challenges that learners have, there should be a way of identifying and improving those challenges in a way improving the education of the entire country. Efforts for educational improvements and achievements were also discussed in this chapter where the Department of Basic Education is involved. It has been shown additionally in this chapter that Mathematical Problem Solving by Polya (1957) has been adopted as the one to guide the study. The four principles of problem solving were outlined showing how they should be engaged in improving learners' problem solving skills and strategies. The next chapter will present in detail the methods used in conducting the study and how the four principles of problem solving by Polya (1957) were administered.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. INTRODUCTION

The purpose of this chapter is to justify the reasons for using particular methodologies and designs as against the choice of others. It discusses in detail the research methodology that has been adopted in this case study of Sedupe Primary School (pseudonym) in Lebopo Circuit of Limpopo Province. The action research collaboration that has been adopted in this research was carefully designed as to align with the area of inquiry. The enquiry was carried out from within Sedupe Primary School by members of the school, that is, Grade 6 mathematics educator and I and 26 learners.

The first section describes the design of the study entailing research site and sampling; followed by data collection and data analysis. The fourth and fifth parts describe quality criteria and ethical considerations respectively. The literature reviews have assisted me to focus on the type of research method that would be most suitable for this area of study. The work builds on earlier studies of knowledge sharing over mathematical word problem solving such as those discussed in Chapter 2.

3.2. DESIGN OF THE STUDY

The study followed classroom action research collaboration where I (as the researcher) went to work with the participants (Denzin and Lincoln, 1994). According to the purpose of this study action research design is characterised by a process involving educators working together to improve their own practices (Bassey, 1998). It is persuasive and authoritative, since it is done by teachers for teachers, and is collaborative; that is, it is composed of educators talking and working with other educators in empowering relationship (Mertler, 2010). This means that myself as the principal of the school and mathematics educator worked together with the Grade 6 mathematics educator towards a common goal (Fister-Mulkey and DeBoer, 1995; Thousands and Villa, 2000; Lin and Xie, 2009; Zhou, Kim and Kerekes, 2011).

According to Welman, Kruger and Mitchel (2011) the enquiry was carried out from within an organisation: Sedupe Primary School, by the employees of the organisation, that is, Grade 6 mathematics educator and I, co-teaching the group of Grade 6 learners (Cook and Friend, 2004), instead of by someone approaching from the outside and retaining the role of an outsider. The nature of action research is that it is carried out within the context of the researcher's environment: that is with the participants and at the school in which the researcher works (Ferrance, 2000). This was easy for me as I understood and had compassion with the participants, and the intention being to interact with them in a natural and unobtrusive manner.

The focus of the study was on promoting change (Bassey, 1998 and Biggam, 2011) on learner performance specifically on mathematical word problem solving. Central to this idea of study was the idea of self-reflection or self-reflective enquiry. The purpose of action research is therefore to turn up with suggestions for good practice that will tackle a setback or improve the performance of the organisation and individuals through changes to the rules and procedures within which they operate (Denscombe, 2010). The idea was that one teach, one observe (Friend and Bursuck, 2002; Zelkowitz, 2008; Logsdon, 2013), then critically reflect on the happenings of the class and also raise voice as participant considering that collaborative action research include participation (Cook, 2010).

3.2.1. Research site

This study formed part of the daily normal activities of Sedupe Primary School (pseudonym) in the rural area of Lebopo Circuit of Mankweng Cluster, Lebowakgomo District of Limpopo Province in South Africa. The school is categorised under quintile 2, with 330 learners. All learners at the school receive free meals. This ascertains that being categorised under quintile 2, our learners are disadvantaged. Their home language is Sepedi and at school the language of teaching and learning is English.

The setting was chosen as the school was accessible to me as the researcher. As the researcher, I form part of the daily activities of the school as I am the mathematics teacher and also head of the institution (Leedy and Ormrod, 2010). In that regard the study focused on phenomenon occurring in a natural setting and involved studying those phenomena in all their complexity (Leedy and Ormrod, 2010).

3.2.2. Sample and sampling strategy

The participants in the study were 26 Grade 6 learners, aged between 10 and 11 years, together with their mathematics educator at Sedupe Primary School. To the same extent that action research is characterised by exploratory and descriptive focus (Bassey, 1998), the sample strategy chosen was convenience sampling. This sample strategy tends to be used as a form of exploratory research, giving ideas and insight that may lead to other, more detailed and representative research (Biggam, 2011). The study involved accessible and readily available participants (Marshall, 1996; Latham, 2007) to me.

Besides, Grade 6 has been chosen by the government and the society so that more emphasis on monitoring learner performance happens at this stage, given that it is the exit stage at the lower Grade, the Foundation and Intermediate Phase (DBE, 2010). Grade 6 is the class which is targeted for the national baseline to benchmark annual targets and achievement towards realising the desired 60% threshold of learners mastering the minimum Literacy and Numeracy competencies (DBE, 2010). In addition to that the class is an exit class of the Intermediate Phase. The setting was

not only for data collection but also formed part of my daily routine duties as a mathematics teacher and head of the institution.

3.3. DATA COLLECTION

The plan of this research was to involve myself and the Grade 6 educator to work collaboratively in improving learners' mathematical word problem solving skills and strategies. The intention was to collaborate through participation (Ferrance, 2000; Cook, 2010). As action research is a cyclical process of planning, acting, developing, and reflecting (Creswell, 2012) data were collected in a routine structured process for continuous confrontation with the data. Corresponding to the purpose of this study action research is more than a process as the problem was defined, planned the solution, implemented the proposed solution and evaluated the results (Biggman, 2011). All this was a commitment to improve learners' problem solving skills and strategies in word problems.

Repeated cycle of planning, teaching and reflecting was done by both the educator and the researcher. The idea was that the researcher and the educator take turn in their roles, as reflective practitioners and as a facilitator (Maoto and Wallace, 2006). The routine was guided by the following phases:

Phase 1: Pre- intervention

Learners were given the word problems activities to work on whereby both the educator and I identified the challenges learners had (See Appendix A for phase 1 activities). The activities in this phase required lower-level of understanding and application that allowed learners to recognise a correct answer after performing a single computation. Challenges identified during this intervention phase were that learners found it difficult derive meaning from given problem statements as they were unable to decode difficult or unfamiliar words. That also made them to have difficulties in deriving number sentences that would help them to make calculations easily. As the four steps of problem solving inform each other, learners were further challenged by performing simple arithmetic and committing calculation errors. The other challenge was that learners were unable to justify answer by using inverse operations. These

challenges which were identified during this stage of intervention were addressed during the second phase of intervention which is the intervention stage.

Phase 2: Intervention

The researcher and the educator as a team planned on how to help learners overcome the identified challenges mentioned in the pre-intervention phase based on the sample of learners' work. The intervention was done collaboratively where I observed and recorded the happenings in a journal. During the intervention, unstructured interviews were conducted to get clarity of what learners were doing and trying to make sense of their thinking behind what they have written. At some stage I was facilitating and the educator recorded the happenings.

The activity used to address the challenges identified in this intervention phase (see Annexure A for activity given in phase 2) required only one computation. This activity assisted learners on how to decode unfamiliar or difficult words in order to make sense of the problem statement. With the problem statement given, learners had to identify words which they did not understand and find meanings in the dictionary. It was highlighted to them that meaning of words should be in line with the problem statement as there may be more than one meaning given in a dictionary. Only suitable words for the problem statement should be used.

The activity in this phase was also used to show learners how number sentences are derived from the problem statement. Number sentences assist in carrying out the plan, direct on how calculations are made. It was further highlighted that evaluating or rechecking the solutions help to identify errors committed when calculating.

Phase 3: Post intervention

After the intervention both I and the educator checked if improvement has occurred by giving learners more word problems to work on. We both checked whether the data clearly provided the supporting evidence, and planned on more intervention leading to the next step to be taken. Learners were given activities that required them to perform more complex procedures (see Appendix A for phase 3 activities) on the next step to be taken.

The purpose of activities given in this phase was to make learners practice more in order to overcome their challenges identified in the first and second phases. The activities allowed them to work more on breaking up the problem statement in order to make sense of it. They also had to derive the number sentences that will lead them to carry out the plan by making calculations, and as well allowed them to check for errors and whether their solutions made sense.

