UNIVERSITY OF STELLENBOSCH

Realistic Mathematics Education and Professional Development: A Case Study of the Experiences of Primary School Mathematics Teachers in Namibia

Barbara Peters

Dissertation presented for the degree of

DOCTOR OF PHILOSOPHY IN EDUCATION

In the Department of Curriculum Studies

Faculty of Education

University of Stellenbosch

Supervisor: Dr. M. F. Gierdien

March 2016

Declaration

By submitting this dissertation electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date : March 2016

ABSTRACT

The study's context is the current reform movement adapting continuing professional development (CPD) as a means of upgrading teachers' subject knowledge as well as their teaching.

Professional development (PD) aiming at primary school mathematics teachers (PSMTs) is a significant issue, because these teachers themselves have not had rich experiences with and in school mathematics. This study reports on PD based on Realistic Mathematics Education (RME) principles and the process of Lesson Study (LS) in a primary school in Namibia. In this study I focus on primary school teachers' subject knowledge as well as their teaching. The study draws on data collected over a period of three school terms involving fifteen teachers. Through LS and RME principles the teachers were involved in a process where they collaboratively planned, designed, presented and reflected on lessons. Analysis of the findings shows the teachers were positively disposed to the use and development of RME-based materials and found the latter to be helpful in terms of their subject matter content knowledge.

The study concludes that PD in general and the need for collaboration between the teachers and mathematics educators from the University of Namibia are important.

OPSOMMING

Die raamwerk van hierdie navorsingstudie is die huidige hervormingsbeweging van voortdurende aanpasbare professionele ontwikkeling (CPD – Continuing Professional Development) by wyse waarvan onderwysers se vakkennis en praktiese onderrig opgegradeer en/of verbeter kan word.

Professionele ontwikkeling (PD – Professional Development) wat gerig is op laerskoolonderwysers wat Wiskunde onderrig (PSMTs – Primary School Mathematics Teachers) is ŉ gewigtige kwessie, want dergelike onderwysers het self nie diepgaande ervaring met en in skoolwiskunde nie. Hierdie studie doen verslag van professionele ontwikkeling gebaseer op die beginsels van Realistiese Wiskunde-Onderrig (RME - Realistic Mathematics Education) en die proses van Lesstudie (LS – Lesson Study) in ŉ laerskool in Namibië. In hierdie studie fokus ek op die vakkennis van laerskoolonderwysers asook op hul onderrig. Die studie is gebaseer op die data-insameling oor ŉ tydperk van drie skooltermyne waarby vyftien onderwysers betrek is. Deur gebruik te maak van LS- en RME-beginsels, was die onderwysers betrokke in ŉ proses van gesamentlike lesbeplanning, die skep van kreatiewe media, die aanbieding van lesse en die refleksies op lesse wat aangebied is. ŉ Analise van die bevindings toon dat die onderwysers positief blootgestel is aan die gebruik en ontwikkeling van RME-gebaseerde materiaal en daar is bevind dat bogenoemde ŉ groot hulp was om die inhoud van hul vakkennis uit te brei.

Hierdie studie bewys en het tot die gevolgtrekking gekom dat professionele ontwikkeling in die algemeen en die behoefte van samewerking tussen wiskunde-onderwysers en lektore/lektrises van die Fakulteit Opvoedkunde van die Universiteit van Namibië van die grootste belang is.

ACKNOWLEDGEMENTS

I have many people who supported, inspired and encouraged me along my way to reach the destination in this journey.

Firstly, I would like to acknowledge my indebtedness to my supervisor, Dr M. F. Gierdien, to whom mathematics education is very close to heart. Throughout the process of this study and in writing the final dissertation his constructive advice and critical comments contributed towards the completion of this project. I would like to thank Dr Gierdien for his moral support and for being my ‘lifeline’, my anchor and mentor throughout the duration of this study.

I wish to acknowledge my colleague and dear friend, Rudolf Wittmann, for his devoted assistance and critical comments by reading through all my chapters. His encouragement and valuable, positive and constructive feedback enabled me to complete this dissertation. Rudolf passed away on 15 August 2015. May his soul rest in eternal peace.

A special word of thanks goes to Dr W. Daher who assisted and helped me with my data analysis. His interest in my work and valuable advice how to present my data in categories contributed to my personal and educational growth in this project. I appreciated his helpfulness and encouragement very much.

To the dean of Faculty, Dr C. Villet and the Head of Department, Mathematics, Science and Sport Education, Dr H. Miranda, of the Faculty of Education of the University of Namibia, thank you very much for granting me the opportunity to do this study. The financial assistance granted to me by the Staff Development Office is highly appreciated. To my two colleagues in the department, Mr T. ≠Naweseb and Mr T. Dzambara thank you for taking on my workload so that I could take study leave to finalize my dissertation.

A special word of thanks goes to the Primary School mathematics teachers who participated voluntarily in this study. I am grateful to the principal of the participating school, who realized the need of professional development of primary school mathematics teachers. The participants welcomed me into their classrooms and opened their hearts and minds towards me. It was for sure not always easy and ‘comfortable’ to have a researcher, being me, in their classroom. This study would not have been possible without the participation of these teachers. Their positive attitude and valuable contribution towards this research, made it an unforgettable experience and a very valuable venture. The hospitality and helpfulness were very much appreciated.

I would like to thank Ms G. Reimers for proofreading the dissertation. She ensured that the linguistic part of the study was taken well care of with her critical questions in cases where issues and concepts were not clearly presented.

Finally, I would like to thank my family for their interest, understanding and generous support in completing my study. Their moral support and assistance was many a times a ‘light in the dark’.

DEDICATION

This study is dedicated to

my husband Immo,

my son Christian

my mother Inge

And

sister Gisela

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

AED	Academy for Educational Development
B Ed	Bachelor of Education
BES	Basic Education Support
BETD – INSET	In-Service Basic Education Teacher Diploma
BETD	Basic Education Teacher Diploma
CES	Centre for External Studies
CPD	Continuing Professional Development
CPI	Critical Practitioner Inquiry
DE	Diploma in Education (Three year qualification specializing for Grades 1 -7 offered by former Windhoek College of Education)
DNEA	Directorate of National Examinations and Assessment
ECP	Education Certificate Primary
EFA	Education for All
ELPP	English Language Proficiency Programme
EMIS	Educational Management Information System
ETSIP	Education and Training Sector Improvement Programme
FDM	Further Diploma in Mathematics
HDE	Higher Diploma in Education (Four year qualification specialising for Grades 1 – 7 offered by former Windhoek College of Education)
HOD	Head of Department
HPEC	Higher Primary Education Certificate
HR	Hoogeschool Rotterdam (Netherlands)

ICT	Integrated Communication Technology
IOL	Institute for Open Learning
INSET	In-service Training
IWT	Interactive Whiteboard Technology
JSC	Junior Secondary Certificate Examinations
LP	Lower Primary
LPTC	Lower Primary Teachers Certificate
LS	Lesson Study
MBEC	Ministry of Basic Education and Culture
MBESC	Ministry of Basic Education, Sport and Culture
MEC	Ministry of Education and Culture
MECYS	Ministry of Education, Culture, Youth and Sport
MHEVTST	Ministry of Higher Education, Vocational Training, Science and Technology
MiC	Mathematics in Context
MMU	Manchester Metropolitan University
MoE	Ministry of Education
MYS	Ministry of Youth and Sport
NAMCOL	Namibian College of Open Learning
NCBE	National Curriculum for Basic Education
NEC	National Education Certificate
NGO	Non-Governmental Organization
NIED	National Institute for Educational Development
NPSTN	National Professional Standards for Teachers in Namibia
NQA	Namibia Qualification Authority
NQF	National Qualifications Framework
NSSCH	Namibia Senior Secondary Certificate Higher level
NSSCO	Namibia Senior Secondary Certificate Ordinary level

PD	Professional Development
PISA	Programme for International Student Assessment
PMRI	Pendidikan Matematika Realistic Indonesia
PSMTs	Primary School Mathematics Teachers
PTC	Primary Teacher Certificate
RME	Realistic Mathematics Education
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
SADC	South African Development Cooperation
SATs	Standardized Achievement Tests
SBS	School-Based Studies
SPTD	Senior Primary Teacher Diploma
TIMSS	Trends in International Mathematics and Science Study
UK	United Kingdom
UNAM	University of Namibia
UNESCO	United Nations Educational, Scientific and Cultural Organization
UP	Upper Primary
USA	United States of America
USAID	United States Agency for International Development

CHAPTER 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

This study explores the experiences of primary school mathematics teachers who participated in Realistic Mathematics Education–based professional development in Namibia. The study will point out how Realistic Mathematics Education (RME) principles can possibly contribute to the professional development (PD) of primary school mathematics teachers (PSMTs). I also included Lesson Study (LS) in the research and discussions because it was proved to be an effective development tool to introduce and make participants acquainted with RME principles through research lessons. The views and beliefs about mathematics teaching of PSMTs before and after the intervention will also be elaborated on.

This chapter provides the motivation and explains the background of the problem to give relevance to the study. A brief description of RME in the Namibian context, LS and the current situation for PD for PSMTs in Namibia is dealt with.

The statement of the problem and the aims of the study will provide the reason for conducting this research. A brief outline of the research methodology, the data collection and an explanation of key definitions and terminology used in this study are discussed in this chapter.

Finally this chapter provides an overview of the study topic:

Realistic Mathematics Education and Professional Development: A Case Study of the Experiences of Primary School Mathematics Teachers in Namibia.

1.2 MOTIVATION FOR THE RESEARCH

In accordance with good practice throughout the world it is recognized that mathematics is one of the crucial school subjects for any country to realize its full potential. Mathematics has always been at the core of education in all societies.

Therefore mathematics teaching should be effective, purposeful and relevant. There is a widespread concern about Namibian learners' mathematical achievements and, in particular, the ability of learners to apply mathematics both in subsequent education and in employment (*The Namibian*, 20/01/13; 7/03/14 & 16/01/15).

In Namibia, 25 years after independence, learners are still not performing at a satisfactory level (Clegg & Courtney-Clarke, 2009; Nambira, Kapenda, Tjipueja & Sichombe, 2009). In its concern about learner performance in mathematics the Namibian Ministry of Education (MoE) has done much to implement changes that might bring along a change in performance. The latest intervention was that the possibility of standardized achievement tests (SATs) for Grade 5 and Grade7 in mathematics and English were investigated. When the second round of results was published in April 2013, serious concern was raised that very little improvement in the performances of Grade 5 and Grade 7 learners in mathematics has taken place (Ferdous, 2012). This concern was reiterated in a meeting when the Grade 5 follow-up results for mathematics and English were discussed in March 2014 (MoE, 2014a). Thus Namibian teachers are under greater pressure than ever before to produce performance in the classroom, because they are measured against the performance of their learners in the SATs.

In response to the concern about learner performance in mathematics in Namibia, I contend that there has to be a refocusing of attention on the professional development of PSMTs. The effectiveness of the PSMTs has to come under the microscope and the PD of these teachers is one way to address the possible improvement of their teaching. Since very little improvement in the results of the SATs was achieved I maintain that there is a need to update and refine the professional and subject knowledge of PSMTs. While one purpose of PD might be to update teachers' knowledge and skills, the objective of the envisaged PD in terms of the intended study will be to bring about some kind of change in teachers' way of thinking about mathematics teaching.

The direction any such intended change necessarily will follow is from a judgement by someone about one kind of teaching practice being, to a certain extent, preferable to another. Change is a complex and unpredictable process. The classroom is where the real change will have to take place and where its effects will be most visible and influential. Properly done change takes time and effort and there are no short-cuts. Some teachers' teaching practice may change drastically, whilst others will not change at all. I argue that it is important that the ideas of PSMTs are considered and that they should be aware that they are valued as reformers of their own teaching.

The motivation to conduct this research began with my experience of RME in the Netherlands. The former Windhoek College of Education had a co-operation agreement with the Hoogeschool Rotterdam (Netherlands) for four years. The aim of this co-operation was to exchange ideas about how to improve mathematics education and also how to conduct School-Based Studies (SBS) in a more efficient manner at college (tertiary) level.

I visited many schools in and around Rotterdam and observed quite a number of mathematics lessons. I realized the importance of skilful teachers to lead learners to experience mathematics as a part of human activities, i.e. part of everyday life. Observing how teachers applied the RME approach in their teaching and how positively learners reacted towards this type of instruction, made me realize that this approach could possibly address a perceived need to improve the quality of mathematics teaching in Namibian schools. My personal interest in the teaching profession and my desire to bring about improvement in teachers' lesson presentations in Namibia convinced me to undertake this study.

I am interested to find out what the possible effect of RME might be in the PD of PSMTs. I am also interested in what the exposure to the processes of LS as a model for PSMTs own learning and teaching improvement in this envisaged PD might have.

1.3 BACKGROUND TO THE PROBLEM

Namibia is an arid but resource rich country with a small population of about 2,1 million people. There is a denser settlement pattern in the northern region, because of higher rainfall patterns. The people of Namibia are culturally and linguistically very diverse. The Ovambo-speaking groups form more than 50% of the population and less than 10% of the people are of European origin (Ellis, 2010). Since independence from South Africa in 1990, the country has since then roughly invested 25% of its annual budget in education (*The Namibian, 10/04/15).* However, there is growing disappointment that education does not achieve the national aims, because learners are not achieving similar high levels of performance compared to our neighbouring countries (SACMEQ, 2011a & 2011b). The education system currently provides for 13 languages, but English is the official language and the medium of instruction from Grade 5 onwards.

The nature and quality of teacher education consistently seem to be a concern after the Grade 12 results were published in Namibia. As a nation we underperform in mathematics achievement (*The Namibian*, 20/01/13; 7/03/14; 22/08/14 & 10/04/15). However, this is indeed a worldwide concern, according to Bennett and Carre (1993). They argue that it is essential for primary and secondary school teachers to acquire both an effective comprehension of a broad curriculum's repertoire and a deeper knowledge of some specialised aspects of it. A question arises whether PSMTs in Namibia possess this required subject and pedagogical content knowledge.

In Namibia yet another school and curriculum structure reform is planned. All school mathematics syllabi are revised and a 'new' curriculum for the first four school Grades will be implemented in 2015 (*New Era*, 22/09/14). I claim that the purpose of the education reform by the Namibian government should first and foremost find ways to improve the teaching and learning process in the primary school mathematics classrooms. It is essential that if learners' performance in school mathematics needs to improve, one has to start at primary school level.

In Namibia there has been a long tradition of teacher education being condensed into two years (resulting in a certificate), or into three years (resulting in a diploma) or four years (resulting in a degree) of full time study at either a teachers' college or at a university. The majority of primary school teachers have been left for the remainder of their teaching career with very little or no additional assistance at all (Clegg, 2008).

The PD of PSMTs received limited attention in Namibia, if at all (Clegg & Courtney-Clarke, 2009; Nambira *et al*., 2009). Clegg (2008) states that most modern teacher education programmes focus much less on the front-end element and much more on the continuous support element. It is expected that teachers take on more and more the responsibility for learners' performance without being equipped with the necessary tools to do so. The latter can be supplied about through on-going PD which is long overdue in Namibia (Clegg, 2007; Nambira *et al*., 2009).

Since 1993 the former Colleges of Education in Namibia trained teachers from Grade 1 to Grade 10. According to a study done in Namibia in 2006 (Clegg & Courtney-Clarke, 2009) the colleges' academic courses considerably fell short of providing adequate subject knowledge. The curriculum courses on the other hand failed to adequately cover several crucial areas of professional competence.

From my perspective the long-term effects on learners' confidence in school mathematics may be a result of their teachers' own mathematical misconceptions and quite possibly a limited understanding of the subjects. This is probably a result of teachers themselves having been taught mathematics by old fashioned ways such as drill or as a set of rules and recipes when educated at school and tertiary levels.

The PSMTs might not have had positive experiences with school mathematics, because their teachers were not sufficiently qualified to teach mathematics, which caused them to experience school mathematics as 'very difficult' (Ndinda, 2011; Novak, 1998; Sifuna & Kaime, 2007; Webb, 2010; Woods, 1995). At the Annual Mathematics Conference held in Swakopmund, Namibia, in May 2014, for all school teachers and stakeholders of mathematics education for primary, secondary and tertiary education it became evident that the majority of primary school teachers themselves very often do not understand nor do they have opportunities to learn about the underlying mathematics concepts themselves. It is thus important that in terms of a foundation primary school learners need mathematics experiences that are sound and powerful. The important role that PSMTs play in the mathematics education of their learners can therefore not be underestimated.

I regard teaching as a field that is dynamic with innovations necessitating the continuous upgrading of skills and education of teachers for the successful implementation of the curriculum. With the new reform underway I reason that it is time that primary schools need to experiment with new ways of doing things in order to re-engage learners in mathematics.

Efforts to improve education by creating a fundamental shift in what learners learn and how they are taught are done through ‘reforms’. Any reform will bring forth changes and these changes might create uncertainty within the teaching community. Even taking that into consideration teachers should not be afraid to take risks and should be willing to exchange their experiences in order to note what works and what does not (Cobb & Visnovska, 2008; Kwon, 2002; McAleavy, 2012). I suggest that with any reform implementation a mind shift is necessary. This mind shift could be achieved by involving PSMTs in RME-based PD.

The process of enhancing teaching and learning in the primary school years requires a change of hearts and minds about what constitutes good mathematics teaching and, if necessary, the suspension of prior long-held beliefs of teachers. Teachers should progressively strive to improve their teaching methods by working with other teachers to examine and critique one another’s teaching techniques (Cerbin & Kopp, 2006; Hurd & Licciardo-Musso, 2005; Nambira *et al*., 2009). Therefore, by attending a well-structured PD on mathematics teaching PSMTs can possibly experience ‘new’ strategies with the help of their colleagues and a facilitator. They can then experience whether they find the ‘new’ approach as something that can possibly enhance their performance in the classroom.

I experience in my current position as a mathematics teacher educator and with many years in the teaching profession that apparent efficient teaching where learners are guided step by step through ‘recipes’ can easily be mistaken for good teaching. Learners are not allowed to use their ‘own’ methods in solving problems because the teachers require that they just follow the ‘rules’. Learners are seldom given the opportunity to experience the satisfaction of solving a problem on their own, using their own way to find the correct answer to the problem. However, Moodley, Njisane and Presmeg (1992) state that classroom activities should be arranged in such a manner that learners are lead to a way of thinking and not to a way of just following instructions.

Currently in most Namibian primary schools learners are ingrained in a mathematics classroom culture in which the learner accepts that the teacher is always right, and do not take actively part in the teaching process, let alone share their thinking. The same appears to be the norm in Indonesia. In Indonesia learners are also accustomed to being asked questions for which the teacher already knows the answer and conform to what is expected of them (Fauzan, Slettenhaar & Plomp, 2002; Sembiring, Hoogland & Dolk, 2010**).**

I am of the opinion that in the long term principles of RME-based PD could help to realize the vision that every learner will be able to enjoy doing school mathematics in Namibia. A PD programme for PSMTs can be the result of a change towards behaviour and attitudes towards teaching and learning (Ndinda, 2011; Ramatlapana, 2012). In a RME-based PD for PSMTs change might be brought about by new experiences. These experiences might be created by involving PSMTs in challenging tasks, offering them the opportunity to use different concrete materials that allow for different ways as well as different levels of solving a problem. In such a PD the participating PSMTs could exchange ideas, motivate and learn from each other.

The focus of this study will be to develop a stronger mathematical foundation among the participating PSMTs by exploring ideas and concepts in the mathematics syllabi through a study of teaching lessons. This could be brought about by involving PSMTs in the process of LS. This will enable PSMTs to plan lessons collaboratively, present these lessons individually and report back (reflect) and discuss their experiences in order to refine the lessons.

Improving something as complex and culturally embedded as teaching requires the efforts of all players, including learners, parents and teachers as well as politicians, as Stigler and Hiebert (in Easton, 2009) state. It takes long for teachers to experiment with and adapt rules and procedures they must apply in their classroom, to develop and refine lesson plans, and to embrace a sense of communality and camaraderie with their learners and colleagues (Glasgow & Hicks, 2003).

It would, therefore, be worthwhile to investigate the implementation of the main ideas adapted from RME principles through LS in PD. This might help address some of the many critical issues concerning the way teachers teach mathematics in primary schools in Namibia.

In the National Professional Standards for Teachers (NPSTN) in Namibia (MoE (NPSTN), 2006b:2) the above links with a competency which reads:

> '*engage in own professional development and participate in the professional community'*.

It is also mentioned under this competency that

> '*there is provision for pre-service and continuing professional development but no state structures to support this'*. (MoE (NPSTN), 2006b:106)

I will thus argue that PSMTs need support in the form of on-going PD based on RME-based principles in order to bring about positive change in Namibian primary mathematics education. PD might enable PSMTs in Namibia to improve their subject knowledge and their teaching skills. However, the fact whether PSMTs in Namibia until now had any opportunities to partake in PD will be explained next.

1.4 PROFESSIONAL DEVELOPMENT FOR PRIMARY SCHOOL MATHEMATICS TEACHERS IN NAMIBIA

In the NPSTN (MoE, 2006b) on page 19 the following is written:

> *' Education and training in Namibia is at a turning point…We now know what is working and what is not working…at the current level of performance in education, we will not be producing citizens who are capable of making Namibia a knowledge-based economy as is expected of us in Vision 2013…'*

There is no doubt that PSMTs play an important role in the mathematics education of their learners (Clegg, 2008). The Namibian education system is no exception to this fact. In recent years local policymakers and educators have launched efforts to improve education by creating a fundamental shift in what learners learn and how they should be taught. Changing from a teacher-centred to a learner-centred approach was a major shift in our education system. Teachers are necessarily at the centre of any educational reform for they have to carry out the demands for high standards in the classroom (Ministry of Basic Education and Culture (MBEC) and Ministry of Higher Education, Vocational Training, Science and Technology (MHEVTST), 1998; *The Namibian*, 16/01/15). Thus, the success of ambitious education reform initiatives is dependant, in large part, on the qualifications and effectiveness of teachers, i.e. the performance of teachers. Changes in classroom practices will require a great deal of learning on the part of the teacher and it will be difficult to be brought about without support and guidance (Ball & Cohen, 1999). I argue that teacher PD should be a major focus of any systemic reform initiatives. It was quite a shock to realize that with all the reform initiatives that have taken place in Namibia I was not able to find any mentionable PD for PSMT that was documented.

Learning opportunities are needed in the form of a PD programme aimed at PSMTs in order for these teachers to be sufficiently equipped to carry out the demands of a curriculum (Nambira *et al*., 2009). A thorough understanding of school mathematics not only enhances learning in science and technology subjects but it is also a fundamental skill relevant to many aspects of everyone's work and social life.

My opinion is that it is very important that PSMTs possess the ability to not only communicate basic mathematical subject knowledge to learners but also to develop advanced thinking and problem-solving-skills among their learners. In order to be able to generate 'new' expectations for PSMTs classroom behaviour as well as for learners' performance PSMTs have to learn more about the subject content and understand how learners learn mathematics through intensive PD initiatives, which are currently 'non-existent' in Namibia.

In Namibia, a Lower Primary phase teacher (Grades 1 – 4, the first four years of formal schooling) is trained as a 'generalist' and not as a 'subject specialist'. This might be the challenge these PSMTs experience; they might feel 'inadequate' to teach mathematics. The Upper Primary phase (Grades 5 – 7) teachers are trained as 'subject specialists', i.e. they have majored in two academic subjects during their tertiary education. This might result in these PSMTs' experience of being 'able to teach mathematics'.

Current mathematics practices in primary school classrooms are apparently not documented in Namibia. This is for me the basis from which to assist PSMTs in seeing and using alternatives in terms of materials, teaching style and activities, content and the organization thereof during a year of on-going PD. As the PSMTs have to take into consideration the current situation of their learners, so must the educators at the tertiary institutions, including myself, take into consideration the current situation of teachers.

I have observed after being involved in the training of PSMTs for almost 25 years that for many of the mathematics education students there are a number of issues relating to the learning of mathematics which are not replicated in any other subject. In Namibia very few PSMTs are really specialists in mathematics, they indeed come from a variety of educational backgrounds (Peters, 2006). Many of these teachers in Namibia did not even have mathematics up to Grade 12 school level but are qualified as PSMTs. This will be further be elaborated on in Chapter 2.

Mathematics became an entry requirement for all PSMTs in Namibia only in 2010 when the former Colleges of Education merged with the University of Namibia (UNAM) in 2010. Thus, with an understanding of current practices it is relevant to think about developing PD for all these PSMTs who do not possess the required minimum of at least school mathematics at Grade 12 Ordinary Level. PD will be a possible way to determine what is working and what not concerning their teaching practices, especially in ways to determine how teaching practices should change and to determine the effectivity of a PD programme to implement the ‘new’ curriculum in Namibia.

A lack of PD opportunities for PSMTs in Namibia currently might be a reason why learners’ performance in mathematics is still not addressed effectively. This study attempts to test and suggest a possible solution on how to upgrade the knowledge and skills of PSMTs through an RME-based PD. RME is a new concept for all PSMTs in Namibia. A brief discussion of how RME can serve as an approach for implementation in Namibia will be discussed next.

1.5 REALISTIC MATHEMATICS EDUCATION (RME) IN A NAMIBIAN CONTEXT: A Brief Outline

At first I will give a brief overview of what RME is about. Secondly I will elaborate on why I consider that RME- based PD could be beneficial to the Namibian PSMTs.

RME is a domain-specific instruction theory for mathematics education and has its origin in the Netherlands (Treffers, 1987; Van den Heuvel-Panhuizen, 2013). RME is an approach in which mathematics education is conceived as a human activity (Freudenthal, 1973; Gravemeijer, 1994a; Treffers, 1987). In this theory one of the most important principles is that learning mathematics is a constructive activity. This principle actually contradicts the idea of learning as memorizing knowledge which is presented or transmitted, which portrays the current situation in Namibian schools. Another important issue is that in RME a learner must always have a tool (teaching aid/model) at his/her disposal to help bridge the gap between the concrete and abstract. This theory promotes the construction of mathematical knowledge and skills to a structured entity.

In RME learning mathematics means doing mathematics of which solving everyday life problems (contextual problems) is an essential part. In the RME approach the issue of concern with context problems is that it aims to eventually surpass the level of just finding solutions to practical problems. The aim is to teach learners to start thinking mathematically. Learners can initially work out mathematical context problems using mathematical tools or models they have at their disposal. Using mathematical tools or models are not the only characteristics of RME. In fact there are six principles that guide the RME approach. They are the activity principle (learners use their own productions); level principle (use of models); reality principle (use of context); intertwinement principle (use of various learning strands); interaction principle (interactivity in the teaching process) and the guidance principle (guided re-invention). These principles will be described in detail in Chapter 3.

There are also three key-principles of RME for the instructional design, namely

- ✓ guided re-invention and progressive mathematization,
- ✓ didactical phenomenology and
- ✓ self-developed models (Van den Heuvel-Panhuizen, 2010).

Didactical phenomenology has played an important part in Freudenthal's work. In his work Freudenthal stresses explicitly the feature of mental objects versus concept attainment. In the RME theory the didactical scope of mental objects and activities and the onset of conscious conceptualization, if didactically possible, is the main theme of this phenomenology (Freudenthal, 1983). I understand that mathematical ideas are a means of organizing phenomena of the physical, social and mental worlds. Therefore, the phenomenology of a mathematical idea is its description in relation to the phenomena of which it was created, and to which it has been extended in the learning process of learners, i.e. the didactical phenomenology. Concept attainment is preceded by grasping mathematical ideas as mental objects.