3.4. DATA ANALYSIS

Analysis of qualitative data is an inductive process (Mertler, 2010). This means that data were analysed through the development of a system of categorisation of learners' responses (Mertler, 2010; Welman, Kruger and Mitchell, 2011). In this case analysis of learners' response was done being guided by four steps of problem solving by Polya (1957) namely the way they understand the problem, devise the plan, carrying out the plan and looking back. The purpose thereof was to group data that provided similar types of information and to understand steps that were unclear to learners (Mertler, 2010; Welman, Kruger and Mitchell, 2011).

3.5. QUALITY CRITERIA

Credibility: just like validity in qualitative research, asks if there is a correspondence between the way the respondents actually perceive social constructs and the way the researcher portrays their viewpoints (Mertens, 2005). Being mentioned as internal validity in quantitative research (Hannes, 2011; Flick, Kardorff, Steinke, 2004); credibility refers to the equivalence of research results with the objective reality (Bitsch, 2005). To ensure the dependability of the findings of this report, the following credibility techniques were considered: prolonged engagement, persistent observations and triangulation (Bitsch, 2005; Mertens, 2005; Hannes, 2011). To ensure the conclusions of this study were supported by sufficient data sources, I have chosen classroom action research as the design of the study in order to develop a baseline of learners' challenges in solving word problems. The design guaranteed daily engagement with learners as participants whereby enough time was spent on the research site of which the context and its culture were well understood (Bitsch, 2005).

The process of the study took place in a normal setting of teaching and learning of mathematics. In order to gain detailed data, activities which required learners to both perform single computation and more complex procedures in the three phases of intervention were used. Work given to learners as classwork and homework was not only for data collection, but also formed part of the daily activities of learners. The way in which data was collected guaranteed the integrity of the findings of this study.

With the upper hand, to ensure that sufficient data was gathered, observations were also recorded in a journal. Through that I was able to compile insights about how learners responded and solved the word problems. I asked learners questions as part of another way of gathering data in order to dig out the thinking behind what learners wrote as their responses. It was clear from what has been said that observations, interviews and document review as various sources of data had been employed in this study to ensure the credibility of my findings. It was by using all of these data collection methods that I came to my final conclusions.

3.6. ETHICAL CONSIDERATIONS

The study was informed by action research in which the activities involved the process of teaching and learning of mathematics. There was in no way that physical harm could be incurred by the participant, both the educator and learners. This means that the participants could not be subjected to unusual stress, embarrassment, or loss of self-esteem (Leedy and Ormrod, 2010). All actions performed during the process of this study involved behaviours within the scope of participants' normal daily activities at school.

The study involved Grade 6 learners who are minors and could not sign consent forms. As the principal of the school, I requested permission from parents during parental meeting. Permission was also requested from the Department of Basic Education through the Circuit Manager (See Appendix B for the letter of permission). The nature and quality of the participants' confidentiality was kept. In the case where an in-depth description of the learners' responses was done, such learners were given fictitious names to ensure anonymity. The findings were reported in a complete and honest

fashion, without misinterpreting what has transpired during the observation. Full acknowledgement on materials and/or ideas belonging to others was honestly done.

3.7. CONCLUSION

This chapter outlined the research design and methods that were adopted in the study. The study followed action research collaboration where the Grade 6 class and their mathematics teacher and I were involved. The focus was on promoting change on learner performance specifically on mathematical word problem solving. Self-reflective enquiry was used where 26 learners of Sedupe Primary School in a rural area of Lebopo Circuit, Limpopo Province, participated.

Data were collected in a routine structured process. The routine was guided by three phases namely: pre-intervention phase, intervention phase and post-intervention phase. It was also shown in this chapter that analysis of data was done being guided by the four principles of problem solving by Polya (1957) on all the three phases of intervention. In the next chapter, the focus will be on the research findings, analysis and interpretations of the results attained using the methodology outlined in this chapter.

CHAPTER 4: RESEARCH FINDINGS AND DISCUSSIONS

4.1. INTRODUCTION

In this chapter the results of data analysis are presented. The data were collected and then administered in response to the problems posed in chapter 1 of this study. Three fundamental research questions drove the collection of the data and the subsequent data analysis. Those research questions were: What are the challenges faced by Grade 6 learners in solving mathematical word problems? What are Grade 6 learners' strategies in solving mathematical word problems? How can learners' problem solving skills and strategies focusing on word problems be improved?

This chapter comprises the analysis, presentation and interpretation of the findings resulting from the methodology adopted in chapter 3 of this study. The analysis and interpretation of data is carried out in three phases. The first part reports findings collected during the pre-intervention phase. The second and third phases report the findings resulting from the intervention phase and the post-intervention phase respectively. In all the three phases, analysis is carried out according to Polya's (1957) four principles of problem solving, namely understanding the problem, devising the plan, carrying out the plan and looking back.

4.2. DATA ANALYSIS

For all activities given, learners were expected to show their (a) understanding of the problem by unpacking the problem before attempting to find the solution. The expectation was that they identify difficult words and give their meaning if ever there were words they did not understand. Furthermore, they were required to restate the problem in their own words. Lastly, they were supposed to write exactly what the problem required them to find or do. (b) Devising the plan by showing the step they were to use in solving the problem. They were required to find a way to solve the problem and state the procedure they were to follow when solving the problem. At this stage learners had the options of using pictures or diagrams and equally by making a table and an organised list. (c) Carrying out the plan by using the selected strategy in (b) above. It was at this point that they were supposed to compute using relevant operations, implement their plans to find solutions. (d) Looking back by justifying their answers or solutions. This was supposed to have been done by checking whether their answers made sense or not and by showing what they learned during the process of solving the given problem.

4.2.1. Pre-intervention phase

Out of 26 learners, 10 learners did not respond to activity 1 and all of them responded to activity 2. During this phase learners were working individually. For those who did not respond to activity 1, when asked the reason for not writing anything in an attempt to find the solution to the activity, they could not give reasons of not writing. They just kept quiet. I think this was because of lack of confidence in working with word problem and or not being used to such activities.

Most learners did not do well in both activities. For activity 1, I think the question was elusive as it does not specify whether it requires the profit or income made by Mr Peterson. Only 4 learners could give the solution as the income and the rest could not respond positively. For activity 2, all learners' solutions were not positive. The activity required more than one computation where learners should have calculated the profit of one chocolate and then for 67 chocolates. As they were unable to find the solution for activity 1, they were also challenged by this activity. Let us now look at how they responded to the two activities as per Polya's (1957) four problem solving steps.

4.2.1.1. Understanding of the problem

Activity 1: Mr Peterson buys a chocolate for R3, 45 and sells it for R5, 50. How much money did he make by selling the chocolate?

From the 16 learners who attempted to work on the problem, 6 responses emerged. Different sets of learners got their solution as R2-15, R8-95, R5-50, R3-45 and R3-95. Most of the learners wrote answers only without showing their work. I made sense of those solutions by letting them explain how they arrived at their solutions. The following is how they responded:

Response 1: R2-15

Some learners here wrote the answer only, whereas others wrote as the example below:

$$\begin{array}{r} \text{R5,50} \\ -\text{R3,45} \\ \hline \text{R2,15} \end{array}$$

The explanation of those who wrote the answer only was similar to those who responded as above. One explanation was: the person was having R5-50 and the chocolate was R3-45 so his change is R2-15.

If learners did not explain verbally, I would say they had a sense of what was required of them but the challenge was the computation. The explanation on how they arrived at the answer showed clearly that the problem was not understood. When asked what informed them to find the change they did not respond. They did not know exactly what is being asked and what question they were supposed to answer.

Response 2: R8-95

$$\begin{array}{r} \text{R3,45} \\ +\text{R5,50} \\ \hline \text{R8,95} \end{array}$$

With the above response, learners were asked why they added. They did not respond to the question. Their silence and looking at their solution showed that they copied figures and decided to add with no understanding.

Response 3: R5-50

This set of learners just wrote the answer only. When requested to explain their answer, they showed that if Mr Peterson buys a chocolate for R3-45 and sells it for R5-50 then he made R5-50 by selling the chocolate. I think they literally understood what was asked. I am saying so because they could not tell whether R5-50 is an income or profit.

Response 4: R3-45

Here the group explained that the selling money was R3-45. The example of their response was as follows:

The selling money is R3-45

I think the challenge here was with the language of teaching and learning as a first additional language. There was no sign of understanding the problem.

Response 5: R3-95

$$\begin{array}{r} \text{R3,45} \\ - \text{R5,50} \\ \hline \text{R3,95} \end{array}$$

With the illustrated example of the response, same as response 2, learners here just copied figures and decided to use subtraction sign without knowing exactly what they were doing. The response shows that learners totally did not have a sense of the problem.

Activity 2

With activity 2, almost all learners showed a lack of understanding to the problem. Their solutions were not correct. Their approach to the problem showed that they did not know what had been asked or what they were supposed to find. Some of them multiplied R5-50 by 67, whereas some multiplied R3-45 by 67 and still others multiplied R3-45 by R5-50. The other group multiplied 67 by 5. The last set of learners added the figures they saw on the statement. Most of them failed to explain how they arrived at their solutions.

For those who multiplied R5-50 by 67, I explained that as Mr Peterson made R5-50 by selling one chocolate, then by multiplying the two figures they would get the profit he made by selling 67 chocolates. I think they did not understand the word profit. On that they lacked the ability to decode the word 'profit' as unfamiliar to them and that

made them unable to derive meaning from the problem statement (DBE, 2013). Similarly, those who multiplied R3-45 by 67 also did not understand the same word as they were to find the expenditure for Mr Peterson buying 67 chocolates.

The other three sets of learners showed that they were totally lost with regard to the understanding of the problem. They showed that they did not know what had been asked. According to Polya (1957), this stage of problem solving does not entail any computation or solution. All what was needed was to show their understanding of the problem by unpacking the story or statement. The two activities show clearly that learners were faced with a big challenge of making sense of the problems, which led to the difficulty in devising the plan.

4.2.1.2. Devising the plan

For both activities on this step of problem solving, all 26 learners did not show their strategy or procedure to be used or followed on how to find solutions to the problems. This might have been caused by learners not being exposed to any strategy or procedure on solving word problems. Instead of devising a plan, learners just carried out the plan by computing using number sentences which they did not show how they were derived.

4.2.1.3. Carrying out the plan

This stage is informed by both the stages of understanding the problem and devising of the plan. If learners are unable to unpack the problem in order to make sense of it then it will not be easy for them to derive open number sentences so that they perform some computations. With reference to activity 1, besides the 10 learners who did not respond, all of them carried out the plan. I think this was easy for them as they believed that when given a problem one should just perform some calculations. Activity 2 also had learners carried out the plan. The unfortunate part is that for almost all of the calculations, their solutions were not correct and not even relevant to the problem posed to them. Below are some examples of the calculations made to both activities showing incorrect computations and calculations not relevant to the problem.

Activity 1

Response 1:

$$\begin{array}{r} \text{R}3,45 \\ + \text{R}5,50 \\ \hline \text{R}8,95 \end{array}$$

The learner here just takes figures and decides to add. The solution of the calculation is not related to the problem.

Response 2:

$$\begin{array}{r} \text{R}3,45 \\ - \text{R}5,50 \\ \hline \text{R}3,95 \end{array}$$

The response is similar to response 1 above. Figures are copied according to the sequence they appear in the problem. The subtraction operation was the auspicious operation to be chosen.

Response 3:

$$\begin{array}{r} \text{R}5,50 \\ - \text{R}3,45 \\ \hline \text{R}2,15 \end{array}$$

The response shows that the learner seemed to have understood the problem statement on finding the profit. The challenge is the computation or performing simple arithmetic.

Activity 2

Response 1

$$\begin{array}{r} \text{R}5,50 \\ \times 67 \\ \hline 3850 \\ 3300 \\ \hline 36850 \end{array}$$

The computation in this regard is correct. The challenge appeared to be learners confusing the two words, profit and income. Instead of calculating the profit as the question required, income was calculated. This shows the relationship between these stages of carrying out the plan with the other two first stages.

Response 2

$$\begin{array}{r} \text{R5,50} \\ - \text{R3,45} \\ \hline \text{R2,10} \end{array} \qquad \begin{array}{r} \text{R3,45} \\ \text{67} \\ \hline \text{24,15} \\ \text{187,0} \\ \hline \text{R121,15} \end{array}$$

The response above shows that the learner here had an idea that there should be more than one computation to perform. The challenge was to attach meaning to the figures and to perform simple arithmetic. The learner should have at least multiplied R2-10 by 67 not R3-45 by 67 to show understanding of what was done.

For both activities, in most cases, the number sentences were correct according to what the questions required learners to do. Most of the learners used the vertical method of subtraction, addition and multiplication with an attempt to find their solutions. Hence, their number sentences were not in line with what they wrote or calculated. Having their number sentences correct, they were unable to perform simple arithmetic.

4.2.1.4. Looking back

Learners did not respond to this step of problem solving. When asked whether their answers made sense or not they could not respond. They were not able to justify their answers or solutions. Mistakes which learners did with their calculations also confirmed that they were not able to recheck their work. The following example indicates that they were not checking their work as their solutions did not make sense:

Activity 1

Response 1

$$\begin{array}{r} \text{R3,45} \\ - \text{R5,50} \\ \hline \text{R3,95} \end{array}$$

The learner here should have noticed before even performing the calculations that R5, 50 cannot be subtracted from R3, 45. Again addition has also been used when calculating the tens as the answer is 9. I think the challenge also is with working with decimals.

Activity 2

Response 1

$$\begin{array}{r} \text{R5,50} \\ - \text{R3,45} \\ \hline \text{R2,10} \end{array}$$

The mistake here shows exactly that the work has not been rechecked or evaluated. The issue of borrowing and what remains when borrowed was a challenge and this type of a mistake can be overcome by rechecking the answers.

Looking at what transpired above, we then set and discuss what should be done next. From the analysis above we deduced that learners had a challenge with all four steps of problem solving. We then conclude that we intervene by helping learners understand the four steps of problem solving.

4.2.2. Intervention phase

After collaboratively reflecting on the pre-intervention activities above, we agreed that at least one period per week be allocated for word problem solving activities. The duration of the period was 45 minutes. We also found it necessary to intervene by elaborating the four steps of problem solving working together with learners on one activity in order to help them understand the four steps of problem solving. The session was facilitated by me. We decided to use the activity that requires a single computation. The activity was:

How many R100 rand notes are there in R1 456?

4.2.2.1. Understanding the problem

Learners were requested to read the problem aloud and identify the words that they did not understand. The identified word not familiar with learners was 'notes'. I requested them to find the meaning in their school dictionary. Two responses were given as follows:

Response 1:

Note is a short piece of writing and information written on paper.

Response 2:

Notes means bank notes.

I further asked: which meaning of the word 'notes' above is relevant to our problem statement?

Tebogo: I think bank notes.

Facilitator: why bank notes?

Tebogo: ka go re bank ke mo go dulang tshelete. (Because bank is where we put money)

Almost all the learners could not understand what Tebogo had said. It was not clear to learners what bank note is. We then talked of South African money where learners mentioned all monies, coins and notes, used in SA. Learners realised that notes in question is paper money which they refer to as 'tshelete ya pampiri'. Learners then understood that R100 is a bank note.

I highlighted to them that when trying to understand words from a given problem when they look up such words in a dictionary they must check meanings related to the problem statement. Learners were also asked if they knew what exactly they were supposed to do. They did not struggle to show that they were to find the number of R100 notes in R1456.

This session confirmed to me that it is possible for one not to know that he/she knows something. I think the reason is lack of vocabulary. Learners know a R100 note but they did not know that it is a bank note. When we proceeded to the next step, it was clear that they understood the problem.

4.2.2.2. Devising the plan

As we identified that learners were not exposed to any strategy of solving word problems, we introduced to them the strategy of listing of facts and making relationships. The choice was based on the fact that the strategy would help boost their confidence and communication skills when reporting their solutions.

The following conversation with learners took place:

Facilitator: List anything you think is important from the statement.

There was no response on the question posed. Learners appeared confused. I further showed them that what we know from the statement is that we have R1456. The next step is what do we do with R1456? Learners still could not respond. I then asked them: What are we going to do?

Tshepo: We are going to divide.

Facilitator: What are we going to divide?

Tshepo: 1456 by 100.

I told learners that it was important to write the open number sentence at this stage as it would help in carrying out the plan.

Facilitator: From what Tshepo said, what will be our open number sentence?

Kamogelo: $1456 \div 100 = \square$

Facilitator: How are we going to work it out?

Kamogelo: I am going to use long division method.

I showed learners that now that we had a number sentence we could then proceed to the next step of carrying out the plan.

4.2.2.3. Carrying out the plan

As Kamogelo showed that they were familiar with long division method, I requested them to work using the method. It was easy for them to execute steps followed in long division method.