My understanding is that in RME lessons learners should be given the opportunity to re-invent mathematical concepts and the teaching-learning process should be highly interactive. The main role of a teacher is to determine in which way optimal results can be obtained, for example by organizing learners' interaction, individual work, classroom discussion and teacher presentation to name a few. Given its characteristics, RME can be considered as a very promising approach to change the teacher's way of instruction and classroom climate in order to improve mathematics teaching and to make it more relevant to the Namibian learner.

Gravemeijer (1994a) states that RME is a domain specific instructional theory which offers guidelines for instruction that aims at supporting learners in constructing or reinventing mathematics in problem-centred interactive instruction. However, learners will only be able to benefit from this theory if their teachers are capable and knowledgeable to initiate the use of this approach. In the Namibian context PSMTs will need PD activities to experience the possible positive effects the RME approach can have on learners' understanding and learning.

It can be argued that an RME-based PD will also fit into the National Professional Standards for Teachers in Namibia (MoE, 2006b) because it is mentioned that values of professional development acknowledge the interdependence of teacher and learner learning as well as to stay abreast of teaching strategies that might enhance learners' understanding and learning (MoE (NPSTN), 2006b:106, Teacher Competence # 27).

In Namibia the textbooks are named '*Mathematics in Context'* (Patyus, Van der Westhuizen & Roos, 2010) and '*Maths for Life'* (Lategan & Silver, 2010) but teachers find it difficult to make the content link to the learners' experiences (Clegg, 2007). The textbooks title refers to 'in context' or 'for life', however, I found that there are very few exercises that could be linked to the reality of the learners. In my view, it is for this reason that most of the instruction is mainly done in a teacher-centred method.

Since RME is new to many people in Namibia (teachers, teacher educators, curriculum developers, advisory teachers and learners) research is needed to investigate whether and how it can be translated and realized in the Namibian context.

With this research it is hoped to determine whether teachers' beliefs and views regarding mathematics education have changed or not changed and whether RME ('new' teaching and learning methods) had an influence on their performance.

My own beliefs which guided the design of the RME-based PD are:

- ✓ All teachers should be entitled to a rich, broad and challenging mathematics experience.
- ✓ All teachers should have the opportunity to experience and learn 'new' strategies/practices, in particular the RME principles.
- ✓ Primary school mathematics should make sense to learners and that it is an essential part of being numerate.
- ✓ All teachers should experience primary school mathematics teaching aimed at the development of deep conceptual understanding.

It is important that during this RME-based PD the PSMTs should work together, share experiences and assist each other. However, for teachers to work collaboratively and discuss issues of common interest is not a given in Namibia. In order to achieve collaboration and reflection I have utilized the concept of LS. A brief outline of the concept LS is discussed next.

1.6 LESSON STUDY (LS): A Brief Outline

LS is a form of PD used in Japan and has recently also gained attention in many parts of the United States of America (Hurd & Licciardo-Musso, 2005; Lewis, 2000). In

Namibia, as in Japan and the USA, a national curriculum is prescribed and the use of LS as an instructional tool may be applicable. The common link between Indonesia, USA, Japan and Namibia is that the performance of learners in mathematics leaves much to desire. In LS the focus is on teachers planning, observing and revising lessons.

LS can be summarized as an embedded peer-to-peer professional learning strategy. It requires of teachers and other educators to work collaboratively to improve a given lesson until it has been refined. The process in LS consists of four stages. Firstly, the long-term goals for learner learning and development out of the curriculum have to be established by a group of participants. Secondly, a research lesson is selected and planned collaboratively by the group. Thirdly, the research lesson is presented by one group member with the others observing the presentation. Fourthly, a reflection of the research lesson is done.

LS focuses strongly on the classroom instruction, i.e. what really takes place in the classroom between the teacher and the learners. I maintain that it should be normal practice that the observation of the actual classroom instruction should be the foundation for instructional improvement. In Namibia PSMTs might not have opportunities to observe classroom instruction or to be observed by colleagues resulting in a situation where change of instruction never happens.

LS could be the solution to value teachers as professionals. An aim of LS is to allow teachers to use their collective talents and experiences to increase learner performance by increasing teacher knowledge and skills as professionals (Cerbin & Kopp, 2006). During LS teachers collect information on the supports and barriers to learners learning during lessons and share and discuss this data with their colleagues. This then results in possible improvement of their teaching.

In the NPSTN (MoE, 2006b) it is stated that one value of PD in particular is that teachers have to show commitment to the idea of collaboration, cooperation and collegiality. Experiencing LS will be something totally ‘new’ to the participating teachers but the commitment to the idea of lifelong learning is also indicated as a value under PD (MoE (NPSTN), 2006b) and teachers might realize the benefit of using LS as a form of PD.

A research study is needed in order to bring PSMTs in Namibia together to determine the experiences of each mathematics teacher after they have taken part in a LS activity.

1.7 STATEMENT OF THE PROBLEM

The above information indicates that PSMTs in Namibia have very limited opportunities to study school mathematics teaching in depth. A reason for this is a lack of PD initiatives. A RME-based PD programme aimed at PSMTs is one possibility to address this issue. How these teachers experience and implement the concepts and ideas they encounter in the RME-based PD is what we would like to know.

Having the above in mind I intend with this study to investigate the experiences of PSMTs who participate in such a programme. LS can be a particular useful methodology that can be used in cases where the teachers implement RME principles, which they have encountered in PD, in their classrooms in order to determine whether they have gained additional pedagogical and subject knowledge.

A research study of this kind is needed to determine how PSMTs experience this type of PD which includes the RME principles and LS over a period of a year (three school terms). These experiences of PSMTs will indicate the way forward in order to identify the processes and mechanisms that may contribute to the development of teachers' learning and the influence thereof on the teaching community in Namibia.

Since PD for PSMTs was so far severely neglected in Namibia this study aims to investigate how RME and lesson study can be used in PD for PSMTs and to find answers to the main research question:

> *What are the experiences of primary school mathematics teachers who participated in RME-based professional development?*

Related to this, I repeat the following research sub-questions:

- ✓ *How can RME principles and LS contribute to the professional development of the primary school mathematics teacher?*
- ✓ *What are the primary school mathematics teachers' views and beliefs about mathematics teaching?*

In the following sub-section the aim of the study will be explained. The aim will indicate the way this study will take.

1.8 AIM OF THE STUDY

I would first like to contextualise the aim of this study in terms of recent developments in school mathematics reforms in other countries.

From international research studies it is clear that countries that are the strongest in the field of mathematics implement strong mathematical foundations in the primary years. In these countries learners are encouraged and equipped to think and to be creative and confident in using mathematics from an early age. Rather than simply memorizing facts and figures learners have the ability to adapt their mathematical understanding depending on the required application. Noting advances in the field of mathematics teacher education it is important that such programmes be informed by principles such as those based on RME.

RME played an important role in school mathematics reform in the Netherlands (Gravemeijer, 1994a & 1994b; Treffers, 1993; Van den Heuvel-Panhuizen, 2008), Indonesia (Hadi, Plomp & Suryanto, 2002; Ilma, 2011; Sembiring, Hadi & Dolk, 2008), Kenya (Ndinda, 2011), China (Cheung & Huang, 2010), United Kingdom (Dickinson & Hough, 2012) and the United States of America (Menon, 2011; Romberg, 2006). It is therefore important to investigate the influence of a PD programme offered to PSMTs in particular aspects of RME as well as on concepts in primary school mathematics that are problematic in Namibia.

To be able to teach for the purpose of effective learning I am of the view that learning is optimized if mathematics is taught by teachers who are able to use realistic and real life examples ('everyday') in their mathematics teaching. This study will therefore focus on the application of RME principles that are adapted in a PD programme. Why should the principles be adapted? It is necessary that the programme is authentically Namibian, the national curriculum has to serve, and that teachers take ownership of it. Teachers will have to locally develop teaching materials.

My aim with this study is to determine:

- ✓ What are the PSMTs' views and beliefs about mathematics teaching, i.e. their pedagogical beliefs?
- ✓ How can aspects of RME possibly empower teachers to focus their teaching towards perceiving mathematics as a human activity, i.e. their instructional practices?
- ✓ How does PD (supportive) assist teachers to promote ideas of mathematization in learners, i.e. mathematical understanding?
- ✓ To what extent have PSMTs' teaching approaches changed for the better?

The above questions will be addressed during the process of LS. The afternoons set aside to reflect on research lessons will provide valuable data that can be used to address main research question:

> '*What are the experiences of primary school mathematics teachers who participated in RME-based professional development?*

Including the sub-questions:

- ✓ *How can RME principles and LS contribute to the professional development of the primary school mathematics teacher?*
- ✓ *What are the primary school mathematics teachers' views and beliefs about mathematics teaching?*

If the collected data does not support the notion that RME can be an efficient strategy for instructional improvement, then the following questions will be applicable:

- ✓ What do teachers find difficult in the implementation of the RME principles (and why)?

- ✓ What is different compared to what teachers have done in the past (and to what extent)?

These questions will be reflected on after the research lessons, i.e. a lesson that is collaboratively planned but presented individually, has taken place. This research study will indicate how teachers feel about themselves and focus on ideas of a possible change in teachers' views and beliefs by asking them about significant agents of change (for example RME and lesson study) in their teaching.

It will be interesting to determine to what extent the RME-based PD programme has changed teachers' views and beliefs of mathematics teaching and of promoting effective teacher behaviour in the classroom. Possible explanations for the good or low impact of the programme, as well as solutions and recommendations, will be discussed in detail.

I argue that this study can provide possible advice for and support in many facets of teaching that are especially troublesome to all PSMTs regardless of their experience and qualification level. RME can provide ideas and strategies to strengthen and support classroom theory and practice with reality-based suggestions.

This study is necessary to be used as a basis for the planning, implementation and evaluation of future PD activities and initiatives in pre- and in-service training. During the progress of the study integrity and sustainability will be addressed more comprehensively.

The following sub-section will shortly describe the research design and methodology.

1.9 RESEARCH DESIGN AND METHODOLOGY

1.9.1 Introduction

This study employed a qualitative approach to data collection and interpretation. Patton (2002) states that qualitative designs are naturalistic to the extent that the research takes place in a real-world setting. Furthermore, in a qualitative inquiry the researcher sets out to understand the day-to-day reality of the participants and accepts the complexity of the changing of a programme.

1.9.2 Research aim

This study's aim is to determine what the experiences of PSMTs are who participated in an RME-Based PD. In the *Collins Dictionary of the English Language* (Hanks, Long & Urdang, 1983:514) 'experiences' are described as

> *'direct personal participation; a particular incident, feeling that a person has undergone'.*

Participants were involved in on-going PD for one school year.
The experiences of participants had to be documented. The research orientation will describe the process of the documentation.

1.9.3 Research orientation

To document the participants' experiences was no easy task. I argued that by meeting participants only once or twice a week would not give value and validity to this study. As the title of this study indicates a case study was intended.

A qualitative case study examines phenomena within its real-life context (Yin, 2009). The primary purpose of this case study is to understand the complexity of a single case, i.e. participants' experiences partaking in an RME-based PD from one school in Windhoek, Namibia.

This study was conducted with a group of mathematics teachers at a primary school in Windhoek, Namibia. The participants took part on a voluntarily basis. A total of 15 teachers participated in this study. Nine participants were from Grades 1 – 4 (Lower Primary phase), and three participants were from Grades 5 – 7 (Upper Primary phase), one participant was the Head of Department (HOD) for the Lower Primary phase, one participant was the HOD for the Upper Primary phase and one participant was the principal of the school. More information on participants will be supplied in Chapter 4.

I was aware of the fact that the flexibility of a case study might introduce new and unexpected results during its course and this might lead the research to take new and unforeseen directions.

The main research question requires an in-depth understanding of the social context (the school) in which the participants, in this case the PMSTs, engage in a particular set of behaviours. This motivated me to use the ethnographic approach to be able to get an in-depth understanding of the school culture within which the participants engage in a particular set of behaviours in their everyday teaching.

An ethnographic design was very suitable for the intention of this case study. Hesse-Biber and Leavy (2011) state that an ethnographer is a researcher who ‘goes inside’ the social world of the participants, ‘hanging out’, observing and recording everyday settings of the participants. I was part of the daily school life for a period of almost one year starting in January 2014 and ending November 2014. This enabled me to record the daily life experiences of participants as well as their experiences regarding the RME-based PD. It enabled me to identify the cultural ideologies, views, beliefs and social patterns of the participants. Culture should not be seen in this context as that of an ‘ethnic group’ but rather the culture of the school and other related aspects that might have an effect on the outcome of this research.

Data was generated through classroom observation, LS, workshops and interviews. By using the combination of observation, interviewing and document analysis (LS and workshops), I was able to use different sources of data to validate and cross-check findings. I state that each type of data has its weaknesses and strengths. Patton (2002) states that by using a combination of data types can increase the validity of the outcomes as the strengths of one approach can compensate for the weakness of another approach.

I took note of the fact that limited classroom observations could result in the possibility that I could interpret the situation being observed in unknown/incorrect ways, e.g. the participants may behave differently from when observed than normally and this might distort the data. Classroom observation is also limited in focusing only on external behaviour and the inner views and beliefs of participants cannot be determined in this case. In addition my experience as a teacher educator made me aware of the fact that classroom observations are very time-consuming.

Interviews, on the other hand, have the limiting factor that possible distorted responses to questions are due to personal bias, anxiety and maybe a lack of awareness. Interviews can be affected by the emotional state of the interviewee at the time the interview is conducted (Patton, 2002).

Recordings of the research lessons and workshop sessions can also have limitations. Due to time constraints it can happen that the completeness of the findings in some cases may not be optimal.

During the study I regularly attempted to have a look at what was observed and reported in interviews and informal conversations to go beyond the obvious external behaviour to explore inner feelings and thoughts.

A short description of how the data was collected by using the four different research instruments will be discussed next. Once again the sequence will be the same as that in which the data was actually collected.

1.9.4 Data collection: A brief Outline

Classroom Observation

Data obtained through classroom observation served as a means of comparing observations with participants' subjective reporting of what they believe and do (Patton, 2002). I argued that classroom observation is useful for gaining an understanding of the physical, social and cultural circumstances in which the participants teach, the relationship among and between colleagues, context, ideas, their behaviour and the activities they apply in their teaching. I wanted to observe what participants do, how frequently and with whom.

Classroom observation in this study served two purposes. Firstly it was used to describe the setting that was observed, the activities that took place and whether learners participated in the activities and the meanings of what was observed before the intervention (workshops) started. Secondly, the observations of the research lessons were documented to determine whether participants' teaching practice has changed/not changed during the study while research lessons have been implemented.

The shift in classroom teaching practice from before and after the intervention is important because this will point out whether the RME-based PD had any influence on participants' teaching.

Lesson Study (LS)

LS is a process that involves a small group of participants who meet regularly to plan, design, implement, evaluate and refine lessons for a unit of work (Hurd & Licciardo-Musso, 2005). In this study the lessons will target specific focus areas within a pre-scribed topic. I have decided to include LS in this research because it addresses issues of concern and interest, mainly (but not exclusively) identified by the participants themselves. This will involve a degree of choice to participate in this study.

Structured sharing of experiences during research lessons were planned and conducted. Feedback and discussions between participants and me took place.

Since the main research question of this study was to determine what the experiences of PSMTs were who participated in an RME-based PD, it was important that participants recorded their thoughts and experiences regularly. Prior to the study questions in the study addressed participants' views and beliefs regarding primary school mathematics teaching.

Participants were regularly asked to reflect on their experience regarding the implementation of the RME principles through the method of LS. Participants had to reflect on the possible benefits of the process of LS, the possible benefits of applying and implementing RME principles as well as obstacles experienced during this study.

The aim of reflection was to enable participants to share their experiences, successes and anxiety with one another.

Interviews

The purpose of including interviews was to find out from the participants those issues that could not be observed. Feelings, thoughts and intentions cannot be observed (Patton, 2002). I argued that the interviews would enable me to get an understanding of the participants' perspectives. I used two basic approaches to collect data through interviews, i.e.

- ✓ Informal conversations (after classroom observations)
- ✓ Questions drafted for interview sessions to gain more information regarding views and beliefs of participants. Some of these questions were posed to individuals and due to the time constraint the interview session later changed to focus-group interviews.

Individual as well as focus group interviews were conducted before the study commenced as well during the study.

The interviews captured how participants view their world. It helped to get to know and to understand their terminology and judgements. The interviews portrayed the complexities of participants' individual perceptions and experiences.

Workshops

This study's focus is on the PD of PSMTs. I argued that during workshop session, participants can experience all activities as 'learners' which might possibly convince them to implement these activities in their teaching. The participants may have an extensive knowledge base of their learners and learning environment which I as facilitator need to be informed about. The workshop sessions should also preferably change the relationship participants have with me, the researcher, if I treat them during the sessions as partners in the discovery process.

I contend that workshop sessions might enhance team building which might add value to our relationship during this study. Participants would be involved in all stages of this research and this might possibly help them to arrive at concrete findings.

Workshops were designed cognisant of the principles of RME (described in Chapter 3) and mindful of the key role of participants' views and beliefs in affecting lasting change. The content of the follow-up sessions were specifically based on discussions about what the participants perceived as needs that occurred in the previous sessions. Preparations for classroom practice were done after the first session. Participants were encouraged to try out ideas introduced in each of the workshops and to share ideas and experiences they had during the research lessons (LS).

I provided additional resources in the form of hand-outs, teaching aids (for example number frames, bead strings and worksheets to name a few) and ideas for preparing own useful teaching aids as well as additional relevant textbooks. RME was explicitly mentioned as the framework of the study underpinning the ideas presented in the workshops. Explicit discussions about relevant beliefs were facilitated.

In the next sub-section key definitions and terminology used in this study will shortly be defined in the context it was used in this study.

1.10 KEY DEFINITIONS AND TERMINOLOGY

The following key terms are explained and or defined in order for a common understanding of the use of these terms in the remainder of this thesis.

1. Realistic Mathematics Education (RME)

   It is a teaching approach in which mathematics education is regarded as human activity. In RME learning mathematics means doing mathematics, of which everyday life problems (real-life context problems) are an essential part.

2. Lesson Study (LS)

   It is a cycle of activities in which teachers collaboratively design but then individually implement and improve on their lessons to make positive changes in their instructional practices and contribute to more effective learner learning. It is a form of long-term professional development in which teachers collaboratively conduct research within the context of the classroom.

3. Research lesson

   A research lesson, at the heart of the LS process, is the actual classroom lesson that was planned collaboratively by participants but presented individually.

4. Standardized Achievement Tests (SATs)

   These are tests that provide diagnostic information about what learners in Grade 5 and 7 know and are able to do in key learning competencies in the Namibian curriculum. It helps to monitor schools' progress from year to year.

5. National Professional Standards for teachers in Namibia (NPSTN)

   The Namibian Qualification Authority (NQA) has developed a National Qualifications Framework (NQF) to promote a competence-based approach to education and training. The intended outcomes are described in documents called 'standards' which form the building blocks of the NQF. These National Standards describe what competent teachers will know and should be able to do.

6. Lower Primary phase

   The school phase for learners attending Grades 1 – 4. In 2015 this phase will change to Grade 0 – 3. A pre-primary school year will become compulsory (Grade 0) being phased in 2015.

7. Upper Primary phase

   The school phase for learners attending Grades 5 – 7. From 2018 this phase will be for learners attending Grades 4 – 7.

8. Code switching

   It is a term in linguistics referring to alternation between two or more languages in the course of discourse between people who have more than one language in common. Learners at lower Grades may 'code-switch' between their mother tongue and the official language (English) as they learn. In the Namibian context it is important to note that in almost all classrooms learners come from different cultural backgrounds, meaning their mother tongues would differ. For the school partaking in this study only two mother tongues are implemented, namely Afrikaans and English. However, learners attending this school in reality speak various mother tongues like Otjiherero, Oshindonga, Oshikwanyama, Rukwangali, and Khoekhoegowab. A very small minority of learners really have English as their mother tongue.

9. Classroom climate

   The atmosphere or tone of a classroom is indicated by the total class environment including the way teacher and learner relate to one another.

10. Classroom management

    The way a teacher organizes and administers routines to make classroom life as productive, time-effective and satisfying as possible. This is what some people might describe narrowly as 'discipline'. Teachers with good classroom management are clear about how things are to be done.

11. Facilitation

    It is the role for classroom teachers that allow learners to take an active role in learning. Teachers assist learners in making connections between classroom instruction and learners' own knowledge and experiences by encouraging learners to create new solutions by challenging their assumptions and by asking probing questions.

12. Performance

    It refers to how good or bad learners did in tests and examinations or how they react in daily class situations. It refers also to accomplishments of a set objectives/aims.

13. Effectiveness (Educational)

    It refers to aim/objective attainment. In actual practice in Namibia tests and examinations in basic school subjects are predominant criteria for effectiveness. In this study the main focus will be on instructional effectiveness – teacher behaviour in daily class situations, for example teacher behaviour, learning material, time on task and the opportunity to learn. Under this term I will concentrate on the effectiveness of the teacher and not so much on the learning of learners.

1.11 OUTLINE OF THE CHAPTERS

In this study the outline of the chapters was done as follows:

Chapter1 provides an overview of the research. It includes the motivation for this research and the background to the problem. It provides a broad overview of RME and LS and also puts the current situation regarding PD in Namibia in context. The problem statement and the aim of the study will indicate the focus of the chapters following. This chapter gives a brief outline of the research design and methodology. The data collection, key definitions and terminology applicable for this study is also briefly elaborated on.

Chapter 2 describes the Namibia Education System with special reference to PD for PSMTs. The intention of this chapter is to inform the reader about reform initiatives that have taken place since independence and the current status of PD in Namibia. It outlines the different school Grade levels and what primary school mathematics content a teacher is expected to teach. The potential value of RME-based PD in Namibia will be discussed. The ‘new’ school reform which will be implemented in 2015 will be addressed to put RME-based PD in context.

Chapter 3 reviews relevant and current literature regarding PD, LS, RME principles, primary school teachers’ views and beliefs as well as learners experiences with school mathematics. It also provides the theoretical background to the study. The focus of the literature review is to emphasize important information that is already available, e.g. about the history of RME, what the principles of RME entail, how RME can serve as theoretical framework for this study as well as current criticism against applying RME principles in school mathematics. Different experiences of countries where RME is in use will provide important background information to this study. Since PD focuses on PSMTs it is important to also focus on literature about primary school mathematics teachers’ views and beliefs since this will provide information and insights necessary for the data collection.

Chapter 4 outlines the methodology of this research. Special reference to the research design, i.e. ethnography and case study, and how data was collected and generated will be provided. The selection of the participants and a short description of the data analysis are presented.

Chapter 5 presents the research findings. The findings will be reported on in the form of vignettes of PSMTs teaching in the spirit of RME. The limitations and verification of this study are also explained.

Chapter 6 presents the discussion on the findings. This is necessary to put the main research and sub-research questions into perspective. This chapter concludes with a comprehensive summary of all findings of this study as well as the contribution this research has brought forward for future PD for PSMTs.

Chapter 7 will conclude this study by making several practical recommendations on PD in general and especially also on how to organize PD sessions. These recommendations are derived from the literature review and the findings presented in Chapter 5. The way forward with this study will conclude this research.

1.12 CONCLUSION

The motivation, background and the problem statement of this study motivates the main research question, i.e.

'What are the experiences of PSMTs who participated in RME-based PD?'

Despite the importance with which teacher professional development (MoE (NPSTN), 2006b) in Namibia is apparently regarded there has been little local research done in this regard. Limited published data exists regarding the quality or impact these PD initiatives had on teaching and learning in Namibia. Limited opportunities, therefore, have existed for PSMTs to partake in PD to develop their mathematical knowledge or their pedagogical knowledge in mathematics. This might have made it more difficult for PSMTs to develop the skills and the confidence necessary to become effective primary school mathematics teachers.

This study is a descriptive and qualitative ethnographic case study. It also addresses the issue of trustworthiness and transferability.

By studying the experiences of PSMTs partaking in an RME-based PD I can understand how PD affects the practice of these teachers and learner performance. I argue that through this study I can learn the extent to which the aim of this study has been achieved, which ones are desirable and what continuum of mathematics PD for PSMTs career might look like in future.

The following chapter describes the Namibia Education System with special reference to PD for PSMTs to put this study into context. The intention is to provide the reader not familiar with the Namibian Education System with a historical overview of the school structures and teacher education before and after independence. Reforms that have taken place since independence and the current status of PD in Namibia will also receive attention. It outlines the different school Grade levels and what is expected of a primary mathematics teacher in each.

CHAPTER 2

THE NAMIBIAN EDUCATION SYSTEM: PAST AND PRESENT

2.1 INTRODUCTION

The purpose of this chapter is to place my study in the Namibian education context with specific reference to professional development (PD) for primary school mathematics teachers (PSMTs).

I will start with a historical overview of education in Namibia, addressing the school structure and training of teachers before and after independence. Special attention will be given to the period 2010 – 2014 since the primary school syllabi developed for this period will have the most direct influence on the current study.

This will be followed by an explanation of teaching in the primary school phase and the new reform implementation phased in in 2015.

The place of PD within the Namibian education system, focusing on PD that took place in the past as well as suggested PD activities for the future, will receive attention. The potential value of Realistic Mathematics Education (RME) principles applied in PD through lesson study (LS) for PSMTs will be discussed.

The possible value of PD in the professional life of a PMST in Namibia will be explained. I will then argue that PD based on adapted RME principles and LS are most likely to bring along a definite improvement in the mathematics subject knowledge and teaching of PSMTs.

The Government of the Republic of Namibia has placed a high priority on and devoted considerable resources to education so as to improve the system after independence in 1990. An aim was to meet the basic learning needs of all children, young people and adults. Since independence Namibia has invested roughly 25 % of its annual budget in education (Fischer, 2010; MoE, 2013). The desire of the people of Namibia were to provide an education that is accessible, efficient and of good quality and includes lifelong learning and democratic participation in all spheres of education (Kamupingene, 2002).

However, thus far there is growing disappointment with the results because learners are not yet achieving high levels of performance when compared to neighbouring countries and a lack of skills persists which is constraining growth (MoE, 2013; SACMEQ, 2011a & 2011b).

2.2 A HISTORICAL OVERVIEW OF THE NAMIBIAN EDUCATION SYSTEM

The school system and the training of teachers before and after independence will be discussed with special emphasis on the most recent reforms.

2.2.1 The Namibian Education System before 1990

The political and educational history of Namibia has made education a national preoccupation. The education policy has been intertwined with colonial rule, first during German Colonial Rule from 1885 – 1915 and then by South Africa Occupation from 1920 until independence in 1990 (Ellis, 2010). Both occupying powers did not pay any particular attention to the education level of the indigenous black population and therefore the striving for quality education became part of the national liberation struggle.

During German Rule it was mostly missionaries who were responsible for establishing schools and for teaching especially in the rural areas. The German government funded some private schools for German children in the territory.

During the South African Occupation (1920-1990) education in Namibia was for most of the time fragmented. In 1953 the Bantu Education Act was passed in South Africa, and it was soon also applied in Namibia (Republic of South Africa: Bantu Education Act No 47 of 1953). According to this Act education for all black children became the responsibility of the Bantu Education Department (later Black Education Department) in the South African Ministry of Native Affairs. African children were to be educated in a way that was appropriate to their culture (Bantu Education Act No 47 of 1953). Its aim was to deny Africans an education that would lead them to positions they would not hold in society. Instead Africans were destined to receive an education that equipped them with skills to serve their own people or to work in manual labour jobs under white control (Du Pisani, 1986).