The learners were told that on this step of problem solving the computation are done on the open number sentence developed on the previous step as the example below:

$$\begin{array}{r} 100 \overline{) 1456} \\ \underline{-100} \\ 456 \\ \underline{-400} \\ 56 \end{array}$$

The facilitator asked the learners:

Facilitator: From the computation above, what is our solution?

Tshepo: Our solution is 14 remainder 56.

All learners agreed to what Tshepo said. I showed them that 14 remainder 56 is our answer when we divide 1 456 by 100. I then explained to them that a conciliatory statement should be written in order to show our solution. This means that we have 14 R100 notes in R 1 456. With the conciliatory statement we answer the question which was exactly asked in the problem statement. When we are done with our computation, having obtained the solution, we have to check for mistakes.

4.2.2.4. Looking back

This step of problem solving is for justifying the solution got in the previous step by checking whether the solution makes sense or not. With the computation above, the opposite of division is multiplication. Learners were requested to use the tip to justify the answer on long division method.

It was difficult for learners to realise that they should multiply 14 by 100. I think they could not relate division with multiplication. I started to direct them through the question as follows:

Facilitator: How do we know that $1456 \div 100 = 14$ remainder 56 is correct?

Thomas: Sir, we go back to the steps and check for mistakes.

Facilitator: Thomas we have to check whether our answer is correct by using the tip that division is the opposite of multiplication. How do we do that?

Learners seemed challenged and I referred them to the mental maths activities in their textbook for revision.

Malebo: ohoo! If $3 \times 5 = 15$ then $15 \div 5 = 3$. Ok, $100 \times 14 = 1400$.

John: 56 *yona*? (What about 56?)

They all kept quiet.

Facilitator: 56 is the remainder as we cannot divide it by 100 and when we add it to 1400 it gives us 1456. This shows that our answer makes sense.

The next thing to do in this step was to find the easier way to solve the problem. With this activity it can be to directly divide 1456 by 100 without using the long division method. That is: $1456 \div 100 = 14, 56$

Looking at what has been learned when solving the problem; learners thought that they learned dividing using the long division method. I then made them aware that they learned what a bank note is and also showed them that they revised the money used in SA. More word problem activities were then given to the earners to work on. The purpose of the activities was to see how they would perform after the intervention.

4.2.3. Post-intervention phase

In this stage of data collection, 7 word problem activities were given to the learners. With activities 1, 3 and 5 learners worked individually, whereas activities 2, 4, 6 and 7 were done in groups. Learners happened to do well on activities 1, 3, 5 and 7 with set of solutions R37.90; R36.95; R62.90, 55; 1078; 53; 16674, 10.8; 0.5ml; 50.4l; 840 and 686; 586 respectively. With the other set of activities: activity 2 with solutions 7400; 18; 41; 3700, activity 4 with solutions R1 600; R2 140; R540 and activity 6 with solutions R0, 06; R69; 69^c, R0.14; R0.67; R0.70; learners did not thrive. I think this was caused by the level of difficulty of the given activities. The first set of activities (activities 1, 3, 5 and 7) were of level 3 according to Bloom's Taxonomy (Pohl, 2000; Anderson and Krathwohl, 2001) or low level of complexity as per NAEP taxonomy (Berger, Bowie and Nyaumwe, 2010) and cognitive level routine procedure (DOE, 2008). Activities 2, 4 and 6 were of cognitive level complex procedure or moderate level according to DOE (2008) and Berger et al. (2010) respectively. Analysis with examples on how learners responded to 7 activities is discussed below according to the four steps of problem solving by Polya (1957).

4.2.3.1. Understanding the problem

In this stage of problem solving, with the 7 activities given, most learners did well on activities 1, 2, 3, 5 and 7 they were able to unpack the problem statements easily. Examining the problem statements of the said activities, the language used in those word problem activities were simple that most learners could easily decode phrases and identify what had been asked. The word problem activities were also more related to what learners experienced on a daily basis as Langer (2002) and Williams (2005) suggests.

Even though they did well on activity 3, some had challenge in identifying what was exactly asked. The following are some of the examples of their response:

Response 1: 1078

For those who got the solution as 10780, some responded to the guiding question 'write what was exactly asked' as follows: to find the number of 14 workers in R770; to find the number 770; to find the number of 14 notes in R770.

Response 2: 55

Learners here got the correct solution but their response to the guiding question 'write what was exactly asked' they said: to make the voucher.

My take on the response made to the guiding question above was influenced by inability to comprehend the text by those few learners. Agreeing with Duke and Pearson (2001) and Hervey (2013), the factor that influenced those learners to respond as they did above is that they did not engage with the problem statement in order to clarify meaning. This was similar to how they responded to Activity 4 where they could not identify what was asked. Other groups responded as follows:

Response 1

What was exactly asked: why?

Response 2

Write what was exactly asked: to choose

With the problem statements of the set of activities most learners did well (Activities 1, 4, 5 and 7). These appeared clear to them and they did not show any difficulty in

stating exactly what was asked. The way they responded gave an impression that the problem statements of the activities were not complicated.

Most learners showed to have been challenged by activity 6 at this stage of problem solving. Their response of this stage of problem solving was in this fashion:

Activity 6:

Out of 26 learners, at least 4 learners showed that they should find what amount the friend possibly paid, and those are learners with the response of R0, 70. Twenty-two learners with responses R0, 06; R69; 69^c, R0.14 and R0.67 responded to the guiding question as follows:

Response 1: R0, 06

Who paid 69^c?

Response 2: R69

I asked to pay toffee.

Response 3: 69^c, R0.14 and R0.67

Who did they pay R0, 69?

Examples of responses of the guiding question above shows that on this word problem activity, learners seemed to have been confused by the phrase: My friend paid less than me but more than Sipho, who paid R0, 69. The way they responded it shows that they thought the phrase wanted them to tell them who had paid R0, 69. However, their responses gave no the name of the person who paid. I think what made them unable to comprehend the phrase is the lack of background knowledge (Duke and Pearson, 2001) of the language of teaching and learning (LOLT). It was evident when they could not even restate the problem statement in their own words to show that they were unable to connect the meaning of the phrase to themselves (Williams, 2005).

4.2.3.2. Devising the plan

For all the seven activities, learners were advised to use one strategy in solving the problem: strategy of listing of facts. For activities 1, 3, 2, 5 and 7 most learners were able to list facts identified from the statement even though some could not relate those facts. In some of the activities (activity 3, 5 & 7) learners carried out the plan at this

stage of devising the plan. Several were able to list facts but could not relate those facts in order to derive an open number sentence (activity 1, 4 & 6). Here are selected examples of their responses on devising the plan:

Example 1: Responses where learners worked out a solution instead of devising a plan.

Activity 5

Response 1: 50, 4ml

We are going to multiply 60 by 5; next we multiply answer by 24; later we multiply answer by 7, then we get an answer.

Strategy – listing of facts

- No. of leaking tap drips every minute-5ml
- Relationship: if leaking taps drips 5ml every minute then $60 \times 5 = 300 \times 24 = 7200 \times 7 = 50400 \text{ml} = 50,4 \text{ml}$ will be wasted in a week
- $50400 \text{ml} = 50,4 \text{ml}$

The response above shows that the group anticipated what would be done in the next step of carrying out the plan. They understood the word problem, but they did not sequentially list the facts, instead they worked out the solution to then confirm their prediction (RAND Reading Study Group, 2002).

Activity 7

Response 1: 686

Listing the facts and making relationship.

Truck carried 56 sacks of mealies with a mass of 12,25kg. The truck is certified to carry 700kg.

1 sack = 12.25kg

Is the truck overloaded =?

Relate the facts 1 sack = 12, 25 x 56

The challenge of the learners here I think was to summarise the word problem by determining important ideas (Duke and Pearson, 2001) and that led to their inability to sequence the information logically from the word problem as one of the strategies of key comprehension strategies (Williams, 2005; Hervey, 2013).

Example 2: Learners listed facts but could not relate them.

Activity 6:

Response 1

To solve the problem:

I paid R0, 75^c for a toffee

Who paid 69^c?

What did my friend possibly pay?

Relationship:

- a. I paid R0,75^c
- b. Sipho paid R0,69^c
- c. My friend paid less than me but more than Sipho who paid R0, 69^c ; what did my friend possibly pay?
- d. My friend pay = ?