The Bantu Education Act was from the beginning strongly rejected especially by the Black people who regarded it as inferior to the education of the white people. For white children the syllabi and examinations of the South African Cape Education Department were used. Another point of criticism was that black education (for black people) was not nearly as well-resourced as education for white people (Du Pisani, 1986).

Initially education for black Namibians was thus justified in terms of its vocational utility. This led to gross disparities and inequalities in the education sector especially in the subject mathematics. The idea was that education should be functional and people should get the training for what they would need. It was considered that mathematics was not an important subject to teach to black learners because 'pick and shovel is the natural work of the native' as Mr. H Schoeman, former Minister of Agriculture in Apartheid South Africa was apparently quoted to have said (Zeichner & Dahlstrom, 1999).

There were also at least two attempts to let each ethnic group take control of its own education.

In 1964 the Odendaal Commission recommended the partition of Namibia in ten homelands for the various black ethnic groups (very much according to the Bantustan policy in South Africa). The whites were also allowed to own property, much of it in the economic heartland of the country. The Coloured population, who mainly lived in the bigger townships, received no homeland but a council (Du Pisani, 1986).

Each homeland was expected to gradually take over the functions of their group, of which one of the first was education. However, the plan was abandoned before much of it could be implemented. Only four of the groups at some stage have taken over certain functions of their group. They were Ovamboland (1968), Kavango (1971), East

Caprivi (1972) and Rehoboth (1976). However, they did not claim independence (Du Pisani, 1986).

The plan was severely criticized internally and by the outside world. It was never fully implemented.

In 1979 an interim government was established in Namibia. This government followed the election of 1978 but was recognized neither by the major Namibian political groups nor by the outside world. The National Assembly of this interim government revoked the Bantu Education Act but they did not really change the structure of education in Namibia. They again passed a law (AG 8) according to which each ethnic group should take responsibility for its own education. Also this idea was not successful since most of the groups preferred not to take control of their own education but to place it under the Department of National Education (which was an option at the time) (Du Pisani, 1986).

The normal teaching style could be described as teacher-centred before independence. Learners were exposed to a situation where the attention and activities were focused on the performance of the teacher. Teachers paid very little attention to learners' interests, backgrounds and the orientation of their learners.

Before independence, education was not only separated by race but also within each ethnic group. The selection of a few who would reach higher levels of education was applied within each ethnic group. This negatively influenced the education of the Namibian nation even further.

Examinations were utilized to filter out and restrict the number of learners who could proceed to higher education. Unequal distribution of power and financial and material resources created a hierarchy for those who were able to find jobs. Access into this hierarchical structure of employment opportunities was determined by ethnic origin and results obtained by individuals in end of the year examinations. Examinations were used as a supplementary tool to the Apartheid policy in order to strengthen and sustain disparity between races and ethnic groups (Shilongo, 2004). The emphasis on examinations was felt extremely in schools and in the then Teacher Training Colleges.

Since the focus of this study is on the experiences of PSMTs participating in PD, it is of special importance to look at how teacher education was conducted before independence. Participants in this study might have been trained during this era, i.e. before 1990.

In the 1970s seven training centres, these were like teacher training colleges, were in operation. These were 'extensions' (having teacher training wings) of secondary schools. Afrikaans was the medium of instruction and the entry requirement into these training centres were as low as Standard 2 (Grade 4 currently) (Cohen, 1994). The teacher training centres, i.e. the secondary school wings offered the 'Lower Primary Teachers Certificate (LPTC)' and the 'Primary Teachers Certificate' (PTC). These were courses also offered in South Africa but were phased out there because of their low standards. Namibia continued to offer these courses (Cohen, 1994). Additionally to the LPTC and PTC, three colleges in the north of Namibia, Ongwediva, Rundu and Caprivi College, offered the courses 'National Education Certificate' (NEC) and the 'Education Certificate Primary' (ECP). After 1990 these courses served as entry requirements into the In-Service Basic Education Teacher Diploma (BETD-INSET) (Fourie, 1999).

To summarize, teacher education and training was poorly coordinated, fragmented and generally of a low standard. It was expected of these prospective teachers to memorize facts which were prescribed by a type of a 're-call' examination system (Nyambe & Griffiths, 1998). Teachers' qualifications were not of a high standard and their learners understandably did not perform well in the national examinations. Resources for teachers were either non-existent or very few (Shilongo, 2004).

White and Coloured teachers were trained at teacher institutions in South Africa. These teachers usually received government bursaries to attend South African Universities or Teacher Training Colleges and their qualifications were regarded as of a 'high' standard. Learners of these teachers achieved high Grades in the national examinations. A possible reason might have been that these teachers had much more resources available to teach (Shilongo, 2004). Most of the schools were e.g. equipped with a well-functioning library.

Before independence education and teacher training were controlled by the occupying power at that time. This occupying power decided which curricula, teaching strategies, instructional material and textbooks were to be used. Educational institutions were then intellectually dependent on the particular occupying power (Cohen, 1994).

The Namibia education system before 1990 could be summarized as follows (UNESCO (EFA 2000 Assessment report), 2011):

- ✓ fragmentation along racial and ethnic lines;
- ✓ unequal access to education and training at all levels of the system;
- ✓ inefficiency in terms of low progression and achievement rates;
- ✓ irrelevance of the curriculum for many;
- ✓ irrelevance of teacher education programmes for many;
- ✓ a lack of democratic participation within the education and training system.

At independence the education system in Namibia was characterized as being highly fragmented and unequal. There was also an extremely unequal financial resource allocation for public education used at that time

Namibia obtained independence on 21 March 1990. Following independence the Namibian government viewed education reform as of utmost importance by introducing the ‘Education for All’ concept (Ministry of Education and Culture (MEC), 1993). The four pillars of the education system were access, equity, democracy and quality. After 1990, the education system in Namibia experienced significant changes and development. These changes and development manifested themselves in ‘reforms’ and ‘transitions’.

The next section provides a discussion of the education system since independence with the aim of providing further contextualization.

2.2.2 The Namibian Education System after 1990

Since 1990 several Ministries of Education as well as other educational institutions were created.

Soon after independence, the Ministry of Education, Culture, Youth and Sport was established (MECYS). A school structure was established in 1990 with a unified system of educational administration, management and control with its head office in Windhoek.

However, in 1991 the above Ministry was separated (split) into two Ministries, i.e. the Ministry of Youth and Sport (MYS) and the Ministry of Education and Culture (MEC).

Once again in 1995 the Ministry of Education and Culture was split into two Ministries, being the Ministry of Basic Education and Culture (MBEC) and the Ministry of Higher Education, Vocational Training, Science and Technology (MHEVTST). The division of 'Sport' was added to the MBEC a bit later and became the Ministry of Basic Education, Sport and Culture (MBESC). In 2005 these two Ministries merged again and became the Ministry of Education (MoE) (UNESCO, 2011).

The Namibian College of Open Learning (NAMCOL) was first established as a directorate in the MBEC to provide learning opportunities for adults and out-of-school youth. Currently NAMCOL is operating as a parastatal organization and provides study opportunities for those learners who were unable to pass Grade 10 or Grade 12 or who do not wish to attend formal school (UNESCO, 2011).

The formal education system exists of seven years of primary schooling (Grades 1 – 7) followed by a three-year junior secondary phase (Grades 8 – 10) and a two- year senior secondary phase (Grades 11 – 12). With current reforms, these phases are in the process to be changed. In Namibia there are also special education institutions for learners with disabilities.

The language policy was developed and the development of the National Institute for Educational Development (NIED) and the Educational Management Information System (EMIS) earmarked the important time after 1990. NIED is responsible for the nation's curriculum development, educational research and professional development of teachers and EMIS provides data regarding supply and demand of teachers (Kamupingene, 2002).

However, emphasis on structural change, learner-centred education, a difficult medium of instruction policy and insufficient attention to gender equity delayed a comprehensive transformation. The first years of independence were guided by the need to redress the past inequalities and injustices through access to Education for All, equity and resource distribution to all and to encourage the population to become a learning nation (MBESC, 2004).

Currently the education system in Namibia is undergoing another reform. This was necessitated by the accumulated experiences of the past twenty four years and the need to link school education to the world of work. Twenty-four years after independence, however, the Namibian education system is still viewed as being inefficient in this regard. Namibia has a very high unemployment rate, which is said to be a result of a poor education system (Fischer, 2010; *The Namibian*, 7/03/14). Fundamental to future progress is to increase the low number of qualified, well-educated Namibians. A report of the 'Friedrich Ebert Stiftung' of 2010 states that 20% of employees in Namibia have no education for the profession they are working in. Of the working force, about 45% of the employees only attended primary school. While the low educational standard and the lack of skilled workers was a legacy of colonial times, the question remains why this is still the case in an independent Namibia (Fischer, 2010).

While much has been achieved in terms of access to schooling, a lot still needs to be done in order to improve quality to ensure equitable distribution of resources (human, financial and material) and to attain greater efficiency. Repetition and dropout rates in particular place an extra demand on educational resources in terms of expenditure, teaching and availability of learning space (Kamupingene, 2002).

Education is highly subsidized in Namibia. The first Minister of Education after Independence, the Honourable Nahas Angula, mentioned in a National Conference on education held in Windhoek, 27 June 2011, that

> *'The education and training sector is overfunded in relation to performance. The way forward in education is to ensure we get value for money'* (Angula, 2011:11).

In Namibia educational reform since the end of apartheid in 1990 has been extensive and teachers have been exposed to several curriculum changes. In my view educational quality depends greatly on learners' access to professional and efficient teachers. The process of curriculum revision is considered as an on-going process as the nation seeks to establish itself among other nations. Therefore, the importance for teacher professional development will also be an on-going process.

The reform of the education system after independence did not only include structural reforms and the development of a new Broad Curriculum but also the reform of teacher education at the four Colleges of Education in Windhoek, Ongwediva, Rundu and Katima Mulilo (Caprivi). Quality education requires quality teachers.

As far as teacher education is concerned, it was regarded as one of the most important areas of reform at independence because of the teachers' strategic role in any reform efforts. In line with the Constitution of the Republic of Namibia education was reformed since independence, based on the four major goals of education, i.e. access, equity, quality and democracy. These four goals were to be realized through the educational principles of learner-centred education (Ministry of Basic Education, Sport and Culture (MBESC), 2004). It is important to understand teacher education reform in Namibia from the following point of departure:

> *'Learner-centred education presupposes that teachers have a holistic view of the learner, valuing the learner's life experience as the starting point for their studies. Teachers should be able to select content and methods on the basis of a shared analysis of the learner's needs, use local and natural resources as an alternative or supplement to ready-made study materials, and thus develop their own and the learner's creativity… A learner-centred approach demands a high degree of learner participation, contribution and production…'* (MBESC, 2004: 19).

This statement links to the RME-based PD focus of this study. Teachers themselves have to be able to select the content, methods and resources to apply in their teaching in order to address the needs of learners.

Within the new paradigm (teacher-centredness versus learner-centredness) of education, teachers are seen to be both agents of change as well as the implementers of change and therefore had to be trained accordingly (MBESC, 2004).

To meet the new expectations and demands of the reform process after independence, a mere re-organization and integration of elements of the pre-independence teacher training programmes were neither politically acceptable nor practically feasible (MBESC, 2004). It was recognized that teacher educators, to a certain extent, hold the position of authority and control over the structure of knowledge, and therefore it was crucial to work on changing the educators' beliefs, attitudes and practices (which also plays an important role in implementing an RME-based PD at primary schools). The design of the new teacher education programme rested on the principles that deliberate and conscious interventions were to be made through the teacher educators and the teacher education programmes to meet the demands of the basic education system.

Within the new paradigm of education teacher education (especially pre-service) was seen as an initial step in an on-going process of professional growth and development and as a result of the rapidly increasing and changing state of knowledge. New and more complex demands which are made on the role and function of the teachers had to be implemented by the newly developed teacher education curriculum. Therefore, teacher education reform in Namibia has since independence been used as spearhead in the efforts to transform the Namibian society within its social context to contribute to a new and different society (Ministry of Higher Education, Vocational Training, Science and Technology (MHEVTST) & Ministry of Basic Education and Culture (MBEC), 1998; MBESC, 2004).

The Basic Education Teacher Diploma (BETD) programme was introduced for the first time in 1993 at the four Colleges of Education in Windhoek, Ongwediva, Rundu and Katima, founded on the principles of the learner-centred pedagogy (Peters, 2006). The overall goal of the BETD was to

> ‘*Provide a national and common teacher preparation related to the needs of basic education, the educational community and the nation at large. It strives to foster understanding and respect for cultural values and beliefs, “social responsibility”, “gender awareness and equity”. It also strives to instill an awareness of how to “develop a reflective attitude and creative, analytical and critical thinking; an understanding of learning as an interactive, shared and productive process and enabling the teacher to meet the needs and abilities of the individual learner’* (MHEVTST & MBEC, 1998:39).

The BETD programme’s aims were to produce teachers who would meet the demands and rise to the challenges of the post-independence basic education system. It was expected of student teachers to have been exposed to a variety of teaching and learning styles, strategies and techniques in order to become a competent and professional teacher. The BETD programme tried to strike a balance between subject knowledge on the one hand and professional skills and insight on the other hand. The programme attempted to integrate various types of exposure into classroom situations so that theory and practice were integrated meaningfully for the benefit of the student teacher (MBEC & MHEVTST, 1998).

Another central concept in the BETD programme was the idea of Critical Practitioner Inquiry (CPI). This is a term used in Namibia since 1995 and can be seen as an umbrella concept used in teacher education and professional development courses for teacher educators. In this paradigm teachers are responsible for the improvement of their own teaching. Teachers are viewed as researchers who should reflect critically on their own practice and the context in which they teach, change their practice according to the outcomes of their inquiry, while growing professionally and changing social reality in the process. This critical inquiry orientation in teacher education was favoured primarily by the Namibian policy makers because it supports the post-independence goals and philosophy of education (MBESC, 2004). Critical reflection will also form an important part of LS in this study.

The situation in Namibia at independence was that 16% of the nation’s 13 000 teachers had no professional training (MBESC, 2004). Therefore, the MBEC and MHEVTST placed in-service teacher education at the top of its priority list and introduced the Basic Education Teacher Diploma In-Service (BETD-INSET) programme in 1994. At first this in-service programme was based on the same broad curriculum as for the pre-service BETD programme (Fourie, 1999). Duplicating the pre-service curriculum over a distance mode soon proved to be problematic and the curriculum for the BETD-INSET was adapted according to recommendations put forward by a review team in 1996 (MBESC, 2004). A shift in pedagogical approaches was required in order to link the programme to the experiences of the serving teachers and to assist them in transforming their pedagogical practices to be consistent with the national goals (Fourie, 1999).

The BETD programme trained teachers for the phases Lower Primary (Grades 1 – 7, Upper Primary (Grades 5 – 7) and Junior Secondary (Grades 8 – 10). Each student teacher had to select a major and minor option. At first all BETD graduates were either certified to teach Grades 1 – 7 (Primary phase) or Grades 5 – 10 (Upper Primary and Junior Secondary phase). This implied that the demand for teachers could be met in a shorter time. This changed within the teacher education reforms undertaken since 1997. The last cohort of BETD students were certified to teach either Grades 1 – 7 (Lower and Upper Primary phase) if the major option was Lower Primary or Grades 5 – 7 (this student was then certified to teach three subjects in the Upper Primary phase) or Grades 5 – 10 if the major option was Junior Secondary (MoE, 2009). In Namibia there were more combined schools after independence, meaning schools catering for learners from Grade 1 – 10 than regular Senior Secondary schools catering for learners from Grade 8 – 12. There were also some Junior Secondary schools catering only for learners from Grade 8 – 10 but these were mostly converted to full Senior Secondary schools since independence.

The Namibian community at large is still not satisfied with the education the learners have received in the 24 years since independence (*The Namibian*, 20/01/13; 7/03/14; 16/01/15; *New Era*, 22/09/14). In 2008 a consultancy by Crebbin, Villet, Keyter, Engelbrecht and van der Mescht provided new guidelines for teacher education reform. This consultancy expressed strong criticism that learners in both the Upper Primary and Junior Secondary phases had poor skills in numeracy and literacy. Such shortcomings in school achievements have led to strong criticism of teachers and the effectiveness of the training of teachers. The BETD programme was criticized heavily by the media as well as by certain other consultancies done in the country (*The Namibian*, 20/01/13; Clegg & Courtney-Clarke, 2009). The BETD programme was indicated as the main factor why learners do not perform since the majority of teachers currently employed are former BETD graduates. However, it has to be mentioned that teachers were not always placed in their fields of specialization (Swarts, 2008). It was quite possible that a Lower Primary qualified teacher ended up teaching mathematics for Grades 8 – 10, for example. It needs no further explanation why this could have a major influence on the performance of learners.

A number of policies and initiatives were put in place to improve the quality of the Namibian education system. In 1993 only 12,6% of teachers were qualified to teach at primary level (MoE, 2013). The overall percentage of qualified primary teachers grew to 41, 1% in 2001 and to 77,8% in 2012 (MoE, 2013). This increase in qualified teachers was due to both the pre-service and in-service BETD training programmes. The current minimum requirement for appointment as a teacher is a BETD, a three-year qualification (or an equivalent). As from 2010 all teachers in Namibia are being trained through a four-year Bachelor Degree at the University of Namibia (UNAM).

I considered it necessary to explain the teacher education programme BETD rather comprehensively since it will put the current study into perspective. The aims of the BETD curriculum and CPI have many similarities with RME principles and with LS. How this is possible will be explained in Chapter 3 which contains detailed clarifications of RME and LS. However, at this stage it can be stated that in RME the first learning principle is that learning mathematics is a constructive activity. Teachers participating in the RME-based PD will be exposed to activities that will demonstrate the importance that learners are granted the opportunity to make sense out of mathematics and that they are stimulated at important junctions in order to be able to reflect on learning strands that have already been encountered and to anticipate what lies ahead of them. Learning mathematics does not imply absorbing a collection of unrelated knowledge and skill elements; it rather is the construction of knowledge and skills to a structured entity. These key principles the participants in this study, through the BETD, might have experienced to some extent already during their training.

In 2005 the Government of the Republic of Namibia adopted a fifteen-year sector-wide strategic plan for education known as the Education and Training Sector Improvement Programme (ETSIP) (MoE, 2013). This fifteen-year plan states that:

> *'the education and training system has not managed to produce the required threshold of adequately educated and skilled human resources required for the economy*' (MoE, 2013: 9).

Key weaknesses of the system pertain to poor quality and ineffectiveness which translates into low learning outcomes as manifested in high failure rates in examinations and low productivity.

Therefore, the National Curriculum for Basic Education (NCBE) was revised in 2010 (MoE, 2010). This curriculum has been developed to give direction to Basic Education towards the realization of Namibia's Vision 2030.

> *'Namibia Vision 2030 sees Namibia as developing from a literate society to a knowledge-based society, a society where knowledge is constantly being acquired and renewed, and used for innovation to improve quality of life'* (MoE (NCBE), 2010:2).

This curriculum aims at ensuring continuity of the foundation principles of the Namibian education system described in '*Toward Education for All: A Development Brief in 1993'* (MEC, 1993) as still being applicable.

An overview of the current Namibian school system will be discussed next. This will provide an indication and understanding of what is expected of learners to be able to achieve at the end of each primary school phase.

2.2.3 The Namibian Education System: 2010 – 2014

The NCBE is based on the Constitution of the Republic of Namibia and the Education Act (MoE, 2010). In Namibia the formal education system comprises seven years of compulsory and free primary education for all learners from the beginning of the school year in which a learner turns seven years until the year when the learner reaches the age of sixteen or when he or she has completed primary education. However, free education does not imply completely free, in my view. There are hidden costs that may hinder learners from attending school such as contributions to the school development funds, the purchase of school uniforms and paying for transport.

Early Childhood Education and Development is provided outside the formal education system and is taken care of by the Ministry of Gender Equality and Child Welfare. This Ministry has the responsibility to oversee the development of various aspects of early childhood development, care and education.

However, in Namibia pre-schools and Kindergarten are currently run by communities, non-governmental organizations, churches and individuals because the existing pre-schools that were state-owned before independence are now utilized as classrooms for primary schools. However, there are a number of private schools which offer early childhood education within their formal school setup (MoE, 2013). From 2015 onwards a pre-school year in government schools will be part of the first phase of schooling and will be compulsory for all learners (MoE, 2014b).

The formal Namibian education system consists of a seven-year Primary phase structure followed by a three-year Junior Secondary phase and a two-year Senior Secondary phase. There are also special education institutions for learners with disabilities. Formal education is divided into four phases: Lower Primary Grades 1 – 4, Upper Primary Grades 5 – 7, Junior Secondary Grades 8 – 10 and Senior Secondary Grades 11 – 12.

At the end of primary education (Grade 7) learners are prepared for a semi-external examination as a transition to Junior Secondary education. Semi-external in this sense means that all schools write the same examinations which are set centrally but are marked at the respective schools.

Learners at the Junior Secondary level write the Junior Secondary Certificate Examinations (JSC). The senior education learners are prepared for the localized but still certified by Cambridge, Namibia Senior Secondary Certificate Ordinary level

(NSSCO) and the Namibia Senior Secondary Certificate Higher level (NSSCH). Formal education is compulsory for all learners from Lower Primary to Grade 10 after which learners have different opportunities, e.g. entry into formal Senior Secondary education, vocational education and training, distance learning or direct entry to employment.

The following schematic presentation should make the structure and substance of the Namibian Basic Education system clear:

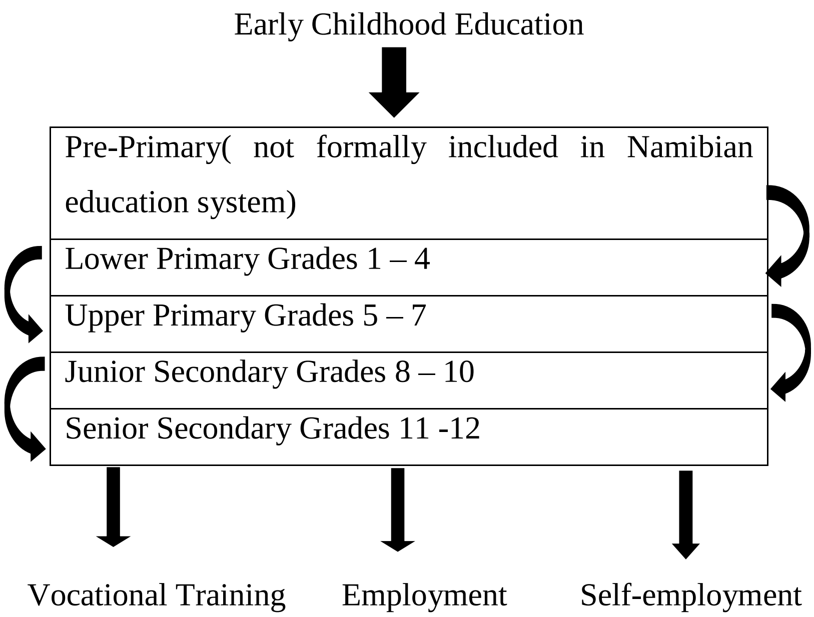


Figure 2.1: The Structure of Basic Education (NCBE, 2010:3)

Namibia has a ten-level National Qualifications Framework (NQF) which is administered by the Namibia Qualifications Authority (NQA). The national system for schools covers twelve years. Learners must be six years old in the year before starting Grade 1. A normal school year contains 195 – 200 school days (MoE, 2013).

A national inspectorate administers the National Standards for Schools. These standards which were for the first time introduced in 2005, have indicators which have been described in some detail and four levels are determined for each (MoE, 2006b). Each school does an internal self-evaluation each year and the national inspectorate arranges for a limited number of schools to be evaluated and rated by the national evaluation system. A school's evaluation in terms of the national standards should result in the drafting of a strategic plan for the development of the school. A subject advisory service provides support for primary education and for the various subjects. However, its deployment is complicated by the large number of subjects in the curriculum and the limited human resources. In a country the size of Namibia communication and transport are constant concerns because of the immense costs involved (MoE, 2013).

In the first three Grades the mother tongue is regarded as the medium of instruction. In Grade 4 the medium of instruction should be gradually replaced by the official language English. From Grade 5 onwards the medium of instruction will only be English.

The NCBE (MoE, 2010) states that the greatest challenge of curriculum reform is in the implementation of the curriculum. With any reform it is important that teachers take ownership and implement it with commitment. Preconditions for successful curriculum delivery which are important for this study are:

- ✓ *teachers are appropriately and fully qualified to teach the phases and subjects with which they are entrusted with, and they are well-informed, committed and competent;*
- ✓ *teachers are equipped with all the necessary teaching aids, technology and other relevant materials to support effective learning and have the skills to develop and adapt materials themselves to suit multi-ability groups of learners;*
- ✓ *teachers' 40-hour working week is clearly set out and fully utilized between 26 hours classroom contact time and 14 hours distributed between preparation and marking . … and continuous professional development*. (MoE (NCBE), 2010:5)

These preconditions clearly spell out the importance of the PD of teachers which can contribute to promote moral development, awareness of their own views and beliefs and to effectively apply their teaching skills.

Namibian Basic Education aims to develop flexible, enquiring minds, critical thinking skills, and the capacity to adapt to new situations and demands. It is stated in the NCBE (MoE, 2010) that learners should be able to construct alternative solutions to problems and to make independent, informed decisions in real-life situations. With the increasing emphasis on science and technology learners must be fully numerate. Numeracy skills involve creating logical models for understanding and apply them to everyday situations.

These conditions can be complimented if teachers themselves experience learning situations in RME-based PD as will be described in Chapter 3. The experiences of these participating teachers can then be applied and implemented through lesson study. To have a closer look at what knowledge and skills teachers need to possess in order to teach, it is important to have a closer look at what the curriculum requires what learners should be able to do at the end of the Lower and Upper Primary school phases.

The description of the Namibian education system for Lower and Upper Primary mathematics education to put the envisaged RME-based PD in perspective follows.

The following schematic presentation of the primary school phase should give a clear idea of its functioning:

	LOWER PRIMARY GRADES 1 - 4	**UPPER PRIMARY GRADES 5 – 7**
Medium of Instruction	Mother tongue	English
Approach to teaching and learning	Learner-centred	Learner-centred
Mode of teaching	Class teaching	Subject teaching

Focus	• Literacy • Numeracy • Environmental studies • Arts • ICT's Foundation • Physical education	• Literacy • Numeracy • Natural sciences • Social sciences • Technology • Commerce • Arts • Physical education
Content of Mathematics	• Number concepts • Mathematical symbols • Problem-solving • Computation • Measurement • Geometry • Data-handling • Estimation (all within prescribed range)	• Rational numbers – basic operations • Problem solving – number, measurement and spatial relations within prescribed range • Data collection

Table 2.1: Primary School Phase with respect to the Learning and Teaching of Subjects, especially Mathematics

The Lower Primary school phase of formal education covers the first four years of primary school education, Grades 1 – 4 (MoE, 2005c). The purpose of these four years is to lay a proper foundation for learning throughout the formal education system. All learning must promote the growth and development of each learner as an individual and as a member of the school and society. In this phase ideally a class teacher will teach all subjects. The official Curriculum for the Lower Primary Phase (MoE, 2005c) states that in cases where teachers are well trained and experienced, they should follow their learners (same class) from Grade 1 to Grade 4. This will ensure that the teacher will get to better know his/her learners individually and will be able to observe their development. In practice it will be a very difficult idea to implement. However, for the current study it remains an important statement since all RME-based PD activities are planned to include the PSMTs teaching from Grade 1 up to Grade 7. This might have the effect that participants will be aware of what is expected of learners to be able to apply at the end of a Grade and phase level.

The focus in this phase is on three areas, being literacy, numeracy and the general knowledge of the immediate environment of the learner. The Curriculum for the Lower Primary phase (MoE, 2005c) states that numeracy can only become functional life skills if applied to the real world around us.

> *"Numeracy is not meaningful as abstract skills"* (MoE, 2005c: 63).

This is an important statement, because the current study aims at investigating experiences of PSMTs participating in RME-based PD. The RME principles, as will be described in Chapter 3, will point out the importance of the 'intertwinement' principle which will link the three areas literacy, numeracy and knowledge of the environment.

Language usage in this phase is not only a question of the medium of instruction but of how the learners' appreciation, understanding and ability of language are developed. The use of correct terminology is essential. In this phase it is important to build on what learners already know and can say, how they can express themselves and of mastering new ways of saying things. The Curriculum for the Lower Primary phase (MoE, 2005c:5) states:

> *'Varied teaching methods should be used to create a language-rich oral environment by facilitating the learners in sharing ideas, thinking aloud …guessing… explaining … talking to each other to solve problems…and presenting their work to the class'.*

In my view RME-based PD (the use of context, the use of models, the use of students' own productions and constructions, the interactive character of the teaching process, the intertwinement of various learning strands) can ideally assist teachers to reach the above situation.

The learning outcomes for mathematics (MoE, 2005c) are that by the end of Grade 4 learners must be able to solve problems in an everyday context by adding, subtracting, multiplying and dividing, estimating and measuring within a limited number range. There are, therefore, six basic competency areas a learner must achieve by the end of Grade 4, namely problem-solving, computation, measurement, geometry, number concepts and data-handling.

The approach to teaching and learning is based on a strategy of learner-centred education. In the Curriculum for the Lower Primary phase (MoE, 2005c) the principles of learning are clearly spelled out. A comparison of RME principles with these principles for the Lower Primary curriculum shows remarkable similarities:

- ✓ The aim in Lower Primary is to develop learning with understanding. The starting point for teaching and learning is the fact that learners bring their own experiences and knowledge to the class. This fact must be used and the knowledge and experiences of learners need to be extended. In RME rich context problems out of the 'world of experience' of the learner should always be the focus point.

- ✓ Learners learn best when they are actively involved in the learning process through a high degree of participation, contribution and production. In RME it is expected that learners develop their own models which can also develop through participation.

It is also stated in the NCBE (MoE, 2010) that effective quality schooling in a text-rich environment ensures that numeracy is attained. On completion of the Lower Primary phase learners should be able to express, orally and in writing, their understanding of number concepts and mathematical symbols.

Since the current study's focus includes the Upper Primary school phase as well an overview of this phase also needs to be explained.

The Upper Primary phase of formal education covers the last three years of primary school education which are Grades 5 – 7 (MoE, 2005b). The purpose of mathematics in these years is to extend the basic competencies in computation with whole numbers to computation with common and decimal fractions (MoE, 2005b). The mathematics syllabus for the Upper Primary phase (MoE, 2005b) states that measurements, time and money should be related to the learner's everyday situation. The reference to 'everyday situations' appears very often in the official documents. This is exactly what RME is also about, namely that the learning content should be presented in a context that relates to the learners everyday experiences.

The Upper Primary phase mathematics syllabus (MoE, 2005b) mentions that working in groups, in pairs, individually, or as a whole class must be organized by the teacher who must decide when it is best for learners to convey content directly or to let learners themselves discover and explore information. Cooperative and collaborative learning should be strongly encouraged. Mathematical problems should always be exemplified in a context that is familiar and makes sense to learners. Learning experiences should be characterized by an atmosphere of trust, mutual support and the sharing of knowledge between learners and the teacher. It is clearly spelled out in the syllabus that mathematical problems should always be exemplified in a context which is meaningful to learners.

The theory of RME addresses issues like involving learners in purposeful activities in a meaningful context, the social interaction as part of learning and the emphasis on problem-solving. On completion of the Upper Primary phase, learners should be able to solve everyday problems involving numbers, measurements and spatial relationships (MoE (NCBE), 2010). The RME approach encourages learners to produce their own concrete objects in order to develop their own informal problem-solving strategies.

Learners are not allowed to use pocket calculators (MoE, 2005b & 2005c) according to the Mathematics syllabi for Grades 1 – 4 and Grades 5 – 7. The emphasis is placed on mental arithmetic strategies to develop learners' awareness of numbers and number sense. In RME for example the emphasis is placed on 'how counting becomes calculating' where it is expected of learners to be mentally able to solve mathematical problems applying different strategies, for example 'counting on' or 'adding in tens'.

Emphasizing links with other subjects and cross-curricular issues are important. Cross-curricular issues in this context include identified areas like Environmental Learning, HIV and Aids and Population Education. Mathematics as a carrier subject can include some of these issues in 'text-rich' problems which learners have to solve (MoE (NCBE), 2010).

In this phase it is expected of teachers to decide, in relation to the learning objectives and competencies to be achieved, how to design learning experiences that ensure mathematical understanding. Co-operative and collaborative learning is encouraged wherever possible. This links to the principles of RME as Chapter 3 will point out. As the learners develop personal, social and communication skills they can be gradually given increasing responsibility to participate in planning and evaluating their work under the teacher's guidance, in terms of the RME principle of 'guided re-invention'.

The paradigm of learner-centred education is also applicable to the Upper Primary phase. Learning in school must involve, build on, extend and challenge the learners' prior knowledge and experience. Teachers are reminded that the learners must be actively involved in the learning process through a high degree of participation, contribution and production. Again, the RME-based PD will include these expectancies.

The curriculum expectancies of the learners in the Primary School phase leads to the question of what is expected of a PSMT in this phase. In the next section the issue of what mathematics teaching in the primary school phase requires from a teacher will be briefly discussed.

2.2.4 Teaching in the Primary School Phase

A major challenge in preparing learners for a knowledge-based society is to provide well- managed flexibility in the approach to teaching and learning and to design learning experiences which motivate the learner to learn more (MoE (NCBE), 2010). The literature review will address how learners learning and understanding can be enhanced. In the NCBE (MoE, 2010) it is expected of teachers to involve learners in classroom activities through participation (RME: interaction principle), contribution (RME: activity and intertwinement principle) and discussion (RME: level principle). Furthermore, it is pointed out that the teacher must be able to identify the needs of the learners, the nature of the learning required and the means to shape learning experiences accordingly (RME: reality and guidance principle) (MoE, 2010).

Teaching strategies must be varied and flexible within well-structured sequences of lessons. It is expected that the teacher has to take on a wider repertoire of classroom roles. These include being a manager and organizer of learning (in RME-terms the role of giving guidance and how to guide learning), a counsellor as well as an instructor (MoE (NCBE), 2010).

In the current research study regular workshops will help the participants to organize their learning content in a manner which will enable learners to make sense out of their daily lessons. Participants' views and beliefs might point out what they regard as the reasons why learners do not perform well in mathematics. Teachers are put under great pressure from their school management because overall learners are not performing well in standardized tests (SATs). One of the realities these teachers face might be that as teachers they lack subject and pedagogical knowledge to enhance their learners' learning and understanding.

This study‘s focus is on RME-based PD and the main aim is to enhance the participants' subject and pedagogical knowledge of mathematics. How exactly the participants will experience and implement the concepts and ideas they encounter in the RME-based PD is what we do not know beforehand, as mentioned in the problem statement in Chapter 1. The outcome of the current study will give an indication of what the way forward could be for all PSMTs in Namibia.

The NCBE (MoE, 2010) clearly points out that the teacher has to exercise professional discretion in deciding which strategy to apply. The teacher's roles are complemented by the way work is organized in the classroom. Textbooks and other relevant learning

resources should be used in a variety of ways. Learners must be guided (in RME as 'guidance principle') to search for information, to share ideas and to know how to come up with a solution to a mathematical problem in context. This implies that the teacher will need support because they are asked to teach in particular ways, for example RME-informed ways, which they have not yet experienced themselves.
The intended learning of Namibian learners is prescribed in the form of subject area syllabi in Namibia (MoE, 2005b & 2005c). The NCBE (MoE, 2010) requires flexible ways of organizing learning in the classroom.

In RME the six principles (the activity, reality, level, intertwinement, interaction and guidance principle) can be applied to assist the teacher in organizing this learning, especially in the Lower Primary phase where class teaching is done. In the Upper Primary phase it would be advisable for teachers to work together for the intertwinement principle to take place. If learners do experience that mathematics is not an isolated subject it will make more sense to them.

A stimulating, text-rich learning environment is prescribed in the NCBE (MoE, 2010). The NCBE (MoE, 2010) states that effective learning and teaching are closely linked to the use of teaching and learning materials in the classroom.

RME-developed material during the presented workshops will enable participants to have suitable teaching aids available for their classroom teaching. However, Brodie and Shalem (2011) point out that teacher learning through PD is a complex process and it is not yet well understood. In Namibia I did not come across any research material that could assist me in developing the RME-based PD since it will be a first time for the participants to be involved in a PD that will take a longer period than a week.

The NCBE (MoE, 2010) mentions that teachers should be capable of designing learning activities in which learners experience, reflect and create knowledge for themselves. By means of reflection understanding grows and this understanding will be added to and modify previous experiences which will lead to further activities and explorations of reality.

The intended RME-based PD will focus through the process of LS on activating participants to be critical about their teaching and to reflect regularly.

In my view the teacher has an influence on the performance of the learners. Therefore, the quality of the primary school will be influenced by what happens in the classroom. One of the main challenges affecting the quality of education in Namibia is that many learners in the first few Grades of primary education do not achieve the desired levels of literacy and numeracy. This in turn affects the performance of learners in the Junior and Secondary school phases (MoE, 2013).

Since independence in Namibia much has been achieved in terms of access to schooling but a lot needs still to be done to improve quality. Namibia has made significant strides in training most of its teachers but many under-qualified teachers are still teaching in primary schools, especially in the lower Grades of primary education. An insufficient number of teachers specialising in Lower Primary and Upper Primary (especially in mathematics) have been trained and those trained are mostly deployed at higher levels (Clegg & Courtney-Clarke, 2009; MoE, 2013).

Being involved in teacher training for many years it would be very interesting for me to determine whether the teaching strategies of the teachers demonstrate what was learned during the pre-service or in-service training programmes of the BETD which was implemented in 1993. In the Broad Curriculum of the BETD (MoE, 1998:5) the competency to be achieved in terms of teaching skills was:

> *'The student should be able to teach their subject(s) through a learner-centred approach'.*

At the end of their BETD studies teachers should have been able to demonstrate their ability to teach their subject (mathematics in this case) through the learner-centred approach which should have included many practical activities and individual discovery of concepts (of which some are similar to RME principles). These skills have been evaluated during the pre-service teachers' School-Based Studies period as students which totalled 22 weeks over the three years of study. However, one of the main challenges affecting the quality of primary education in Namibia is that primary teachers do not meet the criteria to address learners' needs to improve their literacy and numeracy levels despite heavy investment in this sector since independence in 1990.

I am in teacher education for a very long time and it has to be mentioned that Lower Primary students were taught mathematics by their Lower Primary lecturers (teacher educators) who themselves often did not have a proper mathematical background. It is still the case at the University of Namibia (UNAM). It can happen that a student is taught Lower Primary school mathematics by a lecturer who him/herself had the subject 'mathematics' only up to a Grade 8 level in school. To be appointed as a Lower Primary lecturer requires a Master's degree in Education. Lecturers do not need to have 'pure' academic first degrees (e.g. Bachelor of Science).

All learning materials, teaching facilities and textbooks are taken care of by the government. Schools in Namibia purchase their learning materials from government stores. However, schools are complaining that all needs are not catered for by government, e.g. not having enough photocopying paper available, textbooks do not always arrive in time at schools and maintenance of schools are not taken care of properly. The SACMEQ report (2011) states that basic learning materials e.g. one exercise book, a pencil and a ruler are essential to ensure that learning activities can take place in the classroom. Even though the Namibian constitution forbids fees for primary schooling, parents still have to pay certain fees, e.g. school uniforms, school feeding programmes and transportation. In times of rising unemployment, some parents just cannot afford to send their children to school. Namibia is a territorially large country with a very low population density in most parts. Therefore, in some regions schools are very far away for some groups of people and transportation is not provided. It results in learners not attending primary school, because parents refuse to send their young children on a walk of several hours to and back from school every day (MoE, 2013).

These financial and teacher qualification constraints are identified and may influence the quality of education. For this study, however, the quality of education should only be determined by what the teachers accomplish in the classroom. Understanding and the ability of creating knowledge do not happen in isolation (MoE, 2010). It is the responsibility of teachers to create learning experiences which are situated in a natural and cultural context in which learners can interact. Learning is an individual as well as a collaborative experience. If learners are taught in a way which builds on what they already know and have experienced, they can relate the 'new' knowledge to the existing knowledge and to the reality around them. Learners will be able to realize that learning in school can be meaningful. Teachers need to be able to plan and design such meaningful activities. Therefore, my argument is that RME-based PD can be a source to help teachers to design and develop meaningful teaching material that relates to the experiences and circumstances of the learners.

The quality of education determines the requirements of the reform programme. Significant changes to the Namibian school curriculum were announced in 2014. A brief discussion of these changes follows in the next section.

2.2.5 The 'new' curriculum reform implementation 2015

The Ministry of Education (MoE) in Namibia has embarked upon a 'new' curriculum reform of which the implementation will start in January 2015 (MoE, 2014b).

One of the aims of this reform is that the availability of appropriate textbooks and other learning support materials will be improved and provided (*New Era*, 22/08/14).

In an attempt to address the weak achievement of learners the Namibian government has embarked on a wide-ranging curriculum reform as well as a syllabus review. It is hoped that this review will respond to the challenges and needs of the Namibian society. A major change to be implemented is that Early Childhood Development (one year pre-school) will form part of the Junior Primary (previously Lower Primary Phase) phase from 2015 onwards. This reform focuses very strongly on the improvement of number sense and basic numeracy skills of Junior Primary learners. Therefore, RME-based PD could serve its purpose in helping and assisting teachers in coming up with relevant teaching materials. This RME-based PD cannot be done only for a week but should address the challenges teachers might experience with the 'new' curriculum throughout the year. RME-based PD could be a means by which teachers can learn how to implement research lessons through the process of LS to help each other.

The most important changes of the basic education reform for primary education concern school structure, mother tongue instruction and modes of assessment. Each of these will be briefly explained below (MoE, 2014b; *New Era*, 22/08/14).

- School phase structure for primary school education

Primary Education is sub-divided into two phases.

The following schematic presentation should make a comparison easier to understand:

Primary School Phase		
Year	Name of School Phase	Name of School Phase
2010 – 2014	Lower Primary	Upper Primary
2010 – 2014	Grades 1 – 4	Grades 5 – 7
2010 – 2014	Mother tongue instruction	Instruction through medium of English
2010 – 2014	Pass requirement: 30 %	Pass requirement: 30 %
2015	Junior Primary	Senior Primary
2015	Grades 0 – 3	Grades 4 – 7
2015	Mother tongue instruction	Mother tongue up to Grade 5, Grade 6 & 7 instruction through medium of English – this is still an issue under discussion
2015	Pass requirement: 40 %	Pass requirement: 40 %

Table 2.2: Change of Primary School Phase Structure

The Junior Primary phase (previously the Lower Primary phase) will cover the first four years of schooling, namely Pre-Primary and Grades 1 – 3. The Pre-primary course is compulsory for all learners and will be introduced in 2015 at all schools offering primary school education.

The Senior Primary phase (previously Upper Primary phase) will cover schooling from Grades 4 – 7. An important difference is that Grade 4 is now part of the Senior Primary phase, whereas it was previously the final year of Junior Primary.

- Features of the Primary Education Reform (MoE, 2014b)

Mother tongue instruction is prescribed from Pre-Primary level up to Grade 5. The transition to English medium instruction will take place in Grades 6 and 7. This transition is planned with a different implementation schedule especially as far the modes of assessment are concerned.

- Modes of Assessment (MoE, 2014b)

In both primary phases continuous (formative) and summative assessment will be applied. The pass requirement is raised from 30% to 40% across all Grades. Special emphasis is placed on continuous assessment in these phases. An aligned grading structure for all phases will be from A – E. A ‘U-grading’ will indicate a ‘fail’, in other words a learner did not meet the minimum requirement of 40%. A learner will be promoted to the next Grade as follows:

- ✓ From Pre-Primary phase to Grade 1: the school readiness programme must have been completed successfully.
- ✓ From Grades 1 – 3: An E-Grade (40%) or better in the language of instruction, including at least a D (50%) in the Reading Component. An E-Grade (40%) or better in 6 subjects, including mathematics and the second language, provided that the overall average is at least an E-Grade.
- ✓ Senior Primary phase Grades 4 – 7: In Grade 4 a learner should obtain an E-Grade (40%) or better in 4 subjects, which must include English and mathematics, provided that the overall average is at least an E-Grade (40%). In Grades 5 – 7 a learner should obtain an E-Grade or better in seven out of eight subjects, which must include English and mathematics, and provided that the overall average is at least an E-Grade.

Evident from the above is that mathematics in the primary phase is regarded as one of the important subjects in which learners have to be able to demonstrate that they meet the minimum requirements to pass a Grade. Therefore, PSMTs need to be well acquainted with the new approaches and possess the necessary skills to apply them. A possible solution could be to use some of the PSMTs who participated in the current RME-based PD to facilitate similar PD at other schools and regions to update all PSMTs' knowledge and skills.

Quality of education, as is generally interpreted as student learning and behaviour that accord with a country's policies, practices and standard of achievement, is the product of many factors that are combined in schools and in the teaching and learning process (USAID, 2011). A relevant curriculum, effective learning materials and safe learning spaces, as described in '*Toward education for All'* (MoE, 1993), are all important but it is generally accepted that the most essential contributor to quality in education is the quality of teachers and their way of teaching. '*Designing Effective Education Programs for In-Service Teacher Professional Development'* (USAID, 2011:1) states that:

> *'Teaching is arguably the strongest determinant of student learning and achievement. It is therefore important to pay attention to teacher quality and, by extension, to teacher preparation and the continuous development of teachers…'.*

In Namibia 'quality' is normally compared to 'performances of learners' which is determined by marks (Grades) achieved in examinations. In the first round of SACMEQ in 1995 Namibia's Grade 6 learners' performance was rated as second last out of seven countries that participated in the literacy and numeracy tests. In the SACMEQ 11 project of 2000 Namibia's Grade 5 learners again scored near the bottom of the by now fifteen member league. The SACMEQ 111 report of 2007, however, indicated some improvement in the performance of Namibian learners in mathematics (SACMEQ, 2011b).

In terms of learner achievement Namibia has developed a set of tests which is supposed to serve as an indicator for the school community whether the curriculum goals are achieved or not. For this reason the Namibian National Standardized Achievement Tests (SATs) were introduced in 2009 (Ferdous, 2012; MoE, 2013). These tests are means of assessment that provide diagnostic information regarding learners' achievement of key learning competencies in the curriculum in Grades 5 and 7. It is also an indicator of a school's growth from one year to the other in terms of learner achievement (MoE, 2014 a). The baseline tests for Grades 5 and 7 were implemented in 2009 for English Second Language and mathematics. In 2010 baseline tests for English Second Language, mathematics and natural science were implemented respectively. Two follow-up tests at Grade 5 level and one at Grade 7 were administered over the past three years. The Directorate of National Examinations and Assessment (DNEA) implements this census-based assessment for the SATs (Ferdous, 2012; MoE, 2014). This implies that all Grade 5 and Grade 7 learners from around 1160 primary schools in Namibia are tested. Each school principal receives a comprehensive competency-based report. The result is a report for each school indicating in detail how learners have achieved in a long list of topics. The Grade 5 mathematics report for one school is for example nine pages long. This report is meant to improve classroom instruction for better learner performance and will also serve in this study to guide the RME-based PD. The report is regarded as very valuable because it places a school's achievement in context with the rest of the primary schools in Namibia.

The SAT-report (MoE, 2014a) for 2014 (Grade 5 learners were tested in 2013; Grade 7 learners were not tested) shows that learners have improved minimally in mathematics. The school participating in the current study will eventually be compared with this report. The results in general, however, show a worrisome trend that requires a serious effort to reduce the large number of learners who continue to be classified in below and basic performance level categories. These categories will be discussed in Chapter 6. RME-based PD might be an effort to equip teachers with additional skills in order to improve learners' overall performance in mathematics.

In terms of teacher quality, PD could bring changes along (Cerbin, 2011; Coombe, Bennell, Uugwanga & Wrightson, 1999; Forde, Mc Mahon, McPhee & Patrick, 2006). Teacher quality as viewed by the majority of Namibian citizens, according to my own view, is determined by 'how well learners perform'. No research has yet been undertaken in Namibia on what teachers need for improving their teaching strategies. In my view the unrealistic teacher-learner ratio, in general 1:40, is a big challenge many teachers do not know how to handle. Even though government tries to address this problem the situation remains, especially in some of the poorer rural schools (Fischer, 2010; Kamupingene, 2002; MoE, 2004; SACMEQ, 2011).

The efficient use of the official language English remains a crucial issue in Namibian schools. This has an influence especially in a subject like mathematics. Teachers have to be able to present the mathematical content in 'rich-text' but possessing very poor English communication skills they rather stick to straight forward instructions, for example 'simplify ½ + ½'. Currently the Ministry of Education, in collaboration with the University of Namibia, is busy to review and improve teaching through the medium of English from Grade 1 onwards by providing in-service training for teachers and fully implementing the English Language Proficiency Programme (ELPP) (MoE, 2013).

A consultancy focusing on teacher demand and supply (Bennell, Sayed & Hailombe, 2008) found that only one in six students at the former Namibian Colleges of Education had opted to be trained as class teachers for Lower Primary. The same consultancy recommended that teacher training should be changed to a four-year Bachelor of Education (B. Ed.) degree in order to strive for a better balance between subject knowledge and teaching skills. The recommendation that primary mathematics school teachers should be equipped with more in depth subject knowledge and skills, were recommended in other sources as well (Clegg & Courtney-Clarke, 2009, Crebbin *et al.*, 2008; Nambira *et al.*, 2009).

The above information emphasizes the importance of a PD for PSMTs to strengthen their subject knowledge and to improve their teaching skills to be able to implement the 'new' curriculum. This study will discuss the experiences of PSMTs participating in an RME-based PD designed on the current Namibian mathematics school syllabi.

Any educational reform requires a well-developed and comprehensive PD programme to get teachers on board with new developments in mathematics teaching. For this study it is important to explain what the situation of PD for PSMTs was for the past ten years in Namibia.

2.3 PROFESSIONAL DEVELOPMENT (PD) IN NAMIBIA

2.3.1 Introduction

In my view PD is needed to help teachers to keep abreast with new developments in education. It is important to help teachers to design effective and useful learning experiences, prepare plans to guide teaching and learning, prepare useful teaching aids and to improve individual as well as school performance. However, teachers' engagement in the teaching process can be influenced by a range of varying factors (Askew, Brown, Rhodes, Wilian & Johnson, 1997; Beswick, 2008; Brodie & Shalem, 2011; Furinghetti & Pehkonen, 2002). Teachers' subject knowledge, their own experiences regarding their school background; the availability of a library and the availability of teaching aids at the school, as well as the challenges the curriculum may put to them, are some of the factors to consider in this regard.

To understand this study in context it is important to have a look at the Namibian situation regarding professional developments that have taken place over the last ten years. The results of studies that have been conducted over the last ten years will be an indicator of what necessary steps need to be taken to cater for the future.

In-service training (INSET), the term used in Namibia to upgrade professional qualifications, for formal qualifications was one of the means used to increase the number of qualified teachers to its present level in Namibia. The BETD – INSET, the Centre for External Studies (CES) at UNAM, the Namibian College of Open Learning (NAMCOL) and the Institute for Open Learning (IOL) are all assisting students and teachers in the system to upgrade their professional qualifications. However, none of these institutions pay special attention to professional development of school mathematics in particular.

The question that arises is whether PSMTs had the opportunity to attend PD activities to upgrade their subject knowledge and teaching skills. The next section will provide an overview on PD for PSMTs in Namibia.

2.3.2 Professional Development (PD) for Primary Mathematics School Teachers in Namibia

Information on PD for PSMT done in Namibia was extremely difficult to find. The teachers at the school involved in this study claim that they have never been involved in any PD initiatives. In the search for information I came across one research regarding PD for school principals, which has no relevance to this study because its focus was on the managerial skills of principals.

In 1995 the Namibian Ministry of Education participated in the Southern and Eastern Africa Consortium for Monitoring Educational Quality's (SACMEQ) foundation research programme in order to establish post-independence benchmarks for the conditions of schooling and the quality of education in primary schools (SACMEQ, 2011). The initial results were alarming as described earlier. The Ministry of Education took several important decisions related to the management and operation of primary schools system. A Strategic Plan (2001) for the then Ministry of Basic Education, Sport and Culture was prepared with the aim that:

> *'all learners should achieve basic competencies in the required subjects of the curriculum by 2005'* (MBESC, 2001; Government of the Republic of Namibia (ETSIP), 2005; SACMEQ, 2011).

This decision resulted in the launch of the Education and Training Sector Improvement Programme (ETSIP). The ETSIP initiative adopted learner achievement targets that were based on the aim of improving learners' reading and mathematics skills. There was then a collaborative effort between the Ministry of Basic Education (MoE) and United States Agency for International Development (USAID) from 2004 – 2009 in moving towards a better quality of primary education (The Basic Education Support (BES II and BES III)). According to the report of LeCzel (2004) this PD concentrated more on the use of learner-centred teaching strategies and continuous assessment techniques. This PD also concentrated only on certain regions, especially the six northern regions of Namibia. All teachers, therefore, did not benefit from this PD.

In 2006 Namibia embarked upon SACMEQ III to determine whether Namibia's Grade 6 learners were achieving more acceptable levels in mathematics and reading. There was some improvement in the performance of Grade 6 learners in mathematics between 2004 and 2007 in most regions but there were still regions that performed below the SACMEQ mean score. The improvement in learner achievement in the six northern regions can be partially attributed to the interventions taken by educational authorities during the period of 1997 – 2007 (SACMEQ, 2011). The BES Project may have played a major role in improving performance in the northern regions which is an indication that PD is of the utmost importance for teachers. This BES project mobilised collective efforts for improving the quality of education through active participation of parents, learners, teachers, advisory teachers, resource teachers, school inspectors, regional education officers and other educational role players.

The SACMEQ report of 2011 states that the task of improving the quality of education in an education system must be seen as a long-term challenge. Furthermore, it states that in Namibia, while still performing below the overall SACMEQ average in mathematics, the improvement after the intervention of the BES programme should be an indication that PD should be regarded as an on-going prospect. It will be important to see whether the numeracy teaching skills of teachers who participate in this current study have improved and how the numerical and mathematical reasoning skills of the learners will be judged by the national statistics results (SATs) of 2014.