This response shows that the learner struggled in relating the facts listed from the problem statement. The learner could not relate the facts clearly, which led to not being able to come with the number sentence. I think that being unable to unpack the problem statement during the first stage: understanding the problem and the challenge, led the learner to have difficulty in relating the facts.

4.2.3.3. Carrying out the plan

This step required learners to implement the strategy prepared during the previous stage of devising the plan. The computation is performed at this stage of word problem solving. Activities 1, 3 and 7 expected learners to perform only one computation, whereas activities 2, 4, and 5 compelled them to perform more than two computations. For activity 6, no computation was needed. Once more on the seven activities given to learners, activities 2, 4 and 7 necessitated learners to give a conciliatory statement. Examples of learners' responses on all sets of activities are illustrated below:

Example 1: Response of activities with one computation

Activity 1

Response 1

$$\begin{array}{r} 18,95 \\ + 18,95 \\ \hline = 37,90 \end{array}$$

Joseph must buy two 2,5 kg sugar priced

Response 2

$$\begin{array}{r} 18,95 \\ + 18,95 \\ \hline = 37,00 \end{array}$$

he going to buy 2,5kg because when we add R18,95 plus R18,95 it costs 37,90 and is bigger than R36,95, which is 5kg sugar and $2,5\text{kg} + 2,5\text{kg} = 5\text{kg}$.

Referring to response 1, the learner completed the plan well but committed an error when reconciling the statement. According to Jiang (2013) this type of error arises when an error is made in encoding of information although the learner was able to connect the relevant plan to the problem's requirement. The sum shows that buying 2,5kg sugar will be expensive than buying 5kg sugar but an error was committed by saying 2,5kg is the better price. With response 2, the same error was committed. The learner was unable to connect all the relevant information that leads to the correct conciliatory statement.

With the following response of activities 1 and 3 learners were unable to retrieve relevant information and apply it to work out the solution. The information that was retrieved has no link to the question, although learners assumed that the pieces of information retrieved were the best solutions without realizing that the connection was erroneous (Jiang, 2013).

Activity 1

Response 3: R58, 40

I am going to use the adding method

$$\begin{array}{r} 36,95 \\ + 18,95 \\ \hline 55,90 \\ + 02,50 \\ \hline = 58,40 \end{array}$$

Activity 3

Response 1: 16674

He pay

$$\begin{array}{r} \text{R}776 \\ \times \text{R}14 \\ \hline 8914 \\ + 776 \\ \hline 16674 \end{array}$$

For both responses, irrelevant procedure was administered while response of activity 3 has an operational error (Jiang, 2013), that is, the learner was unable to multiply three digits number by two digits number.

Example 2: Response of activities with more than one computation

Activities 2, 4 and 5 required more than one computation. Even though learners calculated their solutions well, some word problem activities were not completed as they wanted learners to perform more than one computation. Here are selected examples:

Activity 2

Response 1: 18

$$\begin{array}{r} 18 \\ 2 \overline{) 37} \\ \underline{-2} \\ 17 \\ \underline{-16} \\ 01 \end{array}$$

The long division method was well done; the challenge is what was calculated. The problem statement does not require number of learners to be divided. I think learners guessed that division need to be applied but did not revisit the plan made.

Response 3: 3700

$$\begin{array}{r} 200 \\ \times 37 \\ \hline 1400 \\ 600 \\ \hline 7400 \end{array} \qquad \begin{array}{r} 3700 \\ 2 \overline{) 7400} \\ \underline{-6} \\ 14 \\ \underline{-14} \\ 000 \\ \underline{-0} \\ 00 \\ \underline{0} \\ 0 \end{array}$$

The group here realised that there is a need to find the amount of cool drink 37 friends will drink and divide the amount by 2 so as to find the number of two litres required. I think they were unable to relate their facts and that led to a different direction. They missed the point that one friend can drink two glasses of cool drink; otherwise they could have got the correct amount.

Activity 5

Response 1: 840

$$\begin{array}{r} 120 \\ \times 7 \\ \hline 840 \end{array}$$

With the response it shows that the group here was satisfied by the mere fact that they have performed some calculation. The 120 to them is the total amount of water wasted in a day. I think their challenge was with converting units of measurement hence their calculation is correct.

Response 2: 10, 8

$$\begin{array}{r} 60 \\ \times 24 \\ \hline 240 \\ 120 \\ \hline 1440 \end{array}$$

$$\begin{array}{r} 1440 \\ \times 7 \\ \hline 10080 = 10,8 \end{array}$$

The group here was on the right track; their challenge was to multiply two digits number by two digits number. They seem to have implemented their strategy developed during the previous stage.

Example 3: Response of activity which does not want any computation

Activity 6

This activity did not call for any computation. Learners here were challenged more as they were struggling to find what to calculate and performed unnecessary calculations. The challenge with the statement was right from the first stage of problem solving: understanding the problem. Learners here were unable to comprehend the problem statement. Corresponding with Jiang (2013) this error is the second level error of language, including reading and comprehension. Here are some of their responses:

Response 1

$$\begin{array}{r} R0,75 \\ R0,79 \\ \hline R0,06 \end{array}$$

My friend paid 69°

The learner did not put an operation sign to. This error is categorised as the second level error of a psychological factor including carelessness (Jiang, 2013).

Example 4: Response of activities where conciliatory statements are required Other activities required learners to conclude by giving the conciliatory statement, that is activities 1 and 7. In these activities, learners just made calculations and got solutions but did not conclude their solutions, meaning their solutions were incomplete. This error is referred to as incomplete schema with no error (Jiang, 2013; Fong 1993). Here are some examples of their response:

Activity 1

Response 1: 37, 90

$$\begin{array}{r} 18,95 \\ +18,95 \\ \hline 37,90 \end{array}$$

The learner was supposed to compare the price of two 2,5kgs with that of 5kg (see Annexure A) but decided to finish at getting the price for two 2,5kg sugar which made the solution incomplete.

Activity 7

This activity required learners to have a conciliatory statement after performing some computation by either saying yes, the truck is overloaded or no, the truck is not overloaded by comparing the two quantities, the 700kg the truck certified to carry and the mass of the mealies. Almost all the responses omitted the statement. Here are some responses:

Response 1

$$\begin{array}{r} 12.25 \\ \times 56 \\ \hline 7350 \\ 6125 \\ \hline 686.00 \end{array}$$

The learner here carried out the plan correctly showing understanding of what is done. What is calculated is what the truck carried but fails to compare what is carried with what the truck is certified to carry.

On the responses of the activities above no actual errors is made other than incomplete retrieval of a plan leading to a solution. The learner had insufficient plan to connect all the relevant information that leads to the solution. To make sure that the plan has been carried out correctly, learners need to go through the following last stage of problem solving.

4.2.3.4. Looking back

On this last stage of problem solving almost all learners did not do well on all 7 activities given. The main idea of this stage was to let learners verify their solutions as that would develop their mathematical skills (Mingus and Grassl, 1999). Four guiding questions were asked in order to assist learners to evaluate their process of working on the activities. The main challenge was that they could not validate their answers or solutions. Most of them did not even try to respond to the guiding questions, whereas those who did responded to the guiding questions without attaching any meaning to their solutions.

Activity 6

Did you answer my question? = Yes we answered all 2 questions

Did our answer make sense? = Yes our answer makes sense

We learned that who paid more than me and less than Sipho

No is no more another way to solve the problem

Again they copied what they wrote on the carrying out the plan as a justification of their solution. Here is the example of such a response:

Activity 5

Did you answer all the questions? Yes

Does the answer make sense? Yes

$$\begin{array}{r} 60 \\ \times 5 \\ \hline 300 \\ \times 24 \\ \hline 1200 \\ 600 \\ \hline 7200 \\ \times 7 \\ \hline 50400\text{ml} = 50,4\text{ml} \end{array}$$

What we learned: multiplication, ml and litres

There are easier way to solve the problem? No

Activity 3

Learners could not respond correctly on carrying out the plan stage but when trying to justify their answers on this step, they got their answer correct. With the following response the learner did not make any attempt to the stage of carrying out the plan but here they justified their solution very well.

Response 3:

Did you answer all the questions? Yes

Does the answer make sense? Yes, because $770 \div 14 = 55$ which means he paid R55 to each voucher.

What I learned: long division method

It shows that there was bit of confusion on justifying the solution and finding the solution. Learners got the correct solution but the solution was written on a different step. Where they should have written the solution, they could not respond.