In Namibia there is no common terminology used regarding professional development or in-service professional development programmes. In talking to various stakeholders like Mrs E. Bohn, director Programme Quality Assurance in the MoE, Mr G. Shaakwa, Education Officer at NIED responsible for staff development and Dr E. Ngololo, deputy director Continuous Professional Development Unit (CPD) at UNAM, I have noticed that the terms 'staff development' and 'in-service training' were used as synonyms. Normally the terms 'staff development' and 'in-service training' are used for short-term workshops or short courses that offer teachers information related to their work in Namibia. These are normally conducted by 'experts' (normally by subject advisors) and the teachers' roles are normally passive.

I could not find any indication of PD done with primary mathematics school teachers on a continuous basis to upgrade their teaching skills. It is also mentioned in the 8th draft of UNAM's Continuous Professional Development Unit (CPD) policy document (2012) that the current education system does not provide for continuing professional development of teachers as a key component for improving teaching and learning.

UNAM hosts two important outsourced in-service training activities of the Ministry of Education, the English Language Proficiency Programme (ELPP) and the CPD unit. The ELPP is a national scheme to improve the English competencies of teachers. All teachers in the country were tested in 2012 and placed on three levels. The intention is that courses will be offered to teachers on the two lower levels to enable them to try to improve and repeat the test until they have reached the highest level. Results from a pilot test taken in 2011 indicate that Lower Primary teachers performed the poorest in all sections of the test (MoE, 2013). The intention of ETSIP is that there should be a similar programme to update the mathematical knowledge of all teachers. Until now no mathematics programme has been developed for such an intervention. I would like to argue that this study could provide the first steps towards developing a similar programme as the one for English teachers to be developed for mathematics teachers.

To summarize, in the Namibian context CPD for teachers (and teacher educators) refers to both the organizational system of support for professional learning that goes beyond and continues after the initial pre-service programme as well as individual activities that support improvements in knowledge and practice. This study aims at finding ways to assist PSMTs to upgrade their mathematics subject knowledge and teaching skills by applying principles of RME through LS in PD.

The NPSTN (MoE, 2010:106) states the teacher competency number 27 as:

> '*Engage in own professional development and participate in the professional community*'.

It is an important competency that all teachers should pay attention too. Currently not much emphasis is given to it on a national basis, as it is also stated in the same competency that *'no state structures to support this'.*

Realizing the importance of PD the principal of the school involved in this study was very excited about the involvement of her school as a case study in this PD. In collaboration with the heads of department of the Lower Primary phase and the Upper Primary phase she identified the weaknesses and strengths in the teaching practices of the mathematics teachers at the school. Teachers need to be able to reflect on their own practice as prescribed in the key element number 3 of the competency number 27 of the NPSTN (MoE, 2006: 106). The key element requires also that the successful approaches and/or strategies of professionals should be analyzed for possible application within one's own teaching. It is within this element that the PD applying RME principles through the process of LS fits very well into the school structure.

During the first meeting with the principal of the participating school she raised the concern that PSMTs might lack the conceptual knowledge for teaching, especially in the Lower Primary phase. The possible lack of pedagogical knowledge in numeracy acquisition and their instruction on basic knowledge level could also be a factor that had an influence on the performance of the learners. She further iterated that Lower as well as Upper PSMTs will benefit from an RME-based PD since these teachers have never been involved in any PD. PSMTs need different teaching strategies to be able to overcome the significant gap of 'teacher teaches and learners sit quietly and listens'.

The findings of this study can provide guidelines how to adapt and improve PD sessions in future for all teachers to benefit from. This study will stress the effect of site-based PD and the meaningful collaboration and interaction among PSMTs and a researcher. The emphasis of the power of collegiality in site-based PD will hopefully also serve since it will be a first experience of lesson study by all participants in this study. A question that is in the mind of all teachers is how the 'new' reform changes will influence their teaching.

The revised curriculum for Basic Education will be implemented for the Junior Primary phase in 2015. The learning support materials for the Junior Primary Curriculum are in the process to be developed and evaluated. For the mathematics curriculum the material focuses on the RME approach. The national training for trainers of trainers for primary school principals took place in June 2014 (*The Namibian, 22/08/14)*.

This intensive national training of one week for Junior Primary facilitators in mathematics were facilitated by two Dutch lecturers from the Hoogeschool Rotterdam, Netherlands. The participants (trainers of trainers) at this training workshop complained that a week's training could not equip them with the necessary skills to train the Junior Primary phase teachers to be able to employ the 'new' approach.

In my view it is the teacher him/herself who needs to experience and realize the value of applying RME principles in order to be an effective implementer of this approach. It is important to mention that in Namibia Lower Primary phase teachers (Junior Primary from 2015 onwards) are not subject experts but 'generalists' that have to teach the foundation of mathematics.

In-service training for the revised Senior Primary curriculum is already planned for the first quarter of 2015. Therefore, the PD of PSMTs is evidently considered as very important. The next section will highlight the probable value of an RME-based PD in Namibia.

2.4 THE POSSIBLE VALUE OF REALISTIC MATHEMATICS EDUCATION PRINCIPLES

Very limited PD for PMSTs in Namibia took place since independence. The Ministry of Education in Namibia embarks on school reform from 2015 onwards and all phases will be implemented finally in 2022 (MoE, 2014 b). For successful implementation it is necessary that teachers are well trained to meet the demands of the new curriculum. The Namibian cabinet at its 3rd/25.03.14/001 meeting approved the curriculum reform proposals for Basic Education and the eight-year implementation period of the curriculum and it was published in all daily newspapers (*The Namibian*, 22/08/14).

One of the current challenges of mathematics education in primary schools is low performance of learners in the National Standardized Achievement Test (SATs) of 2013. A result of low achievement levels of learners could be an indication that teachers lack confidence and enough subject content to let their learners partake in the finding of solutions to mathematical problems. Teachers who lack skills to transform the mathematical content knowledge will not enable learners to form a positive and appropriate image of mathematics. The learner needs to connect the mathematics taught to real life experiences, otherwise learners will see mathematics only as a set of rules that have to be learned by heart. This aspect is exactly what RME will address. In this study participating teachers will partake in PD activities which will enable them to find suitable problems to be solved that will be relevant to learners' experiences, circumstances and interests.

In an attempt to seriously address the poor performance in mathematics the CPD Unit at the University of Namibia has developed mathematics subject material (in the form of written teacher resource books supplementing the textbooks in use) for Upper Primary mathematics teachers (UNAM, 2012b). This additional material is developed with the aim of improving the learners' performance in the SATs. However, inadequate mechanistic teaching methods including inaccurate learning materials and inadequate forms of assessment can still be possible causes of poor performance in mathematics, in my view. In order to achieve better performance by learners in mathematics I maintain that PSMTs must engage in PD to enhance not only their subject knowledge but also their pedagogical content knowledge (their teaching). Chapter 3, in which the literature review is discussed, will point out that many developed countries, such as the United States of America and United Kingdom, have embarked upon the RME approach (Menon, 2011; Romberg, 2006) to improve learners' learning and understanding.

Learners' performance in Namibia is actually only judged by 'how good or bad' they do in the SATs and in the examinations at the end of the year. The MoE usually tried to address this by adapting the syllabi.

The curriculum has been revised again and the implementation date for this curriculum will be in 2015 (Pre-primary Grade and Grade 1 only). At first it might seem as if the new syllabi have not changed as much as with the previous reform but the approach to teaching in Junior Primary phase is vastly different. The new approach is very much based on RME principles where in the past the emphasis was put on counting (mainly rote counting). The proposed approach focuses on using ten frames and emphasizes mathematics in context for example. PSMTs might not have had any experiences themselves on how to apply and implement this approach. PD in this regard can be seen as a definite need for all PSMTs.

However, teachers need to be equipped with knowledge and skills to apply RME principles in order to be able to implement the new approaches to teaching mathematics in the Junior Primary phase. Teachers for the Senior Primary phase need to know what is happening in the Junior Primary phase. If learners in the Junior Primary phase achieve the prescribed competencies in the syllabus, they will be better prepared to face the challenges the SATs demand in the Senior Primary phase. Therefore, the importance to involve all PMSTs in professional development cannot be overemphasized. This might enable PSMTs to overcome their own mathematics anxiety and equip them with more subject and pedagogical content knowledge, which will be essential to be effective agents of change.

2.5 CONCLUSION

Namibian education reform since independence has faced many challenges. Until today very little attention was paid to PD as this brief background information of the Namibian education system points out. A key objective of the Namibian education system should be to invest in human skills and special attention should be given to PSMTs professional development. I claim that PD is crucial because it will empower the PSMTs to be more effective and efficient in their classrooms.

Namibia moved from a highly fragmented apartheid system towards '*Education for All'*. Based on statistics teachers are currently considered 'better' qualified but the SATs results indicate that teachers are still not sufficiently prepared to educate the learners and to face all the changes and challenges in their profession (Kamupingene, 2002; MoE, 2013). The constant attention to and the continuous development of their subject knowledge and teaching skills are of the utmost importance not only to help teachers keep abreast of new developments and changes in their subject but also equip them with knowledge and skills in order to be confident and effective in their teaching. This can be achieved through an RME-based PD (including applying the process of LS) which will also be a new experience and challenge to them.

This case study's focus is on the experiences PSMTs have in an RME-based PD. In my view these experiences might be influenced by their 'knowledge', 'beliefs' and understanding of how learners learn and what they bring along to the PD. Therefore, the next chapter will be a literature review about professional development, lesson study, Realistic Mathematics Education and the views and beliefs of primary school mathematics teachers.

CHAPTER 3

LITERATURE REVIEW

3.1 INTRODUCTION

The research question for this case study requires a review of different but overlapping strands of literature. The main research question of this study is:

> *'What are the experiences of primary school mathematics teachers who participated in Realistic Mathematics Education-based professional development?'*

In Chapter 1 the motivation for the research and the background to the problem explained how the main research question was derived at. Chapter 1 also pointed out that teachers who lack subject and pedagogical content knowledge of mathematics could be a reason why learners' performance in mathematics in Namibia is still not at a desirable level.

The main aim of this study, as presented in Chapter 1, is that since I do not know what the Namibian primary school mathematics teachers' (PSMTs) views and beliefs are regarding mathematics teaching, I have to determine with this study whether the intervention might have a significant influence on their teaching.

Chapter 1 also provided a broad overview of how an adapted form of Realistic Mathematics Education (RME), experienced through the implementation of the process of lesson study (LS), might have an influence on these PSMTs' way of teaching. The question *'To what extent has PSMTs' teaching changed/not changed'* needs to be answered in this study.

Chapter 2 provided a historical overview of the Namibian education system, with specific reference to professional development (PD) opportunities for PSMTs. In Chapter 2 the evidence was provided that the PSMTs had limited opportunities at their disposal to attend any PD that would have given them the chance to upgrade their subject and pedagogical content knowledge of school mathematics.

The main research question indicates that 'PSMTs' experiences' will be the main data category which will be presented in the findings of this study. I reason that these experiences might be influenced by 'PSMTs knowledge' and 'PSMTs beliefs' about the ways their learners learn and understand mathematics. Concepts like RME and PD also appear in the main research question and need to be investigated.

The main research question indicates that PSMTs participating in this study will experience RME-based professional development (PD). LS will be a component of the RME-based PD activities. Through the process of research lessons (described in the sub-section LS of this chapter) PSMTs will be able to experience what they have learned/not learned in the workshop sessions, based on the implementation of an adapted form of the RME approach. I am interested in what their experiences are after a year of on-going PD. These experiences might be influenced by their knowledge (subject content), their beliefs about how learners learn and their understanding of LS.

Therefore, the purpose of this chapter is to do a critical review of the available literature regarding professional development, lesson study, RME and views and beliefs of PSMTs on PD.

As the main research question indicates this study's aim is to provide detailed information on what constitutes RME-based PD. The focus of this PD will be twofold: firstly the PSMTs will be introduced to RME principles and secondly these learned principles will then be implemented through the process of LS. Both concepts, RME and LS, are totally new to all PSMTs participating in this study.

The literature review will in the first place focus on what is known about PD and the known influence PD has on teacher knowledge and practices. It will be important to discuss information available regarding professional communities which might foster teacher learning through PD. I argue that PSMTs will bring along their views and beliefs regarding PD and mathematics teaching. A brief overview of past and future PD that has and will take place in Namibia will be given. The literature review for PD will not be complete if conditions and factors influencing PD are not reviewed as well. The review of literature on LS with reference to the impact, process, importance to teachers' and learners' learning and the future implementation of it in Namibia will be discussed as part of PD. LS, through implementing research lessons, will complement the implementation of the RME principles in the teachers' practice.

RME features very prominently in this study. Therefore, the review will indicate what the history, the principles, experiences of other countries, the didactical phenomenology and criticism for and against using the principles of RME are. Specific attention will also be given to the theory of RME as the theoretical framework for this study.

The adaptations to the theory of RME that are envisaged to suit the PD of Namibian PSMTs will be discussed in detail. Three adaptations are planned:

- ✓ To consider a broader perspective on the means of supporting learners' mathematical learning to include the organization of classroom activities while implementing RME principles;
- ✓ To apply a change in orientation that acknowledges the mediating role of the PSMTs; the goal of instructional design to develop resources that these teachers can use to achieve their instructional agendas rather than to support learners' learning directly;
- ✓ To focus on the teacher and the potential contribution of designed instructional resources as a means of supporting their own as well as the learners' learning.

The envisaged adaptations and applications of RME principles could be done through what is called 'lesson study' (LS). Briefly, LS refers to a process in which teachers progressively strive to improve their teaching methods by working with other teachers to examine and critique one another's teaching (Buhari, 2011; Cerbin & Kopp, 2006). Therefore, as I understand it, teacher learning is at the heart of LS.

In this research the implementation of RME principles in research lessons (RME principles and LS, a new experience for these PSMTs) will be conducted in primary school mathematics classrooms in Windhoek, Namibia. This is necessary to examine the feasibility of empowering PSMTs in Namibia to focus their teaching towards one that perceives mathematics as a human activity as well as to promote ideas of mathematization in learners through practical and integrated applications.

Extensive research regarding RME has been done and much has been written for and against using the RME approach (Barnes, 2005; Buhari, 2011; Cheung & Huang, 2010; Dickinson & Hough, 2012; Freudenthal, 1991; Gravemeijer, 1994a; Gravemeijer & Terwel, 2000; Hadi, Plomp & Suryanto, 2002; Ilma, 2011; Menon, 2011; Romberg, 2006; Sembiring, Hadi & Dolk, 2008; Uittenbogaard, 2007; Van de Craats, 2007; Van den Brink, 1990; Van den Heuvel-Panhuizen, 2008 & 2010; Wittmann, 2005).

However, nothing has been written about RME within the context of Namibia. I state that RME-based PD could be a possible solution to enhance PSMTs knowledge of mathematics and their skills to effectively teach mathematics to culturally and socially diverse learners. Literature on RME principles can point out whether it will be possible to address learners' learning needs and practices regarding the Namibian curriculum and the teaching strategies of PSMTs.

It would be appropriate to start the literature review with a brief overview of the nature of PD. In this study PD will have two components being, LS and RME. This is followed by a brief review of literature on PSMTs' views and beliefs from perspectives based mainly on RME principles. The scheme below of the sections in this chapter gives a systematic and visual layout of what will be discussed. Professional development is placed in the middle and will be addressed first because it is the central theme of this study. To achieve the professional development, this study made use of LS and RME.

<table>
<tr><td colspan="3">LITERATURE REVIEW</td></tr>
<tr><td colspan="3">⇩</td></tr>
<tr><td colspan="3">What are the experiences of PSMTs who participated in RME-based PD?</td></tr>
<tr><td>⇕</td><td>⇕</td><td>⇕</td></tr>
<tr><td>LESSON STUDY ⇔</td><td>PROFESSIONAL ⇔
DEVELOPMENT</td><td>RME</td></tr>
<tr><td>⇩</td><td>⇩</td><td>⇩</td></tr>
<tr><td>• Impact on PD
• Process
• Importance on teacher learning
• Influence on learners’ learning
• Aim in this study</td><td>• Teacher knowledge and practices
• Professional community
• Teachers‘ beliefs
• PD in Namibia
• Conditions and factors</td><td>• RME in context
• History
• Principles
• Experiences of other countries
• Didactical phenomenology
• RME adapted
• Theoretical framework
• Criticism against use of RME</td></tr>
<tr><td>⇕</td><td>⇕</td><td>⇕</td></tr>
<tr><td colspan="3">PSMTs’ beliefs and views about PD
• Change of beliefs
• Factors that influence beliefs
• Influence of beliefs and views on mathematics teaching
• Efficacy beliefs</td></tr>
</table>

Table 3.1: Outline of Literature Review

A two-way arrow indicates the inter-relatedness of the sections. LS and RME are new experiences the PSMTs will encounter in the PD activities. These experiences might influence the currently held views and beliefs of PSMTs.

The next section presents an overview of the nature of PD.

3.2 PROFESSIONAL DEVELOPMENT (PD)

3.2.1 Introduction

Professional development (PD) of primary and secondary school mathematics teachers is presented in relevant literature in many different ways (Avalos, 2010; Brodie & Shalem, 2011; Forde *et al.*, 2006). I understand that PD is about teachers' learning, learning how to learn and transforming their knowledge into practice for the benefit of the learners' growth. It is a complex process because it requires of the participants, individually and collectively, not only to develop cognitively and emotionally but also to be willing to critically examine their convictions and beliefs. Their willingness to accept interventions (PD) as alternatives for improvement, or even change, may enable the participants to experience PD as relevant and worthwhile.

I hold the view that RME-based PD for PSMTs is essential for efforts to improve mathematics education in Namibian schools. Educational reform initiatives currently undertaken in Namibia set ambitious aims for learners' mathematics performance. One of the reform initiatives is that every learner will have to take mathematics up to Grade 12 Ordinary Level. Many factors can contribute to achieve these aims, of which one definitely will be that PSMTs' mathematical knowledge and skills will have to improve. However, the changes in classroom practice demanded by the reform visions ultimately depend on the willingness of teachers to 'adapt' or 'change' their teaching styles and strategies. Changes of this magnitude will require a great deal of learning on the part of the PSMTs and will be difficult to achieve without any support and guidance from other stakeholders such as regional officers, school principals and mathematics teacher educators.

I reason that if this study considers PSMTs' background, experiences, views, beliefs and needs it will contribute to effective classroom practices. I am of the view that the potential is there to positively influence learners' performance if the PSMTs are equipped with the necessary subject knowledge and skills. This RME-based PD will focus on the pedagogical (how to teach; teaching practice) and subject (mathematics) knowledge of the participants. PSMTs need to have in-depth subject knowledge as well as the skills to apply proper strategies in order to enhance learners' learning. This kind of RME-based PD focus might lead to more effective PSMTs in the classroom.

A question which naturally arises is 'what constitutes an effective PSMT'? I have indicated in Chapter 2 that the Namibian community only values 'good results' and teachers are measured against these results. In the Namibian perspective an 'effective' teacher is regarded as one whose learners achieve 'good results'. This study may result in the existing views and beliefs of PSMTs being challenged about what 'effective teaching' entails.

This study aims to investigate how LS and the RME approach can be adapted and used in PD for improving the pedagogical and subject knowledge and the teaching skills of PSMTs in Namibia. The importance of PD for teachers' learning will be reviewed by consulting various literature resources.

3.2.2 The Influence of PD on Teacher Knowledge and Practices

It will be interesting to determine the influence of PD on teachers' knowledge and teaching practice in known cases. Teachers bring subject and pedagogical knowledge along to any planned PD activity. However, during a PD activity, the PSMTs' skills and knowledge should be further developed to meet the demands required by any intended form of reform. This section will in the first place focus on the role of the teacher in the 21st century in general; then it will explain how PD should be understood in the context of this study and lastly it will focus on the effectiveness of workshops as a means of PD.

The role of the teacher in general has changed over time (Forde *et al.*, 2011). In the 21st century a typical teacher is an active professional, liaising and collaborating with a number of other professionals (e.g. speech therapists, psychologists), managing not only teaching and learning in their classroom but also responsible for various other administrative issues related to a school (Forde *et al.*, 2011). Merilainen and Pietarinen (2002) state that the importance of PD for teachers is justifiably emphasized in educational discourse. Taking this into consideration, I argue that PSMTs need to be involved in PD because of the pressure they encounter, not only on national level but also on school level regarding the demands of increased quality and the impact of competition amongst teachers on the performance of their learners. It is important to pay attention to the PSMTs' needs to develop them professionally, i.e. to provide for example opportunities in which attention is paid to the RME theory and LS. This will result in an advantage not only for the PSMTs but especially for the school and the learners (Merilainen & Pietarinen, 2002).

In the search for a definition for PD in the context of this study it was evident that concepts such as continuous professional development (CPD), induction courses and in-service training are broadly described in similar terms. In this study I will use the concept 'PD' as referring to an intensive, on-going and systematic process that aims to enhance the teaching and learning of PSMTs and the improvement of the school environment (Chval, Abell, Pareja, Musikul & Ritzka, 2007; Garet, Porter, Desimone, Birman & Yoon, 2001). I interpret PD for PMSTs in a context of educational quality and as instrumental to learners' learning and for learner achievement.

To foster primary school learners' understanding of concepts in mathematics PSMTs must have comprehensive and flexible subject knowledge (Borko, 2004). I will argue that a key aim for PD is to deepen the PSMTs knowledge of school mathematics and learner thinking and also to improve classroom teaching skills. PSMTs must understand the central facts and concepts of the mathematics they teach, how ideas and concepts are connected and which processes are used to establish 'new' knowledge (Van den Heuvel-Panhuizen, 2000). These are important issues which can be taken care of during RME-based PD. This will enable teachers to develop a thorough understanding of activities they will be involved in. To guide learners' thinking teachers must also understand how learners' ideas about a certain topic in mathematics develop as well as the connection between their ideas and other important ideas in the discipline (Borko, 2004).

In the Namibian context PD has normally been conducted as short, one day workshops or in the form of in-service training for teachers based on needs perceived by subject advisors (Nambira *et al.*, 2009).

In PD the type of activity performed plays an important role. The most criticized form of PD I came across in literature is the 'one-day workshop' (Brodie & Shalem, 2011;

Clegg, 2007; Forde *et al.*, 2006; Garet *et al*., 2001; Good & Grouws, 1987). Participants who attend such sessions often have to attend them after school hours, being a normal practice in Namibia. If PD sessions are offered to PSMTs in Namibia, these sessions normally have to do with the implementation of new syllabi whereby the syllabi structures, and not so much the subject content, are under discussion. In an one-day or afternoon-session of PD (regarded as 'short' workshops) teachers will not have sufficient time to try out what they have learned; neither will they have time to discuss relevant issues of concern to them (Clegg, 2007).

However, Merilainen and Pietarinen (2002) regard that a series of well-developed workshops is a structured approach to PD that normally occurs outside the teacher's own classroom which is normally offered by a facilitator with specific expertise (in the current study by me as a researcher). Teachers will discover that they do not only participate in, but also seek out PD to continually reflect on and strive to improve their teaching practice. When having a series of workshops focusing on 'teacher knowledge and practice' it is likely that teachers might experience these workshops as worthwhile (Guskey & Yoon, 2009). Through PD activities, which include a variety of opportunities for PSMTs to explore learner thinking and plan ways to build on learners' knowledge in their mathematics instruction, PSMTs can learn about learners' conceptions and typical misconceptions about key concepts and the role these play in learning (Chval *et al.*, 2007). In PD activities PSMTs need to be equipped with knowledge related to the understanding of human development and how learners' learn.

Brodie and Shalem (2011) mention that teacher learning through PD is a complex process and is not yet well understood. PD requires cognitive and emotional involvement of teachers, individually and collectively. I am of the opinion that through on-going PD (having a series of consecutive workshops) PSMTs can be engaged in learning activities which will provide them with additional skills which they did not possess previously. Hiebert (in Garet *et al.*, 2001:917) states that:

> *'Research on teacher learning shows that fruitful opportunities to learn new teaching methods share several core features:*

(a) *On-going (measured in years) collaboration of teachers for purposes of planning with*

(b) *the explicit goal of improving students' achievement of clear learning goals,*

(c) *anchored by attention to students' thinking, the curriculum and pedagogy, with*

(d) *access to alternative ideas and methods and opportunities to observe these in action and to reflect on the reasons for their effectiveness'.*

In this study I will focus on the above-mentioned core features of PD as these PD activities might have significant, positive effects on teachers' self-reported increases in knowledge and skills and changes in classroom practice. By being involved in effectively planned PD activities the PSMTs become 'learners' themselves and this should help them in guiding learners in the same activities they will conduct in their classrooms later.

In Namibia I could not find any documentation that supports any argumentation about how PSMTs reacted to any PD done so far. Therefore, for this study it will be important to describe and to meticulously document the process of PD done with a specific group of PSMTs in order to understand the complex issues about PSMTs' learning, learning how to learn, and applying their knowledge into practice for the benefit of their learners' growth.

Several sources point out that for effective PD the teachers participating should be stimulated towards inquiry into their own teaching experience (Benner, 2010; Cerbin, 2011; Dickinson & Hough, 2012; McAleavy, 2012; Wubbels, Korthagen & Broekman, 1997). In this study the inquiry process will apply RME principles which are characterized by consecutive steps of translating a real world problem into a mathematical problem, the analysis and structuring of such a problem, the creation of a mathematical solution to the real world and the reflection on the merits and restrictions of the solution. This will be followed by a next cycle in which the translation of the problem is refined, generalized or changed (Sembiring *et al.*, 2010; Üzel, 2006; Van den Heuvel-Panhuizen, 2013; Wittmann, 2004).

I hold the view that by trying to implement the above during PD activity, the participating PSMTs pedagogical and subject knowledge will increase and that this will result in practices whereby more effective learners' learning is enhanced. In planning the RME-based PD for the participating teachers the above-mentioned assumption gave me the idea to link all the PD activities to LS which in turn would hopefully form a strong professional PSMTs community. A professional community in the context of this study, should be understood as a group of PSMTs having the same interest at heart, i.e. updating and improving their subject content and pedagogical knowledge and teaching as well as improving learners' mathematics performance.

3.2.3 A Strong Professional Community to foster Teacher Learning through PD

An aim of this study is to engage the PSMTs of one school in Namibia in a PD initiative to form a strong professional community which can share their experiences with the larger teacher community in Namibia. Teachers will be engaged in on-going PD activities that will be conducted over three school terms in 2014.

Recent literature (Garet *et al.*, 2001; Glasgow & Hicks, 2003) points out that PD is more successful if sustained over time. Successful, in this context, should be seen in the way that teachers have succeeded in their endeavours because longer PD activities provide opportunities for in-depth discussion of content, learners' conceptions and misconceptions as well as pedagogical strategies. Since PSMTs did not have opportunities to participate in an on-going PD in Namibia I am of the view that activities that extend over time are more likely to allow these teachers to try out new practices (e.g. RME) in the classroom and obtain feedback on their teaching (e.g. LS).

Literature on PD and teacher development (Borko, 2004; Cerbin, 2011) points out that if teachers have to reflect constantly on their experiences, they will share knowledge about methods they have applied, how they can apply them differently in future and how learners reacted towards the new implemented strategies. Research on teacher learning communities (Borko, 2004) typically explores features of PD programmes such as the establishment and maintenance of communication norms and trust, as well as the collaborative interactions that occur when a group of teachers work together to improve their practice (in this research done through LS). Therefore, PD can be a very useful tool to develop the PSMTs' subject as well as pedagogical content knowledge. Different sources (Borko, 2004; Brodie & Shalem, 2011; Chrzanowska, 2013; Garet *et al.*, 2001; Good & Grouws, 1987; Sifuna & Kaime, 2007) point out that a strong professional learning community can foster teacher learning and instructional improvement.

Considering the above I am quite certain that the main focus of PD should be to help PSMTs develop their teaching skills for their own as well as for the learners' benefit. In a fast changing world it is nowadays more important for teachers to engage in PD in order to find their place in the school reform, adapting and responding to changes introduced. In a climate where what it means to be a teacher, it is hard for teachers to avoid reflecting on and questioning their own roles as teachers. This implies that PSMTs should be provided with opportunities where they can regularly reflect on and discuss their teaching to address challenges they experience in their classrooms.

Research has indicated that PD can have an impact on teachers' practice and learners' learning (Askew *et al.*, 1997; Forde *et al.*, 2006; Sifuna & Kaime, 2007). These studies have shown that participation in on-going PD leads to changes in teaching practice, as teachers become aware of 'new' strategies and methods which lead to improved learner understanding. However, to engage in such PD, teachers need time to stand back from their day-to-day routine tasks, to engage with new ideas and to reflect on their practice, their own learning and their learners' learning. The best teacher learning takes place if the PD addresses mathematical knowledge necessary for teaching, engaging teachers in detailed lesson planning, predicting learners' responses and discussing their own practice. The authors Garet *et al.* (2001) state that by focusing on a group of teachers from the same school, PD might help to sustain changes in practice over time. This was an important statement I took into consideration while planning my research. I understand that teachers who teach the same Grade and/or subject might develop a common understanding of instructional aims, methods, problems and solutions. I argued that this might result in a PSMTs community sharing experiences about what works and what does not work.

I am of the opinion that if teachers experience what it means to expose learners to RME principles it can possibly ignite the long awaited improvement in both the attitude and performance of learners and PSMTs. Although the main focus of this study is on PSMTs, learners' performance will have a definite effect on the viewpoints and experiences of these teachers. If learners obviously benefit from the RME approach, teachers might be convinced to implement the approach.

In my view teachers cannot develop entirely by themselves. Hargreaves and Fullan (1992) state that teachers can learn a great deal from collegial interaction with other professional people who are knowledgeable about and who have experience of teaching and learning. They also mention that although teachers learn from both inside and outside their own school environment, they learn more from colleagues at their own working place and their own school.

Avalos (2010) reflects on the importance of understanding how teachers work together and share practices with learning purposes. She also reports on a case in which unqualified and under-qualified teachers in Namibia were exposed to Action Research for PD shortly after independence. The attention is drawn to the fact that PD is a slow and painful process. Leading teachers to critically examine their own practice is complicated and PD should always be a means to engage teachers in opportunities to update their subject knowledge and skills. This was not yet officially done for PSMTs in Namibia and this study will investigate creating teacher networks and teams, communities of practice and communities of learning as well as peer coaching.

In some literature (Borko, 2004; Forde *et al*., 2006) teacher learning is regarded as a process of participation in the practice of teaching and through this participation teachers become more knowledgeable in and about teaching. I would like to argue that teacher learning can occur through many different aspects of practice, including experiences in their own classrooms, discussions with their colleagues during breaks or staff meetings, or after school, when they have to attend to compulsory remedial teaching sessions with poor performing learners. Therefore, the possibility that PD can provide the link for collaboration, participation and reflection which can also act as a motivational factor, is an aim with this research.

However, it is important to note that teachers need to have a positive attitude towards PD in order to be willing to change their teaching strategies and views and beliefs towards mathematics teaching. The possible influence of participants' beliefs regarding PD is reviewed next.

3.2.4 A Brief Overview of Teachers' Beliefs about PD

It is important to acknowledge the relevance of the existing beliefs that teachers bring with them to PD activities. The capacity and willingness of a teacher participating in PD to examine where each one stands in terms of convictions and beliefs and the perusal and enactment of appropriate alternatives for improvement or change, does not happen in a single PD activity (Avalos, 2010).

One study reports some similar characteristics of mathematics teachers whose beliefs and practices changed most profoundly as a result of their involvement in PD (Beswick, 2008). I derived from the report that these include a desire to:

- ✓ improve their own learning
- ✓ improve learners' understanding
- ✓ improve their teaching strategies/practices
- ✓ learn something "new" that seems promising

Novice teachers should be aware that PD is not a one-size-fits-all proposition. So much advice from colleagues, some good and some bad, may be thrown at them during their first years of teaching that they need to take care not to become overwhelmed. Sometimes it would be advisable to distance themselves from veteran teachers who have been in the teaching profession for a longer time already and who may see all forms of PD as a waste of time. There will always be those teachers who have taught in the same way for the last 25 years, have not tried out new ideas or instructional strategies and cannot understand why learners today are not 'achieving'. On the other hand, coming directly out of teacher education programmes, novice teachers may think they are equipped with all the tools and knowledge they will ever need in the classroom, which is also not the case (Peters, 2006).

Avalos (2010), Clegg (2007) and Garet *et al.*, (2001) point out that PD is most successful if teachers are granted the opportunity to reflect regularly on their experiences in order to demonstrate professional growth and learning and also to what extent their beliefs have changed. To reflect regularly might also have an effect on the beliefs teachers have regarding their understanding of PD and how learners learn. I argue that if PSMTs are allowed to reflect on their own practices during PD sessions, they might for the first time realize that their colleagues experience the same or even greater challenges regarding learners' learning and understanding of mathematics.

In the current Namibian situation I did not come across any 'measures' on how to ensure that teacher learning has taken place and with whatever efforts. I could not find any documents or relevant articles on the Namibian situation where teachers' reflections regarding the effectiveness of any training that has taken place, are documented. A detailed review of literature on teachers' beliefs and views will be done later in this chapter.

Teacher unions in Namibia view PD as an important factor for reforms to be implemented successfully (*The Namibian*, 20/01/13 & 22/08/14; *New Era*, 22/09/14). Any reform effort cannot be realized if it is not accompanied by a well-developed PD (*New Era, 22/09/14*). It is therefore important to point out what role PD played in the Namibian reform efforts up to date.

3.2.5 PD in Namibia: History and Future Directions

I could only find one report by LeCzel (2004) elaborating on PD done in Namibia (Chapter 2, p. 64). However, this PD was conducted in a northern region in Namibia and its focus was on the use of English as the medium of instruction. It is a fact that the participants in this study had no opportunities to upgrade their knowledge and skills regarding mathematics teaching.

An initiative on improving education in Namibia today is providing meaningful PD for all stakeholders, not only novice teachers (MoE (NPSTN), 2006:106). In Namibia a Continuous Professional Development (CPD) Unit was established at the University of Namibia (UNAM) in collaboration with the Ministry of Education (MoE) in order to assist the teachers to improve their teaching skills in 2012. The aim of this unit is to organize teachers to get together and share challenges, problems and concerns with their peers (UNAM, 2012a). It is envisaged that teachers should realize that they are not the only ones experiencing particular questions or challenges. Literature points out that support can be as simple as giving practical suggestions for solving problematic situations in the classroom to encourage teachers to step outside their comfort zone and try a new teaching strategy (Glasgow & Hicks, 2003; Peters, 2006).

I reason that the collegial communities that emerge from such on-going PD activities and collaboration can be lifesavers to both a 'struggling' novice and a veteran teacher alike. I am of the view that teachers in Namibia will experience more than ever before the desire to participate in PD with the implementation of the new syllabi in 2015. Therefore, the importance of conditions and factors that influence any envisaged PD needs consideration.

3.2.6 Conditions and Factors influencing PD

Any worthwhile PD should be aimed at teacher learning something 'new' and worthwhile (for example RME) and the possibility of change in classroom practice. However, educational systems, policy environments and reforms, teacher working conditions as well as historic factors can determine the success of PD and also what will be accepted or not as suitable forms of PD in future. An example of the Namibian situation was that a change from teacher-centred to learner-centred instruction was introduced in the reform process after independence. No PD was conducted for all the teachers to practically experience what is meant by learner-centred education (Peters, 2006). Currently most teachers believe that their instruction is learner-centred because according to them they ask learners a lot of questions (Clegg & Courtney-Clarke, 2009). That most of these questions only require 'yes' or 'no' answers, is not taken into consideration.

Glasgow and Hicks (2003) note that PD is often done 'for' or 'to' teachers instead of 'with' or 'by' them. They argue that all too frequently this type of PD may not enhance a teacher's classroom practice because the teachers do not 'buy in' to what is offered to them. Telese (2010) is of the view that PD should be a key component in teachers' lifelong learning process. However, PD is normally considered as being fragmented and relatively superficial. A reason for this view is that PD does not connect teachers' subject and pedagogic content knowledge (Clegg, 2008).

I have experienced that some schools are more appropriate and conducive to teacher learning than others. This is supported by Telese (2010) and stems from the view of school principals that PD is an expensive endeavour and that teachers may experience workshops that do not directly address their needs, making the whole exercise a waste of time and money. Although PD can be an expensive endeavour, it is nevertheless a critical and necessary aspect of any teacher's professional life.

While education policy reforms in Namibia are supportive towards PD (MoE (NPSTN), 2006) teachers will have to find their own personal time to participate in such endeavours. Chapter 2 described that the functioning of the administrative and organizational structures makes it difficult for teachers to interact at their workplace, not even mentioning to interact with colleagues at other workstations. PSMTs have a 'full' timetable and have at the most three 'free' periods per week. PSMTs are responsible for extra-mural activities in the afternoons. Twice a week remedial teaching (i.e. 'special' classes for 'slow' learners or learners who are challenged passing mathematics tests) for the school Grade they are responsible for has to take place. This time factor has a major influence on PD and has to be taken note of while planning for activities for participating teachers.

Perera in Sembiring *et al.* (2010) reports on factors that were taken into consideration for PD in Indonesia. With slight adaptations some of these elements can also contribute to favourable conditions in Namibia. I derived that these are:

- ✓ School-based learning must be integrated with day-to-day school processes
- ✓ Participants define their needs and the PD must provide opportunities to address these needs
- ✓ Meeting individual participants' needs but these needs should be primarily collaborative
- ✓ Providing opportunities for participants to develop a theoretical understanding of the knowledge and skills learned
- ✓ Being on-going with follow-up and support for further learning.

From the PD done in Indonesia I understand that an important characteristic of a successful PD programme is that it should articulate as ‘working with’, rather than ‘doing to’ teachers. This might ensure that PD contributes to the professional growth of the participating teacher as the Indonesian study points out. From this I derive that one of the most important factors influencing PD is that it should be seen as a continuum and be built on reflective practice.

However, I contend that effective learning by teachers is increasingly influenced by the extent to which PD can optimally and meaningfully draw on teacher’s own experiences as learners, their perception of the need of learning, existing demands on their time and the rewards for such involvement. In the NPSTN (MoE, 2006:106) it states that teachers should demonstrate commitment to the quality of education and to the idea of collaboration, cooperation and collegiality. This is exactly what this study would like to promote amongst PSMTs by implementing an RME-based PD through the method of lesson study. Chapter 5 will address the concepts of collaboration, cooperation and collegiality within the context of this study.

In the next section a review of literature on how PD can effectively be implemented by using the method of lesson study is done.

3.3 PROFESSIONAL DEVELOPMENT (PD) and LESSON STUDY (LS)

3.3.1 Introduction

Recent mathematics reform efforts in Namibia motivated me as a mathematics educator at UNAM to collaborate with PSMTs at a local school in Windhoek to focus on deepening their mathematical knowledge and understanding and enriching their teaching strategies. Collaboration is to be understood in the sense that we work together to do research on their (PSMTs’) experiences in an RME-based PD.

While searching for information on how it could be done best, I came across the concept of Lesson Study (LS). Murata, Hart and Allston (2011) state that LS is a collaboration-based teacher PD approach that originated in Japan. In the late 19th century LS referred in Japan to a process through which teachers progressively strive to improve their teaching skills by working with other teachers to examine and critique one another’s teaching skills. What I have read about the process of LS has convinced me to use the concept of LS in cases where teachers implement ideas, which they have experienced while attending PD sessions in their classrooms. The next sub-section critically discusses the impact of LS on PD.

3.3.2 The Possible Impact of LS on PD in Namibia

Before considering the impact of LS on PD in Namibia a brief historical overview of LS is necessary.

LS is a collaboration-based teacher PD approach that originated in Japan (Buhari, 2011; Cerbin & Kopp, 2006; Hurd & Licciardo-Musso, 2005; Ilma, 2011; Murata *et al.*, 2011). According to Buhari (2011) LS places teachers at the centre of the PD with their interests and desire to better understand learners' learning. In Japan lesson studies are either done by teachers across a district or by teachers within a school. Teachers participating in LS immerse themselves in a cycle of instructional improvement focused on planning, observing and revising 'research lessons' (Hurd & Licciardo-Musso, 2005). I interpret a 'research lesson' as a lesson that is planned collaboratively by a group of teachers responsible for the same Grade. One teacher will then present the planned lesson.

To summarize what I have learnt from literature so far the impact of LS is:

- ✓ The initiative of a group of PSMTs to improve their teaching skills.
- ✓ Teachers, who act as observers, visiting research lesson presentations.
- ✓ The opportunity for learning for PSMTs or other participants as well as the teacher as presenter.
- ✓ The forum for discussion or sharing of experiences to improve teaching quality.
- ✓ Colleagues providing inputs from observed lessons in order to make future innovations based on the result of good planning and implementation.

Ilma (2011:2) defines LS in the Indonesian situation as:

> *'An activity carried out by a number of teachers of a certain subject in collaboration with educational experts to improve the quality and content of their teaching'.*

This definition is also applicable in the context of this study. In Indonesia LS is considered as a form of long-term teacher PD in which teachers systematically and collaboratively conduct research on teaching and learning in classrooms in order to enrich learners' experiences and improve their own teaching by applying RME principles.

According to my insight, after having read on the topic of LS extensively, this is a fruitful way for PSMTs in Namibia to learn from their colleagues. Participating PSMTs may e.g. learn from relatively formal discussions and meetings accompanying the planning. They may learn from the structured processes of feedback to review their own practice through LS. This will mean that I have to plan regular meetings to make the above possible since this will be a totally new experience for PSMTs. In Namibia teachers have never been exposed to this type of activity.

The following is a description of the process of LS which consist out of three definite stages.

3.3.3 The Process of LS

The process of LS consists out of preparation for a class, an actual class presentation and class review sessions (Buhari, 2011; Cerbin & Kopp, 2006; Hurd & Licciardo-Musso, 2005; Ilma, 2011). The preparation for the class begins with finding and selecting materials relevant to the purpose of the class and trying to include this in the lesson plan. The collaborative planning, presenting and reviewing of a lesson is called a 'research lesson'.

For the research lesson the teacher should find relevant and realistic examples. In relation to RME it would link to the six principles which will be discussed later. The research lessons, at the heart of the LS process, will be the actual classroom lesson presentations that provide opportunities for teachers to bring their ideas as well as views and beliefs about effective teaching to life as they will learn how to carefully attend to learners' learning in order to evaluate each other's lessons, the learners' as well as their own understanding about teaching and learning primary school mathematics.

From Hurd and Licciardo-Musso (2005) I understand that teachers will work together in LS to:

- ✓ Form a LS group and establish norms and procedures.
- ✓ Identify PD goals. What competencies do the teachers hope learners will have after a chapter/topic has been taught?
- ✓ Formulate aims for learners learning and long-term development. These aims have to be formulated by studying existing curricula, including the mathematics syllabi provided by the Namibia Ministry of Education.
- ✓ Collaboratively plan 'research lessons' based on immediate and long-term aims. RME principles will form an important role in planning these lessons.
- ✓ Teach the research lesson. Ideally one team member teaches while other teachers observe and gather evidence on learner learning and development.
- ✓ Debrief the notes gathered during the lesson observation and use this evidence to revise the lesson, the unit and the teacher's overall approach to instruction.
- ✓ Draw conclusions about instructional strategies and learner learning that can determine future practice.
- ✓ If desired, teach the revised lesson in another classroom in order to study and improve on it again.

The steps above can be summarized diagrammatically as follows:

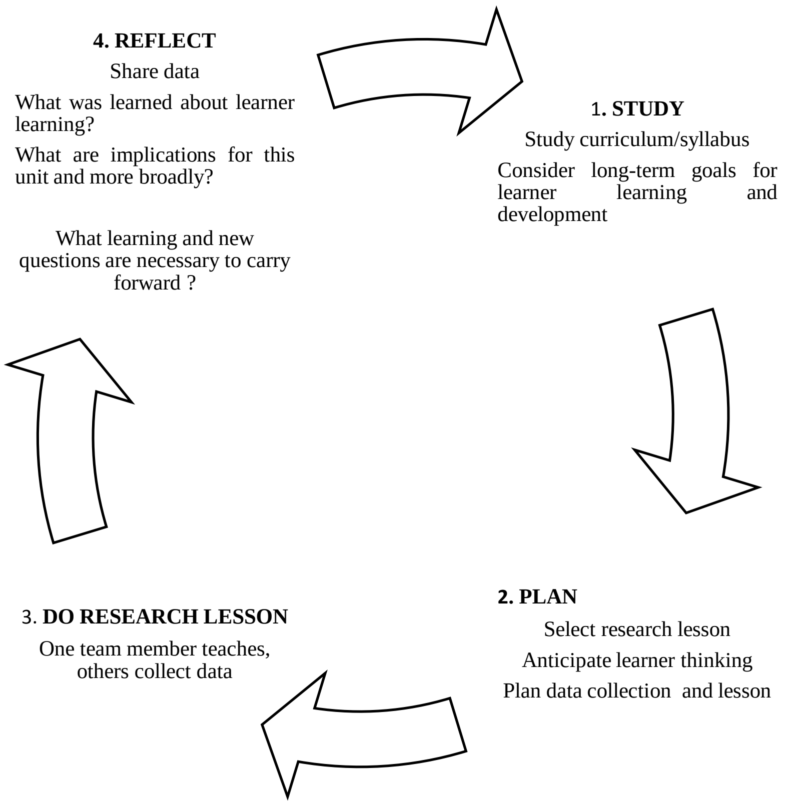


Figure 3.1: Lesson Study Cycle

Source: Hurd & Licciardo-Musso (2005:389)

In LS the focus is on what happens in the classroom between the teacher and learners (Buhari, 2011; Cerbin & Kopp, 2006; Hurd & Licciardo-Musso, 2005; Ilma, 2011). Many teachers have a few or no opportunities to observe classroom presentations or to be observed by others. Namibia is no exception in this regard. This results in an inconsistent basis for effectively changing instruction.

My interpretation is that during LS teachers collect information on the supports for and barriers to learners' learning, share data to form a picture of the learning of the whole class and use the resulting information to improve their teaching, hopefully not only for the single lesson but in their overall teaching (Cerbin & Kopp, 2006; Easton, 2009; Ilma, 2011; Lewis, 2000). It will be a challenge for participating teachers in this research to observe each other's research lessons. One reason for that might be that learners cannot be 'left alone' in class while the class/subject teacher is observing his/her colleague.

The use of 'reflective conversations' with fellow colleagues can be of great benefit (Buhari, 2011; Cerbin & Kopp, 2006; Hurd & Licciardo-Musso, 2005; Ilma, 2011). These conversations should be more than just thinking back about the lesson; they should take place with the specific purpose of improving the teacher's practice and enhancing the learners' learning.

I anticipate that by engaging in these conversations in a non-threatening environment the participating PSMTs will have the opportunity to perceive themselves through their learners' eyes. I regard PD as being effective if teachers are convinced they have learned something worthwhile. Literature can provide the background knowledge about the importance of LS during PD activities in order for teachers to experience LS as something worthwhile.

3.3.4 The Importance LS has on Teachers' Learning during PD

The importance of collaboration of teachers with their colleagues cannot be underestimated (Tobey & Minton, 2011). It is one of the most important components of any good PD for teachers.

The sharing of experiences of participating PSMTs can help give meaning, support and identity to them and their work. Physically, teachers are alone in their classrooms, with no other adult to help or assist them. Psychologically, they never are alone (Hargreaves & Fullan, 1992). The relationship between teachers and their colleagues are amongst the educationally most significant aspects of teachers' lives and work. If teachers can have meaningful discussions, involving sharing of knowledge and focus on teachers' communities of practice, they will progress academically and professionally as many sources point out (Cerbin & Kopp, 2006; Easton, 2009; Ilma, 2011; Lewis, 2000).

I interpret that LS places teachers in the role of researchers in their own classrooms through a teacher-led process of PD. I reason that LS could play an important role in PD in Namibia and should therefore be part in this study. Murata (in Buhari, 2011:2) list the characteristics of LS as follows:

- ✓ LS centres on the teachers' interests, meaning that the interests of the teachers are the central focus point. The LS goals should address aspects of the teachers' content knowledge and teaching strategies they are experiencing problems with and which they feel are important to investigate and relevant to their own classroom practice.
- ✓ LS, however, is also learner-focused. During lesson study the activities planned by the teachers should focus on learners' learning and the connection to the lesson and their teaching.
- ✓ LS is a research lesson because it is expected of teachers to share their physical observation experiences.
- ✓ LS is a reflective process because it provides time and opportunities for teachers to reflect on their own teaching experiences and learner learning. The knowledge and understanding gained from and for the reflective practice should be shared with the larger teaching and educational community.
- ✓ LS is collaborative because teachers work interdependently and collaboratively.

A question to ask then is 'what is so unique about LS'?

LS involves a backward design that starts with the clarification of the endpoint of the learning process and continues with the design of instructional experiences as described above (Buhari, 2011; Hurd & Licciardo-Musso, 2005). My understanding is that in LS teachers try to anticipate (backward design) how their learners will interpret the subject matter, what kinds of difficulties they may experience and what kind of experiences are likely to support their learning.

An important point in this case study is also about how teachers' views and beliefs influence their teaching. Their views and beliefs might possibly influence the anticipation of what can be expected from learners' interpretation of the subject matter. In the next section these views and beliefs of teachers will be described. LS plays an important role in learners' learning because while planning research lessons teachers have to be aware of connecting the mathematical content to the learners' reality and previous experiences.

3.3.5 The Influence of LS on Learners' Learning during PD

In Chapter 2 the Namibian situation around the performances of learners in primary school mathematics was described. In Namibia the issue of 'good results' and the outcome of the Standardized Achievement Tests (SATs) play an important role.

PSMTs are concerned with ways their learners learn. This I observed to be the case from my interactions with and experiences from working with PSMTs in the workshops I conducted at the Annual Mathematics Congress in Swakopmund in 2013 and 2014. PSMTs are responsible for the effective learning of their learners. I argue that LS can be an effective instrument in this regard and the influence of LS on learners' learning during PD therefore needs to be reviewed.

The concern with learners' learning throughout LS distinguishes it from other types of teaching improvement activities (Cerbin & Kopp, 2006). Literature (Buhari, 2011; Cerbin & Kopp, 2006; Cerbin, 2011; Hurd & Licciardo-Musso, 2005; Ilma, 2011) informs me that LS is worth the time and effort because not only is there the possibility of improving the teaching skills of the PSMT's but the PSMTs will assist each other in developing teaching aids for enhancing learners' learning. Through this, the teaching community, i.e. all PSMTs at a school, might be strengthened. LS focuses on classroom practices and teachers focus on how their learners learn and what kind of instructional activities support and improve learners learning and understanding. For the present study, by focussing on research lessons PSMTs might learn about learners, subject content and teaching skills without making major changes or undertaking a course revision.

I reson that PD will promote teachers' and learners' learning. It is not normal practice in Namibia that both phases, i.e. Lower and Upper Primary phase teachers participate in the same workshops. In this study the participants, both from Lower and Upper Primary phase, will attend the RME-based PD together. By involving participants from both phases at the same time, learning from each other might be a first and very worthwhile experience.

I view LS as a key component of RME-based PD in this study. The current PSMTs have not yet experienced any form of LS. It is therefore important to review the aims of LS in PD.

3.3.6 Aims of LS in PD within this Study

The process of LS, planning lessons collaboratively, presenting the lesson and reflecting on/sharing experiences on the lesson, convinced me that it should be a tool in my data collection. I reason that by implementing research lessons the participants can practice and experience the implementation of RME principles they have been exposed to during PD. The first step of considering aims for learner learning will not receive a lot of focus in this study since in Namibia the learning objectives and basic competencies are clearly described in the official mathematics syllabi.

The main ideas regarding LS can be summarized as follows:

- ✓ LS helps teachers to prepare lesson plans and develop a deeper understanding of how learners learn specific subject matter.
- ✓ It is suggested that small groups of teachers meet regularly to plan, design, implement, evaluate and refine lessons.
- ✓ One teacher, i.e. one member of the group, presents the lesson while the other teachers observe it.

After the lesson, the group discusses their observations and reflections and modify the lesson, and the same or another member presents the lesson again. I am convinced that this is an ideal situation to promote PD amongst PSMTs. In Namibian primary schools there are more than one class group per Grade level.

Therefore, in the present study my aim is to bring LS to life by detailing a case study of a primary school in Windhoek. Teachers at this school will be involved in the three steps of LS namely planning, doing and seeing. I envisage that LS can be a potential professional learning strategy which will be carried out by a number of teachers of a certain subject (in this case mathematics) in collaboration with an educational ‘expert’ (me) to improve the quality and content of their teaching. However, LS does not only refer to in-school training but it is a process by which teachers of mathematics at several schools in the same community can work together to research teaching materials, develop teaching aids and practice teaching lessons (Murata *et al.*, 2011).

I argue that it is worthwhile to examine the experience of PSMTs' co-learning through mutual collaboration and feedback, which is the Japanese model of LS. It will be a first experience for both the participants and me.

From the information gathered my focus will be on the following activities:

- ✓ If at all possible, participants have to observe each other's lessons.
- ✓ Research lessons will be planned collaboratively over an expanded period (for at least a week's mathematics periods). Participants will plan lessons for a specific Grade.
- ✓ All planned lessons focus on RME principles.
- ✓ If possible, research lessons will be recorded.
- ✓ All research lessons will be discussed.

In implementing LS, I hope to promote a process whereby the PSMTs will experience gradual and incremental professional growth through the collaborative development of lessons.

The RME theory, as discussed in the following paragraph, will be used and implemented in research lessons to determine whether participants' daily and general classroom practices have changed for the better.

3.4 PROFESSIONAL DEVELOPMENT (PD) and REALISTIC MATHEMATICS EDUCATION (RME)

3.4.1 Introduction and Context of the Present Study

The primary school learner population in Namibia represents a wealth of languages, ethnicities and cultures. The school in this study is no exception. The medium of instruction in the Lower Primary phase (Grades 1 – 4) is the mother tongue and from Grade 5 onwards it is English. The primary school in this study offers English and Afrikaans as medium of instruction (mother tongue languages) for the Lower Primary phase. However, in this school there are a number of other mother tongue speakers among teachers as well learners.

For several years already learners use the textbook '*Mathematics in Context'* (Patyus *et al*., 2000) and '*Maths for Life'* (Lategan & Silver, 2010) in Namibia. The titles of the textbooks give an indication that the mathematics taught should be in context. The reality in Namibian schools, however, looks differently. Evaluating the textbooks is beyond the scope of this study. I hold the view that having a multi-cultural and multilingual environment at all schools the textbooks are not paying attention to the learners' reality and experiences. One expects that a textbook being called 'in context' and 'for life' should address solving problems that make sense to learners and their environmental experiences. Currently mathematics education's focus to use real-life situations or contexts is receiving considerable attention globally (Van den Heuvel-Panhuizen, 2000).