4.3. CONCLUSION

In this chapter, findings were reported from the three phases of intervention. The findings were based on the learners' responses according to Polya's (1957) four steps of problem solving namely understanding the problem, devising the plan, carrying out the plan and looking back.

4.3.3. Understanding the problem

Deliberations made during this step of problem solving made me classify my learners under surface or shallow approach to learning with regard to solving word problems. It was a concern when learners struggled to tell what a bank note was. This was something they use on a daily basis but they could not distinguish background from the problem statement.

It emerged from the data that the problem encountered by learners was the inability to comprehend the problem statement influenced by the lack of background knowledge of LOLT, that is, English, their first additional language. Difficult words identified were finally understood after code-switching. Using their mother tongue made them realise that they did not know that they know the meaning of some words identified as difficult. For them not knowing that they know, alerted me that they were on unconscious incompetence stage of learning. After a series of activities, it was easy for learners to decode phrases and identifying easily what they were supposed to do because the

language used in those activities was simple. They were comfortable when unpacking the problem statement as the activities were more related to their daily life experience.

4.3.4. Devising the plan

In this stage of intervention I used instructional scaffolding to incrementally improve learner's word problem solving skills and strategies. I modelled the procedure on how to solve word problems using prompts and questions to enable learners to understand and be able to apply the procedure.

Initially learners could not respond well on this step of problem solving. Actually no plans were executed by learners in solving word problems. The data revealed that they lacked strategy knowledge on solving word problems; hence they could not devise any plan. It showed that they were never introduced to any strategy of solving word problems and we deemed it necessary to intervene by introducing a particular procedure to them. The expectation was that they be able to discover combinations of previously learned rules and plan their applications so as to achieve a solution.

Through intervention deeper learning was encouraged as learners realised that understanding the problem statement first help out in identifying which operation to use and why and then derive a number sentence. They were able to identify the purpose of figures and understood their relationship in the problem statement. There were some instances where learners were able to list facts but being unable to relate them. This was because of the inability to sequence information logically from the problem statement. If learners could not unpack or comprehend the problem statement, it was unlikely for such learners to devise the plan.

The intervention put learners on conscious incompetence stage of learning as they understood what was needed in solving word problems but they were not sure or confident that they could do it by themselves. To assure that the steps of problem solving had been assimilated, the procedure should be used appropriately in a variety of word problem activities that go beyond the confines of repetitive, targeted word problem activities.

4.3.5. Carrying out the plan

Learners used computations as a way of carrying out the plan. Their responses indicated that they did not consider their prior learning experience because at their level, Grade 6, they should be able to compute correctly using any of the four basic operations. Again, being unable to comprehend and understand the problem, let alone devising a plan, it was difficult for them to carry out the plan. Learners were notified that the background knowledge of simple arithmetic skills was vital in this stage of problem solving.

It was deduced from the data that word problem which required learners to perform only one computation was not tricky for them to carry out. The most difficult challenge was with word problems which required them to perform more than one computation and also need a conciliatory statement. While making calculations, learners also committed errors such as administering irrelevant procedures, operational errors and connection errors where retrieved information had no link to the question.

4.3.6. Looking back

In this step, no attempt was made by learners to justify their solutions. It was evident from the data that learners could not check for mistakes on the computations made. The challenge was that they were not aware that they should reflect on their solutions for mistakes.

The data indicate that this step is challenging to learners as it requires insight. Displaying deep understanding and justification of the solution appeared demanding to them. They were also unable to tell what they had learned. This step encouraged deeper learning as it required insight. Learners were unable to check for mistakes, especially those of operational as they found this step not necessary. Even though most learners were challenged by this step in almost all activities given, progress was shown when they all attempted to respond on the step, not leaving blank space.

On the last phase of intervention: post-intervention phase, learners knew the procedure of solving word problems. The challenge was whether they could apply the

procedure on their own or not. Having one period per week to practise word problems was not sufficient. They felt some discomfort for the mere fact that on that single period per week, they work on word problems. Their setback was that they separated the session from their daily mathematics class routine and that felt unnatural and foreign to them. Besides the work being seen as overload, learners moved from unconscious incompetence and conscious incompetence stages of learning to conscious competence stage of learning through a series of word problem activities. They started to show interest in working on the activities as they were more concentrating and focused in solving the word problems. Still, according to the data collected learners had other activities more strenuous as those activities were of a higher level of complexity. More time and practice was needed for learners to move to the last stage of learning: unconscious competence, where they should be able to follow the procedure of solving word problems as if they speak their natural language.

CHAPTER 5: RESPONSE TO RESEARCH QUESTIONS

5.1. INTRODUCTION

The purpose of this study was to improve learners' mathematical word problem solving skills and strategies in intermediate phase. This chapter presents responses to the guiding research questions of the study which were raised in the first chapter of this study. The questions were: what are challenges faced by Grade 6 learners in solving word problems? What are Grade 6 learners' strategies in solving word problems? How can learners' problem solving skills and strategies focusing in word problems be improved?

The findings presented in chapter 4 assisted in answering the research questions. Responses of the first two research questions are captured from the data collected from both the pre-intervention phase and the intervention phase. The post-intervention phase captured most the responses to the last question. In this chapter the response to the research questions are presented in three sections. The first section outlines challenges faced by Grade 6 learners in solving word problems. Second is learner strategies in solving word problems and the last section presents responses of how to improve learners' problem solving skills and strategies focusing on word problems.

5.2. CHALLENGES FACED BY GRADE 6 LEARNERS IN SOLVING WORD PROBLEMS

From the analysis, the findings revealed several challenges faced by learners in solving word problems. Learners' challenges were identified from all the three intervention phases of the study as language challenge, lack of strategy knowledge, lack of arithmetic skills and lack of reflective skills. Language challenge was identified across all three phases, whereas lack of strategy knowledge was identified on pre-intervention stage as learners were introduced to the new strategy in the intervention phase. Lack of arithmetic skills and reflective skills were revealed in both the pre-intervention phase and post-intervention phase.

5.2.1. Language challenge

My findings reveal that my learners have a major challenge of solving word problems as LOLT, that is, English as First Additional Language. They were unable to understand and attach meaning to the problem statement. Resembling Reynders' (2014) findings learners preferred to discuss the content of the word problems in their

mother tongue to show that they were challenged by the LOLT. When required to explain what they had written, they could not utter a word. In most cases it was not because they did not know what to say but they could not explain what they had written using LOLT. Reynders' (2014) and Jan and Rodrigues (2012) revealed that their Grade 4 and Grade 8 learners language challenge where as I witnessed with my Grade 6 learners.

Confirmation of the language being a challenge to my learners was shown in 4.2.1.1, 4.2.2.1 and 4.2.3.1. The three sections were on demonstrating understanding of the problem where my learners calculated for the change got when one bought a chocolate instead of calculating the profit, showed lack of vocabulary by not understanding the word 'notes'. Regarding this issue, Sepeng and Madzorera (2014) note that knowledge of vocabulary influences success in word problem solving. Inability to make sense of the problem statements influences the whole process of word problem solving by learners. That made it difficult for my learners to attach meaning to figures appearing on the problem statement which then led to incorrect number sentences as revealed in 4.2.1.3. The number sentence used was not correct as it was calculating what was not asked. The stage of carrying out the plan was influenced by the learner being unable to comprehend.

Lack of background knowledge of mathematics language also made learners to be unable to retrieve relevant information from the given statements in order to apply it to work out the solution on the carrying out the plan stage. Failing to understand the phrase or wording, learners just calculate and leave out the conciliatory statement. This was also revealed by Sepeng and Madzorera (2014) in a Grade 11 classroom of a township High School, while I uncovered the challenge from Grade 6 learners of a quintile 2 rural Primary School.

5.2.2. Lack of strategy knowledge

From the analysis, especially in the first stage of intervention being the stage that assisted in identifying learner challenges, learners demonstrated that they lacked knowledge on strategies to be used in solving word problems. They showed that they were not exposed to any procedure of solving word problems before by writing

answers only, as Yeo (2009) also revealed when exploring difficulties faced by learners when solving problems. They also write number sentences without showing how they are derived. One can argue that writing answers only and writing number sentences without showing how they were derived does not mean that there were no procedures followed, but with my learners they could not explain how they got their answers and number sentences even if they were allowed to explain in their original language. In general they had difficulties in finding out the strategies for solving word problems (Loc and Phuong, 2015).