RME and its underlying educational theory could be an answer to reform the teaching of primary school mathematics in Namibia. RME is 'realistic' in that learners learn mathematics through engaging in solving problems in contexts that are meaningful to them. RME originated in the 1970's at the Freudenthal Institute in the Netherlands to meet a perceived need to improve the quality of mathematics teaching in Dutch schools (Zulkardi, 2014). I have visited the Hoogeschool Rotterdam (Netherlands) several times and during these visits I realized that the primary schools there face similar challenges like we in Namibia. It therefore seems useful to explore the possibilities to implement an adapted form of RME through PD at Namibian primary schools. The reason to call it an 'adapted' form of RME is that PD in this study addresses the Namibian situation.

This section will address the sub topics displayed in the table below:

RME	• Primary school mathematics education and RME in context
	• The history of RME
	• The principles of RME
	• Experiences of other countries that implemented RME in PD
	• The didactical phenomenology of RME
	• RME adapted and implemented in PD for PSMTs in the Namibian
	• RME as theoretical framework for this study
	• Criticism against the use of RME

Table 3.2: Sub-Topics within RME Section

The above will serve as sub-headings in order to explore the advantages and disadvantages of a possibility to implement the theory of RME in PD in primary schools in Namibia.

3.4.2 Primary School Mathematics Education and RME in Context

The mathematics used and needed in the world today is not the same as was used or needed in the world a century ago – this is a statement made by Good and Grouws in 1987. The mathematics taught today, however, is actually the same as that taught many years ago, in my view. However, much more is known today than for example thirty years ago. It is now understood that learning mathematics with understanding involves more than being able to produce correct answers to routine problems.

Freudenthal's (1968) important viewpoints that mathematics must be connected to reality (in context) and that mathematics must be seen as a human activity are important in that sense that learners are still having difficulties with this school subject in the 21st century. Instructing learners to 'solve 123 + 567' makes it an 'abstract' or 'naked' problem and learners will do it in a mechanical way. The use of pocket calculators make difficult computations easier and the arithmetical skills needed of a learner today differs quite substantially from those of a learner thirty years ago, in my view.

Some authors (Barnes, 2005; Dickinson & Hough, 2012) are of the opinion that to spend time on computational exercises, like the example mentioned above, could be substituted by exercises where real understanding and learning takes place. The question that comes to my mind is 'how can real understanding and learning in primary school mathematics then take place?'

Since independence learner-centred education is prescribed in the National School Curriculum in Namibia (Ministry of Education and Culture (MEC), 1993), i.e. for the teaching and learning of school mathematics as well. Constructivism as an instance of a learner-centredness theory of learning is maybe too general to reach the classroom directly, according to Confrey and Kazak (2006). They argue that it could be that constructivism is a theory of learning rather than of teaching and that it might not be specific enough for mathematics education. Constructivism emphasizes that knowledge cannot be transferred ready-made from teacher to learner. However, Ernst (1991) argues that constructivism lacks a social dimension in which learners learn dependently. He therefore suggests a type of social-constructivism which views mathematics as a social construction that will enable learners to construct their knowledge in a social process. To link to this view Zulkardi (2014) states that the learners have to be actively involved in the learning process to be able to create their own meaning and solutions of real life problems.

In my understanding of RME, it can be an approach which can serve as a bridging theory between a constructivist and socio-constructivist theory. My understanding is that the main activity in a constructivist classroom is solving problems. Learners use inquiry methods to ask questions and can use resources to find solutions and answers. In social constructivist classrooms on the other hand, collaborative learning is a process of peer interaction that is mediated and structured by the teacher. In RME learners learn mathematics through engaging them in solving problems in context that are meaningful to them.

The focus of this research is on the experiences of teachers in an RME-based PD and the recently revised Namibian primary school curriculum (*New Era*, 22/09/14) with its emphasis on use and application of mathematics in a range of contexts, particularly in real-life situations, echoes the view of Freudenthal (1968:3) who said:

> ‘*Mathematics must be taught ‘so as to be useful’.*

The content of mathematics learning should not only include conclusions of mathematics but also the processes pertaining to the formation of these mathematical conclusions (Buhari, 2011). Different authors on mathematics education agree that it ought to be realistic, meaningful and challenging (Avalos, 2010; Barnes, 2005; Cheung & Huang, 2010; Cobb & Visnovska, 2008; Daniel, Lafortune, Pallascio & Sykes, 1993; De Lange, 1995; Dickinson & Hough, 2012; Freudenthal, 1991; Gravemeijer, 1994a; Sembiring *et al.,* 2008).

Mathematics learning activities cannot simply rely on reception, imitation and memorization (Peters, 2006). Instead, it should be a process that is lively, animating and participatory. Learners should be given room to engage in mathematical activities that are relevant and meaningful to their lives (Barnes, 2005; Freudenthal, 1978; Gravemeijer, 1994a; Haylock & Cockburn, 2008; Menon, 2011).

‘Pedagogical knowledge’ in mathematics is that kind of knowledge a teacher uses to deal with the everyday task of teaching the learners in the classroom (Clegg, 2008). It is that kind of knowledge that teachers hope to improve on when they say they want to become ‘better’ or more ‘effective’ teachers, as I have experienced at previous workshops I have facilitated at different primary schools in Namibia. I argue, therefore, teachers need knowledge and skills, the connection between teaching and mathematics, to be able to make their learners’ learning experiences valuable, in other words it should also make sense to learners why they have to take the subject ‘mathematics’. Most of the learners in Namibia perceive mathematics as difficult and boring (Nambira *et al.*, 2009; Peters, 2006). This is not surprising when one looks at the common practice of teaching and learning mathematics in Namibian classrooms (Peters, 2006). Despite major education reform efforts after Namibian independence, for example, the introduction of learner-centred education, teacher-centredness and focusing on procedural knowledge is still the norm. Teachers actively explain materials and provide examples and exercises, while learners only listen, write and perform tasks initiated by the teachers. Discussions, interaction and communication are seldom conducted (Peters, 2006).

A topic for all Grades in the Namibian school syllabi for primary mathematics education is ‘problem-solving’, mostly referred to by teachers as ‘word problems’. In the context of RME ‘problem-solving’ plays an important role because learners should always be involved in solving context problems that have meaning to them (i.e. relate to everyday experiences of the learner). PSMTs are very aware of Polya’s four principles of problem-solving, i.e. ‘understand the problem’, ‘devise a plan’, ‘carry out the plan’ and ‘look back’ (Polya, 1957). However, in Namibia currently many problem-solving activities that are in the textbooks do not relate to the daily life experience of the learners. In Polya’s (1957) principles the very first principle might already be problematic to learners (in some cases also possibly to teachers) since ‘understand’ implies that the learner (teacher) must be able to interpret the problem situation. The use and interpretation of language is a major factor that can possibly be a cause why learners are not able to ‘understand’ a problem.

A possibility for equipping learners with problem-solving skills is provided by the RME theory. The theory of RME addresses issues like involving learners in purposeful activities in a meaningful context, the social interaction as part of learning and emphasis on problem solving, to mention a few. RME as a bridging theory in Namibia seems to be very promising and needs careful consideration as an approach implemented in the professional development of PMST.

In RME mathematization plays a key role (Murata *et al.*, 2011). One reason for making mathematization a key process in mathematics education is that it familiarizes learners with a mathematical approach suitable to deal with everyday life situations. A second reason is that mathematization is closely linked to the idea of guided re-invention. The concepts of ‘mathematization’ and ‘guided re-invention’ will be described in sub-chapters separately.

The history of the theory of RME will be worthwhile to discuss for readers not familiar with RME and to understand the impact RME might have in an intervention programme for purposes of PD and teacher learning.

3.4.3 The History of RME

RME was introduced in the Netherlands by Hans Freudenthal, a psychologist, mathematician and the founder of the Dutch New Mathematics Movement around 1970 (Romberg, 2006; Van den Heuvel-Panhuizen, 2008). During his professional life, Freudenthal’s views on mathematics education contradicted almost every other contemporary approach to educational ‘reform’, for example the ‘new’ mathematics (in the 1960’s it took its starting point as the attainment of modern mathematics, especially the set theory), operational objectives, rigid forms of assessment and the strict division between curriculum research and development (Gravemeijer & Terwel, 2000). In actual fact, Freudenthal’s approaches to mathematics education can be seen as an alternative to the mainstream ‘Anglo-Saxon’ approaches to curriculum theory (Gravemeijer & Terwel, 2000). Freudenthal acquainted himself with educational and psychological traditions in Europe and the United States of America.

This section addresses issues about how RME originated and why I regard it as a possible approach to be implemented in Namibian schools. The schematic presentation below should provide a better understanding of what the history of RME in this study addresses.

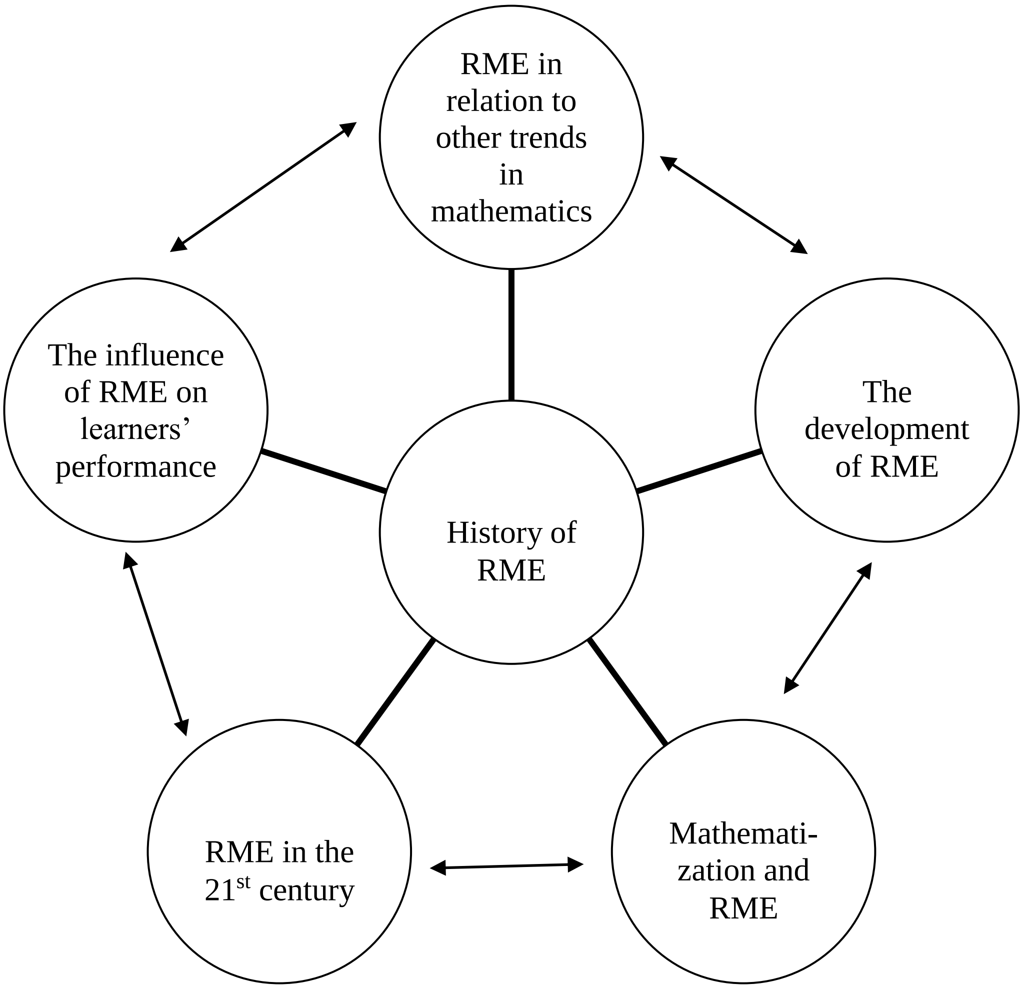


Figure 3.2: History of RME

The two-way arrows indicate the inter-relatedness of the sub-topics. Five sub-topics, RME in relation to other trends in mathematics, the development of RME, RME and mathematization, RME in the 21st century and the influence of RME on learners' learning all form part of the history and development of RME up to date.

To get a better picture of how RME originated it is important to have a look at certain trends that served and still serve globally.

- ***RME in Relation to other Trends in Mathematics Education***

In the 1960's the Netherlands wanted to abandon the then prevalent mechanistic approach to mathematics education (Barnes, 2005; Van den Heuvel-Panhuizen, 2013).

The mechanistic approach is mainly based on drill practice. This implies that learners will be presented with an example done by the teacher and then the learners apply the same rules presented to problems that are similar to the previous problems (Widjaja & Heck, 2003; Wubbels *et al*., 1997). The emphasis is on verifying and applying rules to problems that are similar to previous problems but do not necessarily link with learners' experiences. The use of context problems is very significant in RME. If context problems are used in the mechanistic approach they are mostly used to conclude the learning process. These context problems function also as a field of application, whereby learners have to apply what was learned earlier in a bare situation. To summarize, in a mechanistic point of view, mathematics is a system of rules and algorithms. A lot of attention is paid to a careful 'step-by-step' (stepwise) approach, memorizing and learning the 'rules' or 'tricks' (Brousseau & Gibel, 2005; Gravemeijer, 1994b; Romberg, 2006; Sembiring *et al.* , 2010; Van den Heuvel-Panhuizen, 2010). This approach is currently dominant in Namibian schools and it plays an important part in the Namibian mathematics education (Clegg, 2007 & 2008; Peters, 2006). In Namibian schools much attention is paid to a careful, stepwise approach. Learners have to memorize 'rules' and learn 'tricks' (Peters, 2006).

Conversely, mathematics education in England had an empiricist approach towards mathematics education (Dickinson & Hough, 2012). Typical of this type of education was that learners were let free to discover much themselves and were stimulated to carry out investigations. The empiric approach sees the world as a reality. This implies that learners are confronted with problems from everyday life in the real world. Horizontal mathematization (this term will be explained later) is applied in this approach, although learners are not prompted to come up with an own model (Zulkardi, 2014).

This method deviated greatly from the structuralist approach existing at that time, and led to the so-called New Math movement (Zulkardi, 2014; Wubbels *et al.*, 1997). I understand that in a structural approach mathematics is an organized, deductive system. The learning process in mathematics education is guided by the structure of this system and has usually nothing in common with the learners' real world. In the structuralistic view, mathematics as a cognitive achievement is an organized, deductive system and the learning process of mathematics education should be guided by the structure of the system (Wubbels *et al.*, 1997).

Learning with understanding occurs when learners are given time to discover relationships and learn to use their knowledge and when they reflect about their thinking and express their ideas. In a mechanistic approach this does not happen. Doing mathematics cannot be viewed as a mechanical performance or an activity that solely involves pre-determined rules (Romberg, 2006; Schoenfeld, 2006; Van den Heuvel-Panhuizen, 2010 & 2013).

In its search for an alternative to the mechanistic approach the Dutch (Netherlands) pursued neither the structuralistic nor the empiristic approach. It was through Freudenthal's opposition to the structuralistic 'New Math' movement that the approach later known as RME was formalised. In the realistic mathematics approach the teacher does not start with abstract principles or rules with the aim that learners should learn to apply these in concrete situations (Barnes, 2005; Widjaja *et al.*, 2003; Wubbels *et al.*, 1997). The main aim of the realistic approach is that learners should develop informal strategies and be able to make constructions themselves. In lessons learners should be encouraged to realize and identify mathematical aspects in their daily life and give meaning to problems in a real world context.

The development of the theory of RME indicates how teachers can link everyday real life experiences with school mathematics.

- ***The Development of RME***

The development of RME still continues and Freudenthal's view of mathematics as a human activity still plays a role today (Van den Heuvel-Panhuizen, 2010). Over the last twenty five years mathematics education in the Netherlands has changed considerably, shifting from a mechanistic and sometimes structuralistic to a realistic approach, both in primary and secondary education (Wubbels, *et al.*, 1997).

According to Wubbels *et al.* (1997) mathematics in the structuralistic view is seen as an organized, deductive system and the learning process in mathematics should be guided by the structure of the system. RME, on the other hand, starts from a completely different point of view. It aims at the construction of learners' own mathematical knowledge by giving meaning to problems from a real world context (Freudenthal, 1991; Treffers, 1993; Van den Heuvel-Panhuizen, 2010 & 2013).

I argue that the main difference between the mechanistic and structuralistic approaches and RME is that the latter does not start from abstract principles or rules with the aim to learn to apply these in concrete situations, nor does it focus on an instrumental type of knowledge. In RME the main emphasis is the process of constructing knowledge and principles by the learners themselves.

The purpose for providing the above background is to indicate the global trends that have influenced the development of the theory of RME. Textbooks were developed in order to supplement teaching the theory of RME in the Netherlands. This makes it easier for Dutch teachers to use the textbook as a resource in the classroom. Teachers need a textbook that complements their teaching.

The majority of textbooks for primary school mathematics that are available in Namibia are mostly based on the mechanistic approach. However, an evaluation of the textbooks is beyond the scope of this study.

The main thrust of RME is that it views mathematics as a human activity and has a central element of mathematization. It is therefore important to clarify what is meant by 'mathematization' in the theory of RME.

- ***Mathematization and RME***

The current form of RME is determined by how Freudenthal viewed mathematics. Gravemeijer (1994a) states that the main activity in mathematics education, based on Freudenthal's view of mathematics is mathematization. Freudenthal, beginning in the 1960's, formulated and developed the idea of mathematization, existing out of two components, namely the horizontal, which relates to the 'applied' aspect of mathematics, and the vertical, which relates to the 'pure' aspect of mathematics. This distinction led to the development of design heuristics that included 'guided re-invention' and 'didactical phenomenology'.

The design heuristics provided a genetic aspect to the instructional approaches and worked to capture the need for learners to strengthen their understanding of abstract ideas while linking them to practices involving the application of quantifiable knowledge (De Lange, 1996). Through a process of progressive mathematization learners are given the opportunity to re-invent mathematical insights, knowledge and procedures. Therefore, the design heuristics in RME, as I understand it, is that learners are guided in their investigations and discovery of mathematical concepts.

Treffers (1987) argued that in providing learners the opportunity to re-invent mathematical insights, knowledge and procedures in RME, it goes through stages from horizontal to vertical mathematization. He explained that horizontal mathematization involves going from the world of real-life into the abstract world of mathematics. This means that mathematical tools are used to organize, model and solve problems situated in real-life situations (Barnes, 2005; Cheung & Haung, 2010; Cobb & Visnovska, 2008; Van den Heuvel-Panhuizen, 2013). I understand that horizontal mathematization occurs when learners use informal strategies to describe and solve contextual problems or where learners come up with mathematical tools that can help organize and solve problems set in real-life situations. The content should always be presented in a meaningful and accessible context relating to the learners' real environment.

Vertical mathematization, on the other hand, is the process of re-organization within the mathematical system itself (Van den Heuvel-Panhuizen, 2010). My understanding is that it refers to the process which results in shortcuts by making use of connections between concepts and strategies.

For me, the difference between horizontal and vertical mathematization is not always clear cut. The way I understand it is:

Learning starts when the teacher asks learners to solve contextual problems. By making use of activities, i.e. horizontal mathematization, the learner uses an informal or formal model. Then, when the learners implement activities such as solving, comparing and discussing they deal with vertical mathematization, because they will find a mathematical solution to the problem. They can then interpret and discuss the solution as well as the strategy which can be used for another contextual problem. If the learners are able to do this, they use their mathematical knowledge.

In my view mathematization is closely related to level-raising, which is obtained when we do features that characterize mathematics such as generality, certainty and exactness. To clarify mathematization one should look at the following specific strategies within these characteristics (Gravemeijer, 1994a; Gravemeijer & Terwel, 2000; Treffers, 1987):

- ✓ Generalization – looking for analogies, classifying, structuring.
- ✓ Certainty – reflecting, proving, justifying.
- ✓ Exactness – modelling, symbolising and defining.
- ✓ Brevity – symbolising and schematising.

Cheung and Huang (2010) also state that mathematizing refers to various ways of organizing activities in order to exhibit characteristics of mathematics, such as generality and exactness. According to these authors it is important in the 21st century to involve learners in problem situations which are experimentally real to them in order for mathematics learning to start at and stay within reality. The crucial point is that problems are presented in a meaningful and accessible context. Problems can be presented visually through pictures, models and diagrams. Word problems with complicated ways of explaining a problem should be avoided.

To summarize the different types of mathematization (Barnes, 2005; Widjaja & Heck, 2003) mentioned so far, Treffers (1987) presented it in a table as follows (the presence shown by a checkmark):

TYPE	HORIZONTAL MATHEMATIZATION	VERTICAL MATHEMATIZATION
Mechanistic	-	-
Empiric	√	-
Structural	-	√
Realistic	√	√

Table 3.3: Types of Mathematization

Source: Barnes (2005:53)

PSMTs will have to be exposed to rich learning experiences during the PD, which will have to include mathematization in order to understand and be able to implement practices that apply realistic examples to assist learners to understand mathematical concepts.

In RME mathematization takes place in both directions by means of a re-invention process (which will be described later) that is guided by the teacher and instructional materials (teaching aids).

The background information provided so far made me think:
‘Can the theory of RME contribute to PD for PSMTs in Namibia in the 21st century?’
A brief answer to the question follows.

- ***RME in the 21st Century***

RME became known as ‘real-world mathematics education’. This was especially true outside the Netherlands but the same interpretation can also be found within the Netherlands (Sembiring *et al.*, 2010; Van den Heuvel-Panhuizen, 2010).

For many educators the term ‘realistic’ is at first confusing. The word ‘realistic’ may easily be interpreted as referring to the reality of everyday life. RME would then refer to mathematics instruction based on practical problems in the everyday life context of learners. However, the ‘real’ in ‘realistic’ is to be understood as real in the sense of ‘being meaningful’ or ‘making sense’ to learners (Sembiring *et al.*, 2010). In fact, 'realistic' is not just because of its connection with the real world but it is related to the emphasis that RME puts on offering learners problem situations which they can imagine. The Dutch translation of 'to imagine' is 'zich REALIZEren'. The interpretation of this is that the emphasis is on making something real in your mind and that gave RME its name (Romberg, 2006; Van Den Heuvel-Panhuizen, 2010).

In an RME context the learners should be able to create their own knowledge by interacting with the environment and solve problems through embedding real-life situations or contexts. The implication is that if a teacher presents content to learners, the context should always be one of the real world but this is not always possible and necessary. In Namibian classrooms learners are from different cultures and it will be difficult for a teacher to find suitable examples that link to all cultures. The fantasy world of fairy tales, the television, the radio or other Integrated Communication Technology (ICT) and even the formal world of mathematics can provide a suitable context for a problem, as long as it is real in the learner's mind (Barnes, 2005; Buhari, 2011; Cheung & Huang, 2010; Cobb & Visnovska, 2008; Dickinson & Hough, 2012; Menon, 2011).

The focus in RME is on context that focuses on the learners' everyday experiences. Therefore, it is important to point out the influence the RME theory might have on learners' learning.

- ***The Influence of RME on Learners' Performance***

The performance of the Netherlands in international comparisons of mathematical attainment has been consistently strong over recent years. Two major international comparative studies are the Programme for International Student Assessment (PISA, 2012) and Trends in International Mathematics and Science Study (TIMSS, 2011). PISA compares learners' mathematical problem solving abilities and TIMSS measures purely mathematical attainment. Learners from the Netherlands score well above average in both tests, whereas England, for example, tends to be placed among the middle group. The Netherlands use a curriculum that is based on the philosophy of RME, which is accompanied by suitably theorised on-going PD for teachers. One of the main features of this curriculum is that all the mathematics is developed through context, with a total commitment to enabling learners to 'make sense' of the subject (Van den Heuvel-Panhuizen; 2000).

With the above in mind I interpret RME as being an approach in which the criterion for a problem to be called realistic is that it should be likely that the problem can be experienced by the learners as real (in their minds) and which they find personally interesting. This can be the case with problems that arise from situations in which learners work with hands-on materials which implies that realistic problems need not always originate from learners' everyday life experience. I would like to argue that the solution of real-life problems by learners demands a higher level of cognition to get a clear understanding of the problem in terms of the information provided. Providing learners with real-life problems will demand that they will have to identify the adequacy of the information to attempt the solution, mathematical modelling, manipulation, conclusion and interpretation.

Freudenthal had a big influence on mathematics education by looking at mathematics as an educational task, which means that one should look at mathematics as a field of knowledge that is firmly integrated into culture and determined by both external (applied) and internal (pure) factors (Cheung & Huang, 2010; Wittmann, 2004 & 2005). Freudenthal maintains that mathematics has to be taught with the aim that it should be useful. To increase the applicability of school mathematics to a multitude of contexts, mathematics should be taught as mathematizing (Cheung & Huang, 2010; Freudenthal, 1973, 1978 & 1991). Richness of relationships is a postulate to which he (Freudenthal, 1978 & 1991) constantly refers which includes both structural relationships and relationships with the real world. This will ensure that learners' learning is enhanced.

A study done in three South African Development Cooperation (SADC) countries (South Africa, Swaziland and Zimbabwe) indicates that language plays an important role in interpreting real world problems (Holtman, Julie, Mbekwa, Mtetwa & Ngcobo, 2011). Learners might experience problems with the language in interpreting contextually driven mathematics, as is the case with RME. However, I would like to reason that by 'making school mathematics real to learners' the theory of RME applied in PD for PSMTs can give teachers the experience to adapt a 'new' teaching strategy that builds their understanding through explicit activities, in which language is paid particular attention to. This will familiarize them with the RME approach.

In Dutch schools teachers use realistic contexts to help learners develop mathematically. Learners are engaged with problems having to use common sense and intuition, collaboration with other learners, well-judged activities and appropriate teacher and textbook intervention. The RME approach to teaching is still applied and continues to be refined in the Netherlands (Van den Heuvel-Panhuizen, 2010).

The underlying principles of the theory of RME will be important in the implementation of PD for PSMTs in Namibia. RME as explained thus far reflects a certain view on mathematics as a school subject on how learners learn mathematics and on how mathematics should be taught. I arrived at the conclusion that RME is a theory of both learning and of teaching. This will also be clearly indicated when the principles of RME are discussed.

3.4.4 The Principles of RME

In the RME theory learning mathematics means doing mathematics, of which solving everyday life problems is an essential part (Freudenthal, 1973; Gravemeijer, 1994; Sembiring *et al.*, 2010; Van den Heuvel-Panhuizen, 2010). It is therefore of utmost importance that teachers applying RME are aware of the six principles guiding the theory.

The six principles, some of which originate more from the point of view of **learning** and some which are more connected to the **teaching** principle are described below (Cheung & Huang, 2010; Van den Heuvel-Panhuizen, 2010; Wubbels *et al.*, 1997). Each of the six principles reflects an integral part of the identity of RME. Since the PD will focus on PSMTs experiences, the focus will be on the 'teaching' part during the PD sessions (which will be described in Chapter 4).