5.2.3. Lack of arithmetic skills

At the level of Grade 6, it is expected that learners should be able to apply simple arithmetic but my findings proved quite the contrary. The report given in 4.2.3.3 showed that learners committed careless mistakes of leaving out operations and of not completing their solutions. Looking at 4.2.1.3 response 3, my learners could hardly subtract bigger numbers from small numbers by borrowing. They further showed that simple arithmetic was a challenge to them by being unable to arrange their number sentences as they did in 4.2.1.3 response 2. The arithmetic skill remained a challenge to my learners as they were unable to justify their answers by performing simple arithmetic as it appeared in 4.2.2.4 where they could not justify their answer $1456 \div 100 = 14$ by multiplying 14 by 100. This challenge revealed that they also lacked reflective skill or evaluation skill.

5.2.4. Lack of reflective skills

The reflective skill also is a major challenge to my learners. This skill is aligned to fourth step of problem solving by Polya: looking back, requiring one to demonstrate the skill or ability to recheck his/her work for mistakes in every action taken. My learners could not identify their mistakes as they were not rechecking their work. Most of the errors committed during the stage of carrying out the plan could have been rectified.

The analysis revealed in 4.2.1.4, 4.2.2.4 and 4.2.3.4 that learners were unable to justify their solutions by looking back on what happened when solving word problems. They did not respond to the guiding questions and if they did, they directly responded

by saying “yes” or “no” without elaborating. It was also revealed that my learners could not realise that while solving the given word problems they also learned more, gaining more vocabulary and broadening their knowledge on real life aspects. To them solving word problems was just an exercise to work out solutions and report.

5.3. GRADE 6 LEARNERS’ STRATEGIES IN SOLVING WORD PROBLEMS

My findings in the pre-intervention phase revealed that learners were not exposed to any procedure or strategy that they could use to solve word problems. The analysis in section 4.2.1.2 showed that instead of devising a plan or deriving number sentences, learners at that stage of problem solving worked out the solution by making calculations using number sentences which they did not show how they were derived. In most cases the number sentences were incorrect. It was evident also that after learners had been introduced to the procedure of solving word problems by Polya (1957), progress started to emerge. The procedure was introduced alongside the strategy of listing of facts and making these relate.

5.4. IMPROVING LEARNERS’ PROBLEM SOLVING SKILLS AND STRATEGIES FOCUSING ON WORD PROBLEMS

The study attempted to improve learners’ word problem solving skills and strategies through intervention which was done through collaborative teaching. It was found that working together with the Grade 6 mathematics teacher improved learners’ word problem solving skills and strategies. As delineated earlier, my learners were not exposed to any procedure or strategy of solving word problem. The procedure introduced to them would not have been acquired if the Grade 6 mathematics teacher and I were not engaged in collaborative teaching. The approach assisted because if an educator has a challenge of teaching a particular learning outcome, that learning outcome is compromised. This was evident when the Grade 6 mathematics teacher and I identified the need for introducing to learners procedure and strategy of solving word problems.

Again, it was deduced from my analysis that the role of the teacher in knowledge acquisition and competency development was essential and that intervention should

be done systematically through the learning period. The four steps of problem solving by Polya were selected methods of instruction which corresponded with the level at which my learners were in solving word problems. The knowledge acquired by learners during the intervention stage helped them to solve word problems with ease. During the post-intervention phase, learners also showed that they had gained confidence when reporting their solutions. Much focus on improving learners' word problem solving skills and strategies was on the second and third phases of intervention. Four steps of problem solving by Polya (1957), that is, understanding the problem, devising the plan, carrying out the plan and looking back, were taught to learners in an attempt to improve their skills and strategies to solve word problems.

5.4.1. Understanding the problem

Analysis on my study exposed that learners were challenged by the language used in the teaching of mathematics: English as their first additional language. Section 4.2.1.1 and 4.2.3.1 revealed how learners struggled in trying to understand or make sense of the given problem statements. The intervention stage: 4.2.2.1 is where I made an effort of improving learners' comprehension skill. Learners need to be encouraged to break down the problem statement before they can even think of working out the solution. They should be fostered to be part of the problem statement so as to engage them with the story problem. This will ease their understanding of the problem and be able to pick important ideas or facts that will help in deriving a number sentence or selecting a relevant strategy to work out the solution.

It was also demonstrated that learners found it challenging to decode some words on a problem statement. I highlighted to them that when trying to decipher a word in a statement by using any resource e.g. dictionary, they should check for meanings related to the problem statement not an isolated meaning of the word in question. They need to know that the comprehension skill is crucial in word problem solving as it helps one in selecting a strategy that can be applied to work out the solution. That also helps one know what is to be solved.

5.4.2. Devising the plan

Analysis of this study confirmed in section 4.2.1.2 that my learners were not exposed to any procedures of strategy of solving word problems. It was highlighted earlier on that for developing or selecting a strategy to work out the solution to a problem, learners needed to identify what needed to be solved. Through scaffolding, learners were familiarised with the strategy of listing of facts and making relationships as the key element of knowledge required in problem solving strategies. The strategy was introduced in the second phase of intervention and was selected as a way of developing the learners' comprehension skills, since the strategy necessitates learners to retrieve or pick out important ideas or facts from a text and relate those facts so that they can be used to develop number sentences in order to work out the solution to the problem.

5.4.3. Carrying out the plan

At this stage of problem solving the analysis showed that the learners were challenged by lack of arithmetic skills. More so the stage is influenced by understanding the problem and devising plan stages. It was highlighted to the learners that they should be cautioned by the problem statement if it required more than one computation, that a conciliatory statement is required to conclude the solution. It was also emphasised to them that checking for mistakes when done solving the problem is essential.

5.4.4. Looking back

Similar to the first step of problem solving, understand the problem, my analysis in this stage proved that learners could not evaluate their worked out solutions. The intervention tried to emphasise the importance of rechecking the validity of their solutions. Learners were made aware that calculated solutions could be justified by using the properties of the basic operations in use. They were also encouraged to provide reasons for every tread implemented. Related to the first stage, they needed to engage with the problem statement and check knowledge gained when solving the problem.

5.5. CONCLUSION

This chapter presented responses to the three questions posed in chapter 1, questions that guided the study in improving learners' mathematical problem solving skills and strategies. It has been noted from the responses that the learners were challenged by LOLT, lack of strategy knowledge, lack of arithmetic skills and lack of reflective skills. It was also evident that learners did not possess any strategy of solving mathematical word problems pending the introduction of the strategy of listing of facts. It was also revealed that collaborative teaching and direct teaching of skills and strategies assisted in improving the learners' skills and strategies in solving mathematical word problem.

CHAPTER 6: RECOMMENDATIONS AND IMPLICATIONS

6.1. RECOMMENDATIONS

My study reported on improving learners' mathematics problem solving skills and strategies in intermediate phase focusing on word problems. The study was conducted in three phases, that is, pre-intervention phase, intervention phase and post-intervention phase wherein the four steps of problem solving by Polya (1957), that is,

understanding the problem, devising the plan, carrying out the plan and looking back, were used as a guide for learners to solve word problems.

My findings of the study appeared familiar to the findings of researchers in the area of mathematics word problem solving such as Yeo (2009) and Maluleka (2013). Yeo (2009) found that learners' challenges in solving word problems happens to be lack of comprehension of the problem, lack of strategy knowledge, being unable to translate the problem into mathematics form. On the other hand Maluleka (2013) concurred with Yeo (2009) by revealing that learners attempted solving word problems with no understanding and that communication, reasoning and record process appear to be key factors in assisting learners to make sense of the word problems.

The findings revealed by both Yeo (2009) and Maluleka (2013) are the ones identified in my study when learners solve word problems being guided by Polya's (1957) the four steps. To me the findings cited above by Yeo (2009) and Maluleka (2013) correlate with my three phases of intervention whereby in:

Phase 1:

My learners showed lack of strategy knowledge. The way they responded to the two activities (refer to chapter 4, Pre-intervention stage) it is evident that they did not apply any strategy in attempting to solve the word problems. It is clear that they were not exposed to any strategy of solving word problems.

Phase 2:

On the intervention stage, my learners struggled to find the meaning of the word 'notes' in order to make sense of the problem statement; they were unable to comprehend the problem. This was the stage where learners were introduced to the four principles of problem solving, that is, the procedure on how to solve word problems and the strategy of listing of facts then make relationships as suggested by Yeo (2005) that strategies should be taught to learners.

Phase 3:

Through practice learners showed that the strategy of listing of facts and then making relationships assisted my learners in making sense of the word problems and finally proceeding towards an adequate solution. My research also found that from the three

phases of intervention, when learners follow the procedure of solving the problems they were some difficulties experienced on the four steps of solving problems.

Understand the Problem

This stage of problem solving required learners to read the text, comprehend and make sense of it. Literature indicates that a major component of successfully solving a word problem is by comprehending or understanding what is being asked of the problem solver within the wording (Schwanebeck , 2008; Limond, 2012; Hite, 2009; Langeness, 2011). It is also determined from various studies that integrating reading skills into mathematics classroom is vital as mathematical comprehension improves when reading strategies are incorporated into mathematical instructions (Cartert and Dean, 2006; Franz and Hopper, 2007; Hyde, 2006, as cited by Limond, 2012).

In this stage of problem solving the research found that the inability to read with understanding was the dominant challenge. The problem was the LOLT which was also influenced by learning in a rural, poor context. The results showed that performance on mathematics word problems was dependent to performance in reading comprehension.

Devise the Plan

I have found through my research that strategies for solving mathematics word problems are needed and learners need to be exposed to those strategies so that they are able to apply those strategies when solving word problems. In my study, learners felt more confident when reporting how they derived number sentences by making relations of the facts they listed from the problem statement. After more activities were given to learners, the strategy of listing of facts and making relations assisted learners to carry out the plan.

Carry out the Plan

At this stage of word problem solving my learners committed some mistakes that I did not regard them as part of their challenge in word problem solving such as operational errors. My research found that being unable to take word problem solving serious which led to lack of concentration contributed to those errors. At first they were not

relating their calculations with what they planned in the previous stage, they were not connecting or relating the two stages.

Looking Back

In this stage my research found that my learners did not want to engage deeper when working in mathematics. This stage required deeper learning which made my learners not to be comfortable. Justification through reasoning after working on a problem made them panic and did not like the stage. It appeared also to my learners that this stage of problem solving was demanding to them that it seemed to be in line with the higher cognitive level than of complex procedure, that is, high complexity, conjecture, doing mathematics or solving problems as per NAEP taxonomy, Porter's taxonomy, Stein's taxonomy (Berger et al., 2010) and SAGM (DoE, 2008) respectively. The stage required learners to explore and understand the nature of mathematical concepts, processes or relationships, and to justify mathematical statements and break down problem into constituent parts.

6.2. IMPLICATIONS

The evidence from this study has implications for improving learners' word problem solving skills and strategies. Teachers need to keep their minds open to new ideas. They should allow themselves to seek assistance in sections that they do not know how to approach. Word problems activities should not just be given to learners as activities to work on as class works or home works but strategies on how to solve them should also be taught to learners.

Learners also need to be convinced by their teachers to keep their minds open to ideas that could help them become better problem solvers. They should be encouraged to read texts and make sense of them rather often. This will help in improving their comprehending skills and their vocabulary, leading to being able to make sense of problem statements posed to them. They need to be made aware that there is no way that a word problem can be solved without properly understanding the problem text.

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ANNEXURE A: ACTIVITIES DONE DURING PHASES 1-3

Instructions

1. Read the instructions carefully.
2. Show all working on your answer book.
3. Use the following steps to guide work on the given problems
 - 3.1. Make sense of the problem (understand the problem)
 - a. Read the problem loudly.
 - b. Identify difficult words and find their meanings.
 - c. Restate the problem in your own words.
 - d. Write exactly what you are asked to find out or do.
 - 3.2. Devise the plan
 - a. Find a way to solve the problem, state the way. It can be by:
 - Using pictures or diagram
 - Making a table
 - Make an organised list and etcetera
 - 3.3. Carry out the plan
 - a. Solve the problem using the strategy (method) selected

- 3.4. Check your work for mistakes.
- a. Check if you answered all the questions.
 - b. Check if your answer makes sense.
 - c. Tell what you learned by working on the problem.
 - d. Check if there is another way you can solve the problem, the easier way.

Phase 1 activities

Activity 1

Mr. Peterson buys a chocolate for R3, 45 and sells it for R5, 50. How much money did he make by selling the chocolate?

Activity 2

Mr. Peterson buys a chocolate for R3, 45 and sells it for R5, 50. How much profit can he make if he sells 67 chocolates?

Phase 2 activity

Activity 1

How many R100 notes are there in R1 456?

Phase 3 activities

Activity 1

Joseph is in a shop and would like to buy sugar. He find that there is a 2,5kg sugar priced R18, 95 and 5kg sugar priced R36, 95. Which is the best price for Joseph to can buy?

Activity 2

Maropeng invited 37 friends to her party. Each friend may drink 2 glasses of cool drink. If each glass holds 200ml, how many 2-litre bottles of cool drink should her mother buy?

Activity 3

Tom buys airtime vouchers for each of his 14 workers. He spends R770. How much does he pay for each voucher?

Activity 4

The farm worker earns R1775 per week. How much do they get paid for two weeks work? How much are they paid in a month with four weeks?

Activity 5

A leaking tap drips 5ml every minute. How many litres of water will be wasted in a week?

Activity 6

I paid R0, 75 for a toffee. My friend paid less than me but more than Sipho, who paid R0, 69. What did my friend possibly pay?

Activity 7

A truck carried 56 sacks of mealies, each with a mass of 12,5kg. The truck is certified to carry 700kg. Is the truck overloaded?

ANNEXURE B: REQUEST LETTER FOR PERMISSION TO CONDUCT RESEARCH

P O Box 1784
SOVENGA
0727
09 April 2014

The Circuit Manager
Department of Education
Lebopo Circuit
Lebowakgomo District

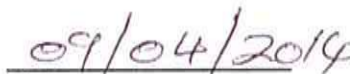
Sir

Request for permission to conduct action research

1. The above matter refers.
2. I, Raoano M. J, request the Department of Basic Education to allow me to conduct Action Research at Mothapo Primary School on the title: **IMPROVING LEARNERS' MATHEMATICS PROBLEM SOLVING SKILLS AND STRATEGIES IN INTERMEDIATE PHASE.**
3. The research will be conducted during the process of teaching and learning of Mathematics involving Grade 6 learners and their Mathematics educator as participants. Everything that will be done during the process of the study will involve behaviour within the scope of participants' normal daily activities. As such learners work will be used as data for the research findings and recommendations.
4. Hope you will find the above in order.

Yours,


Raoano M. J.


Date

ANNEXURE C: APPROVAL LETTER FOR CONDUCTING RESEARCH



PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF EDUCATION

Ref: 2/5/6/1

Enq: MC Makola PhD

Tel No: 015 290 9448

E-mail: MakolaMC@edu.limpopo.gov.za

Raoano MJ
P O Box 1784
Sovenga
0727

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

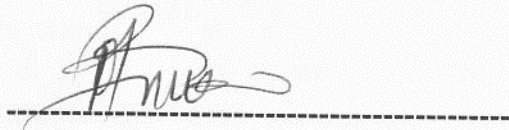
1. The above bears reference.
2. The Department wishes to inform you that your request to conduct research has been approved. Topic of the research proposal: **"IMPROVING LEARNERS' MATHEMATICS PROBLEM SOLVING SKILLS AND STRATEGIES IN INTERMEDIATE PHASE: A CASE STUDY OF A PRIMARY SCHOOL IN LEBOPO CIRCUIT."**
3. The following conditions should be considered:
 - 3.1 The research should not have any financial implications for Limpopo Department of Education.
 - 3.2 Arrangements should be made with the Circuit Office and the schools concerned.
 - 3.3 The conduct of research should not anyhow disrupt the academic programs at the schools.
 - 3.4 The research should not be conducted during the time of Examinations especially the fourth term.
 - 3.5 During the study, applicable research ethics should be adhered to; in particular the principle of voluntary participation (the people involved should be respected).
 - 3.6 Upon completion of research study, the researcher shall share the final product of the research with the Department.
- 4 Furthermore, you are expected to produce this letter at Schools/ Offices where you intend conducting your research as an evidence that you are permitted to conduct the research.

Request for permission to Conduct Research: Raoano Mg2

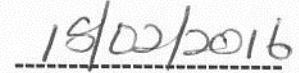
CONFIDENTIAL

- 5 The department appreciates the contribution that you wish to make and wishes you success in your investigation.

Best wishes.



MUTHEIWANA NB
HEAD OF DEPARTMENT (ACTING)



DATE

Request for permission to Conduct Research: Raoano MJ

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