Treffers' initial five characteristics were adapted to the following six principles: the activity, the reality, the level, the intertwinement, the interaction and the guided re-invention principles (Van den Heuvel-Panhuizen, 2010). These principles can be briefly explained as follows:

- ***The Activity Principle:*** *The use of learners' own productions and constructions* (Treffers, 1987)

The idea of mathematization clearly refers to the concept of mathematics as an activity which Freudenthal (1973) argued could best be learned by doing (Van den Heuvel-Panhuizen, 2013). The learners should be actively involved in the learning process and should be treated as active participants in the educational process. Learners should develop all sorts of mathematical tools and insights by themselves.

It is a wrong assumption to think that mathematics can be placed in a framework and then be transferred directly to learners (Cheung & Huang, 2010; Menon, 2011; Van den Heuvel-Panhuizen, 2010). The activity principle implies that learners should be confronted with problem-situations in which they can gradually develop their own strategies based on an informal way of working. Learners' 'own production' plays an important role.

The teacher, however, should facilitate learning in such a way that each individual learner can develop his/her own algorithmic way of solving the mathematical problem. Learners are challenged to develop their own strategies for solving real life problems and are encouraged to discuss these with other learners. However, finding solutions to real-world/life problems is not the end. Teachers should guide and help learners to develop their informal strategies into more formal approaches which they will be able to use later in similar situations (Treffers, 1987).

This principle advocates that learners should have the opportunity to produce more concrete objects themselves in order to develop their own informal problem solving strategies. However, the teacher has to make sure that the learner's strategy is correct, though different from what is for example used in the textbook. The interaction among learners and between learners and teacher is an essential part of RME because discussion and collaboration enhance reflection on the work (Cheung & Huang, 2010; Gravemeijer, 1994b; Menon, 2011; Sembiring *et al.*, 2010; Van den Heuvel-Panhuizen, 2013; Widjaja & Heck, 2003). In interactive instruction learners are engaged in explaining, justifying, agreeing and disagreeing, questioning alternatives and reflecting.

In this study the emphasis will be placed on the fact that learners should be actively involved in their learning. My understanding of this principle is that learners could for example be involved in producing 'fraction strips' (Appendix P3, p. 461), i.e. own production, and gradually develop an algorithmic way of multiplication of fractions starting from an informal way of working. However, this principle always has be linked to the 'reality principle' because the 'own production' should link to the learner's reality.

- ***The Reality Principle:*** *The use of context* (Treffers, 1987)

This principle emphasizes that RME is aimed at making learners capable of applying mathematics. This application of mathematical knowledge is not only considered as something that is used at the end of a learning process but also at the beginning (Van den Heuvel-Panhuizen, 2010). A teacher must start with rich context that requires mathematical organization, meaning context that can be mathematized which is context that includes horizontal and vertical mathematization (Cheung & Huang, 2010; Freudenthal, 1978; Menon, 2011; Van den Heuvel-Panhuizen, 2010).

The general aim of mathematics education in Namibia is that learners must be able to use their mathematical understanding and tools to solve problems (MoE, 2005a, 2005b & 2005c). In RME terms it means that learners must learn 'mathematics as being useful' (Menon, 2011). Even during the early years of RME it was emphasized that if learners learn mathematics in an isolated way, separated from their everyday experiences, it will quickly be forgotten and the learners will not be able to apply it (Menon, 2011; Treffers, 1987). While working on context problems (that make sense to the learner), the learners can develop mathematical tools and understanding.

The importance of using real context that is meaningful and natural to learners as a starting point for their learning cannot be overemphasized (Cheung & Huang, 2010; Menon, 2011; Van den Heuvel-Panhuizen, 2010; Widjaja & Heck, 2003). This will enable learners to become immediately engaged in a learning situation. The phenomena in which the concepts appear in reality can be taken as anchoring points for concept formation (Cheung & Huang, 2010; Widjaja & Heck, 2003). It is important to remember that the 'reality' should not only be understood as problem situations from real life or the real world, but also as situations that are experientially real to learners or to something real in their minds.

To summarize, according to my interpretation in this principle context problems and real-life situations are used to constitute and to apply mathematical concepts. This principle in general aims to achieve that learners are 'realizing' their own ideas. Following their own ideas, experiences and imaginations, learners create visual or mental situations matching mathematical tasks assigned to them. This 'combination' of learners' different ideas, languages and mathematical models is called 'realistic context' (Van den Brink, 1990).

- ***The Level Principle:*** *The use of models* (Treffers, 1987)

In the process of learning mathematics learners pass through various levels of understanding (Van den Heuvel-Panhuizen, 2010 & 2013). This principle implies that a learner develops through stages, from the:

> *'Ability to invent informal context-related solutions, to the creation of various levels of short-cuts and schematisations, to the acquisition of insight into the underlying principles and the discernment of even broader relationships'* (Van den Heuvel-Panhuizen, 2013:5*).*

I understand that an important characteristic of RME is that it is closely related to mathematizing, i.e. the level principle. As the word 'level' indicates, learners pass through different levels of understanding in which mathematizing can take place. My understanding is that from devising informal context-connected solutions learners will be able to reach some level of schematisation. This will give the learner insight into general principles behind a problem which enable them to see the overall picture. My understanding is that learners will acquire insight into how concepts and strategies are related by reflecting on the activities they have conducted. This reflection can be elicited by interaction (Menon, 2011; Van den Heuvel-Panhuizen, 2013).

Van den Heuvel-Panhuizen (2013) states that the level theory of learning of Freudenthal is derived from the observations and ideas of Van Hiele's five levels of geometric thinking (visual, descriptive, abstract, formal deduction and mathematical rigor)(Mc Leod & Gythrie, 2010).

Considering the information above I understand that models serve as an important device to bridge the gap between informal, context-related mathematics and more formal mathematics. Firstly, learners develop strategies closely connected to the context. Later, certain aspects of the context situation can become more general, which means that the context acquires the character of a model. This results in giving support for solving other related problems. In the end these models will give learners access to more formal mathematical knowledge. In order to bridge the gap between the formal and informal level, models shift from a model 'of' a particular situation to a model 'for' all kinds of other equivalent situations (Cheung & Huang, 2010; Menon, 2011; Van den Heuvel-Panhuizen, 2013).

An important requirement for having models functioning in the way mentioned above, is that they are rooted in concrete situations and that they are useful for higher levels of mathematical activities. This means that the models will enable learners to access the formal mathematical knowledge organized as a discipline. Models provide learners with a foothold during the process of vertical mathematization without obstructing the way back to the source (Cheung & Huang, 2010; Cobb & Visnovska, 2008; Ilma, 2011; Menon, 2011; Van den Heuvel-Panhuizen, 2013).

I would like to state that the strength of this principle is that it guides growth in mathematical understanding. There is a strong focus on the relation between what has been learnt earlier and what will be learnt later.

In Namibian schools the number line is often used as an example for applying the four basic operations. The number line can serve as a powerful example in the way that in Grade 1 learners can practice all kinds of counting on a beaded string ('model of'). In higher Grades this beaded string becomes the empty number line supporting addition and subtraction for example ('model for').

The topics in the primary mathematics school syllabi should not be seen as 'separate' identities, but rather as complementing each other. This leads to the following principle.

- ***The Intertwinement Principle:*** *The intertwinement of various learning strands* (Treffers, 1987)

When visiting primary schools in Rotterdam in the Netherlands and looking at textbooks used I realized that it is a characteristic of RME that mathematics as a school subject is not split into distinctive learning strands. It means that within mathematics the chapters cannot be totally separated. Topics in the primary phase like number sense, mental arithmetic and estimation are for example closely related.

The philosophy of RME advocates that various mathematical topics should be integrated. Learners should develop an integrated view of mathematics as well as the flexibility to link to different sub-domains and/or to other disciplines (Van den Heuvel-Panhuizen, 2000; Widjaja & Heck, 2003). This will enable the learner to view mathematics as being 'real life'.

My understanding of this principle is that if learners have to solve problems, they have to be able to apply a broad range of mathematical tools and understanding. Van den Heuvel-Panhuizen (2013) mentions that the strength of this principle is that it renders coherency to the curriculum in terms of the Dutch school curriculum.

In this study this principle can be implemented in different parts of a prescribed mathematics topic like for example 'number concepts'. In number concepts, for example, topics like 'number sense', 'mental arithmetic', 'estimation' and 'word problems' are closely related.

The following principle will provide information about how learners can benefit from sharing their ideas and experiences with one another.

- ***The Interaction Principle:*** *The interactive character of the teaching process* (Treffers, 1987)

In RME mathematics learning is regarded as a social activity. While keeping the whole class together, problems which can be solved at different levels of understanding are presented to learners (Cheung & Huang, 2010; Cobb & Visnovska, 2008; Menon, 2011; Van den Heuvel-Panhuizen, 2013).

A concern I had while reading the views of different authors on this principle was that in a learner-centred environment all learners will not be able to follow the same track and be on the same development level at the same time. However, this principle offers learners opportunities to share their experiences, their strategies and interventions with each other (Van den Heuvel-Panhuizen, 2013). Keeping learners involved in interaction with each other can result in learners being reflective, which can lead these learners to a higher level of understanding.

I argue that learners can get ideas for improving their strategies, by listening to what others find out and discuss with them these findings. Since the PSMTs in this study will be ‘learners’ themselves, they will experience this principle as very helpful. By solving problems the PSMTs will quite possibly experience that these problems can be solved differently and on different levels of understanding.

This principle will be helpful for PSMTs since they have to guide learners who did not derive at the correct answers. This principles leads to ‘guided re-invention’.

- ***The Guidance Principle*** *(guided re-invention)*

One of Freudenthal’s key principles for mathematics education is that it should give learners the opportunity to ‘re-invent mathematics’ (Van den Heuvel-Panhuizen, 2010). My understanding of ‘re-invent’ is that the teacher has a crucial role in how learners acquire mathematical knowledge. This implies that the PSMTs will have to steer the learning process by providing a conducive learning environment in which the process of mathematical knowledge construction can emerge.

Gravemeijer (1994a) notes that the main points of RME are 'guided re-invention', 'didactical phenomenology' and 'emergent models'. For this reason Van den Heuvel-Panhuizen (2010) added to Treffers' five RME principles a sixth one, the guidance principle. This is referred to as the 'guided re-invention' principle in RME.

This guided re-invention principle surfaced in response to 'teaching mathematics as a ready-made system', where the end results of the work of mathematicians are taken as the starting point of school mathematics teaching. This principle puts emphasis on mathematics as a process in which learners learn mathematics in activities guided by their teachers or their peers (Sembiring *et al.*, 2008).

It is therefore important for teachers to provide learners with learning environments in which guided re-invention is possible. Learners need room and tools to construct mathematical insights by themselves. It is important to note that this principle, on the learning side, aims at allowing learners to regard the knowledge they acquired as their own personal mathematical knowledge for which they have been responsible for. On the teaching side, teachers should provide learners with opportunities to develop their own mathematical knowledge. For this reason this principle is inspired by informal solution procedures (Gravemeijer & Terwel, 2000). The informal strategies of learners can be interpreted by teachers as anticipation of more formal procedures or methods. In such a case 'mathematizing' similar solution-procedures constitutes the re-invention process (Gravemeijer & Terwel, 2000).

This principle implies the importance of a route to learning that has to be mapped out by the teacher. This will enable learners to find the intended mathematics knowledge or skills by himself or herself. To do so the teacher imagines a route along which learners will be able to find a solution. In this principle the emphasis is on learning and not so much on inventing as such (Freudenthal, 1991).

All six of the above-mentioned principles will be applied and implemented in the PD sessions during the workshop sessions and in the research lessons in this study. The research lessons will provide valuable data regarding the teaching and learning principles regarding the PSMTs' experiences in applying and implementing the RME approach in their classrooms.

From the literature review I derive at the following schematic presentation of the six principles which indicates which principles are regarded as teaching principles and which as learning principles:

RME Principles

Teaching principles
- Reality Principle (the use of context)
- Intertwinement Principle (various learning strands)
- Guidance Principle (guided re-invention)

↕

Learning principles
- Activity Principle (how learners can use their own productions and constructions)
- Level Principle (the use of models)
- Interaction Principle (interactivity in teaching process)

Figure 3.3: Indication of Teaching and Learning RME Principles

For PSMTs participating in this study it will be a 'first experience' to get involved with RME-principles. It is therefore important to be aware of the experiences of other countries which have implemented the RME-approach in their curriculum or who applied it in PD activities.

3.4.5 Experiences of other Countries that have implemented RME in PD

Learners and teachers in South Africa experience similar challenges concerning mathematics education as in Namibia. Several researchers investigated the possibility of adapting and applying the RME approach in South Africa (Barnes, 2005; Julie, 2004; Ndlovu, 2014; Whittles, 2008). Ndlovu's (2014) research was based on the effectiveness of a teacher learning programme. RME was researched in PD for teachers, focusing on secondary school teachers (Ndlovu, 2014; Whittles, 2012) and on low attaining learners in mathematics (Barnes, 2005), as well as on implementing RME in the school curriculum (Julie, 2004).

A study done in three Southern African Development Cooperation countries ((SADC) South Africa, Swaziland and Zimbabwe) indicated that the learning context for mathematics education of the youth reflect trends of affective orientation to everyday life phenomena in which they are immersed (Holtman *et al.*, 2011).This SADC study (Holtman *et al.*, 2011) indicates one issue that is inherent in real-world problems namely the issue of language complexity. These researchers point out that, nevertheless, RME looks very promising and it could be a solution to put more emphasis on it in the school curriculum to enhance learners' learning. For this study it will be important to remember that language plays an important role in applying real-world problems since participating teachers in this study speak different mother tongues.

The RME theory has been used in several schools in the United States of America (USA) as part of a collaborative project called Mathematics in Context (MiC), between the Freudenthal Institute, the Utrecht University and the University of Wisconsin (Sembiring *et al.*, 2008). The data collected in this project indicated that learners' achievement in national tests afterwards greatly increased.

Cobb and Visnovska (2008) also indicate the positive influence of RME on supporting learners' mathematical learning as well as the influence on classroom activities and the nature of classroom discourse in the USA. These two authors also indicate that RME plays a role in the teacher's mediating role and the goal of developing instructional resources that teachers can use to achieve their instructional agendas, rather than to support learners' learning directly. The report also focused on certain adaptations they have made to the RME approach. This helped me in preparing the afternoon sessions for the participants in Namibia, because RME is a 'new' approach to Namibian teachers. The adaptations in the USA involved the broadening of teachers' learning in designing instructional tools that supported learners' learning as well as organizing classroom activities; the critical role of teachers as co-designers of classroom activity systems and lastly the demands of the envisioned role for the teacher and concerned supports of teachers' learning. The report emphasized the importance of on-going PD for teachers in order to develop subject knowledge as well as to improve teaching skills.

Another research (Searle & Barmby, 2012) reports on a pilot project at the Manchester Metropolitan University (MMU) in Great Britain where researchers used MiC materials (textbooks developed in the USA) with the aim to train teachers to use them in a project based in some schools in the United Kingdom (UK). The researchers found that many teachers who participated in the project embraced RME and generally successfully put its principles into practice. However, they mention that teachers need on-going support to be able to meet with each other and to support trainers and researchers to share and discuss their experiences of the RME approach. In many schools in the area where the pilot project took place there was a mixture of 'RME teachers' and more 'traditional' teachers (being teacher-centred and having a specific objective to be met and a lesson plan to follow.) This is an important fact I have taken note of. I would like to argue that in order to support a network that may bring in other teachers 'new' to RME, it would seem essential for the successful development of RME-based PD.

Research done in the UK (Dickinson & Hough, 2012) indicates that for committed teachers who believe in the approach RME is very successful. However, there are still a number of teachers who still favour their traditional approach. Thus, for teachers to develop effectively and to involve more teachers, a support network that can offer initial training and on-going RME-based PD is essential. In Namibia's situation I could imagine that more lecturers of the Faculty of Education of UNAM who are convinced of the RME approach could become involved in the implementation of the RME approach.

I also consulted reports from China (Cheung & Huang, 2010), Korea (Kwon, 2002) and North and South Ireland (Moffett & Corcoran, 2011). These three countries implemented RME in PD experimentally to determine the possibility of on-going PD in RME or even to implement it in their school curriculum. The research done on secondary school teachers in Korea indicated that through conceptualising RME perspectives to the learning and teaching of mathematical concepts (in this study it has been 'differential equations') learners were engaged in instruction that supported re-inventing conventional representations out of a mathematizing experience and the 'new' concept could emerge for the mathematical activities. This research also points out that students in Korea specifically might more readily adapt their well-developed manipulative skills to experientially real situations with the incorporation of the RME instructional design. In the report I could not find a clear-cut reason for this finding. Researchers in Ireland (Moffett & Corcoran, 2011) and China (Cheung & Huang, 2010) came to similar conclusions that RME should be considered as a promising approach which could serve in the national curriculum. They also emphasize the opportunities for teachers to engage in RME-based PD activities.

Inspired by the philosophy of RME a group of educators in Indonesia developed an approach to improve mathematics learning in Indonesian schools. This approach is known as the 'Pendidikan Matematika Realistik Indonesia' (PMRI), which is an Indonesian adaptation of RME (Sembiring *et al.*, 2008). The mathematics education reform in Indonesia has had a definite positive influence on teachers' teaching skills, because it has put new emphasis on the way of thinking about the purpose and practice of school mathematics (Sembiring *et al.*, 2008). It is a common belief in Indonesia that the objective of teaching and learning mathematics is to develop learners' reasoning and logical ability. Therefore, one of the major concerns of the teachers there is how to make mathematics lessons relevant to learners dealing with everyday problems.

I have a special interest in the Indonesian study since it implemented RME-based PD through LS while reforming their mathematics education (Ilma, 2011). In Indonesian mathematics education many obstacles for applying RME principles were experienced (Sembiring *et al.,* 2008). Sembiring (2008) and his colleagues report that for more than three decades a teaching-as-telling method influenced learners' attitudes in Indonesia. Learners were expected to learn mathematics in passive ways and some hardly learned it all. Therefore, a transition from a more traditional (teacher-centred) towards a problem-based reform approach implies a major and complex transformation. The role of the teacher will consequently need to change from an authoritarian, instruction-oriented orientation towards a more supportive learner-centred approach. This could only be achieved through PD. I am convinced that in Namibia the same scenario will be repeated.

However, it is documented that RME had many positive impacts on the teaching-learning process in the classroom in Indonesia. The differences in the learning behaviour of learners and teachers paying attention to reasoning skills, planning creative activities demonstrated that RME is a potential approach for teaching and learning mathematics (Hadi, 2002; Ilma, 2011; Sembiring *et al.*, 2008). However, these researchers point out that in realizing teachers applying the RME approach, appropriate on-going teacher PD is needed in order to ensure that 'local' relevancy will be obtained. I would like to argue that many challenges that were faced by teachers in Indonesia who were involved in an RME-based PD must be considered when planning for the RME-based PD sessions for PSMTs in Namibia. Studies done in Indonesia (Hadi, 2002; Ilma, 2011; Sembiring *et al.*, 2008) point out that if teachers are actively involved in developing their own teaching material, they experience a sense of ownership and they recognize that their learners' classroom experiences of the materials helped them to avoid standard difficulties. This appears to me a particular advantage of the bottom-up approach characteristic of the PMRI movement. Efforts that are needed in Namibia should not be underestimated, since the notion of what is good mathematics education ('good results') has to change and RME-based PD can be the main agent of this change.

For the participating PSMTs it is important to experience RME developed activities since it might be that for the first time they are exposed to such an approach. The didactical phenomenology of RME will concentrate on the detailed description of such conscious experiences.

3.4.6 The Didactical Phenomenology of RME

I derived from Gravemeijer (1994a) that according to the didactical phenomenology, a given mathematical topic is to be investigated for the following reasons:

- ✓ The kind of applications that have to be anticipated in instruction, have to be revealed.
- ✓ The suitability as points of impact for a process of progressive mathematization has to be considered.

If mathematics is seen as historically having evolved from solving practical problems it should be reasonable to expect to find the problems which gave rise to this evolving process in present-day applications (Van den Heuvel-Panhuizen, 2013). Formal mathematics came into being through a process of generalising and formalising situation-specific problem-solving procedures and concepts about a variety of situations.

In mathematics education the focus is very often on mathematics as a closed system (Barnes, 2005; Cheung & Huang, 2010; Cobb & Visnovska, 2008; Van den Heuvel-Panhuizen, 2013). However, organizing phenomena by means of progressive mathematization, meaning by considering mathematics as a human activity, seems to become more important in the learning of mathematics (Freudenthal, 1973 & 1978; Gravemeijer, 1994a).

I understand that in RME the didactical phenomenology principle is concerned with finding contextual problems and situations that allow generalizations and provide a basis for linking solutions to concepts or ideas in mathematics. Therefore, the aim of the RME didactical phenomenology is to find problem situations for which situation-specific approaches can be generalized and to find situations that can evoke solution procedures that can be taken as the basis for constructing formal mathematics.

According to Freudenthal (1978) subject matter in which learners are presented with 'ready-made' mathematics (in other words it does most of the times not link to the experience of the learner) is an 'anti-didactic inversion' (Barnes, 2005; Cheung & Huang, 2010; Cobb & Visnovska, 2008; Van den Heuvel-Panhuizen, 2013). I understand that this implies that 'events' are upside down for a learner if a teacher starts by teaching the result of an activity rather than teaching the activity itself. In Freudenthal's view a learner should be given the opportunity to 're-invent' mathematics with the guidance of the teacher. The teacher should be able to present the learner with situations which relate from most elementary experiences but will lead to more complex structures as the learner gets more experienced. Mathematical knowledge can thus never be transmitted top-down in a 'ready-made' form (Wittmann, 2005).

I understand that the phenomenological theory of RME has its point of departure in the practice of education and teaching and not in the transmission of mathematics as a pre-formed system. Freudenthal proposes the use of phenomenological-rich situations (Gravemeijer & Terwel, 2000). Situations should be selected in such a way that they could be organized by mathematical objects which the learners are supposed to construct.

In such envisaged workshops participants will understand that for example to explain fractions as a mathematical concept learners must be confronted with situations where the phenomena have to be organized by fractional parts (e.g. a piece of wood cut into different sizes). The aim of a phenomenological investigation is to find problem-situations from which situation-specific approaches can be generalized and to find situations that can evoke solution-procedures for vertical mathematization (Gravemeijer & Terwel, 2000).

With the above information in mind, it will be important to focus on the following important questions during the RME-based PD:

- ✓ What is to be taught in a mathematics lesson?
- ✓ What is the purpose of the topic in the syllabus?
- ✓ Who must be taught and why?

Therefore, in this research the aim of the didactical phenomenology will be to find problem situations for which situation-specific approaches can be generalized and provide a basis for linking solutions to concepts or ideas in mathematics. Learners should be able to make sense out of the lesson presentations by actively re-constructing the content in personal terms. Participants will be engaged during the preceding planning sessions in activities which will give them ideas and experiences to develop and design real life experiences in order to promote learner understanding.
The next section reviews information of how a possible RME-based PD for Namibian PSMTs could be developed for future use.

3.4.7 The RME Theory Adapted and Applied in PD for PSMTs

RME has the basic idea that each individual learner should discover mathematical structures in his/her own living environment and should then create a personal conception of mathematics. According to Freudenthal mathematics must be connected to reality, stay close to the learners' experience and also be relevant in society in order to be of human value (Romberg, 2006, Sembiring *et al.*, 2010, Van den Heuvel-

Panhuizen, 2013). Instead of seeing mathematics as a subject to be transmitted, Freudenthal emphasizes the idea that mathematics should be seen as a subject of human activity. Freudenthal's credo (Freudenthal, 1973, 1978 & 1991; Van den Heuvel-Panhuizen, 2013) is that mathematics is to be perceived as a human activity which will result in a phenomenological theory of mathematics education which is RME. This implies that RME has its point of departure in the practice of education and teaching and not in the transmission of mathematics as a pre-formed system. This is important in that it is a first instance where teachers will have to adapt their teaching strategies accordingly.

My understanding of the above is that in school mathematics the emphasis should be on 'activity'. Learners should be given the opportunity to find out why a given technique works, invent new techniques and justify assertions (Menon, 2011; Romberg, 2006; Sembiring *et al.*, 2010). Mathematics lessons should provide learners with 'guided' opportunities to 're-invent' mathematics by doing (Cobb & Visnovska, 2008; Sembiring *et al*., 2010, Van den Heuvel-Panhuizen, 2013). Mathematics as a human activity is therefore not only an activity of solving problems and looking for problems but it is also an activity of organizing subject matter. Therefore, a teacher must realize that it is his/her responsibility to make sure that activities are organized in a way which will have mathematization as the end result. The organization of activities is central to Freudenthal's conception.

Currently, however, mathematics education is endangered by both a growing specialisation within mathematics and a too strong swing of the pendulum towards application within the school set up. I found during my school-based visits that in primary school mathematics classrooms learners are driven by 'step-by-step' (stepwise, i.e. mechanistic approach) rules in order to achieve the learning objectives. RME as described earlier supposes a certain different view on mathematics as a school subject, i.e. on how learners learn mathematics and on how mathematics should be taught.

In this study the PD sessions will focus on the theory of RME and the issue of mathematization by learners through practical and integrated applications will be discussed. RME principles are not known by PSMTs in Namibia. It will be a 'first' experience to the teachers to participate in an RME-based PD. Therefore, to be successfully implemented teachers (participants) will have to experience situations similar to those their learners' will experience. I reason that if participants experience themselves that their understanding of subject content matter has increased they might be motivated to implement the RME approach in their teaching. In the workshop sessions RME material will for example be distributed and developed that makes use of the context that is experimentally real to their learners. This might convince the participants that it can increase learner motivation towards mathematics. The participants might also be more capable of guiding learners from the real level to the abstract level of mathematical concepts by applying the distributed or self-developed teaching aids.

In designing learner activities in the PD sessions, participants will be guided by the six principles Van den Heuvel-Panhuizen (2010) has developed, namely the activity, reality, level, intertwinement, interaction and guidance principles.

A description of how these principles can possibly be adapted and implemented follows below. This is necessary since the sub-research questions require that the planned intervention is informed by already existing knowledge about RME and how I can most effectively facilitate the planned RME-based PD.

To remind the reader, the sub-research questions of this study are:

> *'How can RME principles and LS contribute to the PD of PSMTs?'*
>
> and
>
> *'What are the PSMTs' views and beliefs about mathematics teaching (also in relation to RME-based principles)?'*

- **Activity Principle**

During the envisaged PD the link between the constructivist theory and the theory of RME will be mentioned throughout lesson study. Amongst the ten key principles for effective PD designed to improve teachers' practice Leu and Ginsburg (2011) recommend using teachers as participants in classroom activities to model desired classroom approaches in order to project clearer visions of the proposed changes.

Therefore, participants will have to assist each other during the PD sessions in designing activities for the relevant content applicable to the Namibian context. I can then examine the feasibility of empowering teachers to focus their teaching towards one that perceives mathematics as human activity.

- **Reality Principle**

This principle emphasizes that RME is aimed at having learners to be capable of applying mathematics (Van den Heuvel-Panhuizen, 2010). In RME, it is the context that makes activities effective.

In the planned PD, attention will be given to find relevant context for the content participants will have to teach in the weeks which follow the PD. Participants will experience that the context problems function as a source for the learning process. While working on context problems, learners can develop mathematical tools and understanding. At first, learners will develop strategies closely connected to the context. Later on, certain aspects of the context situation will become more general and will lead to a model which can give support for solving other related problems. Participants will experience in the workshops how context for learners can be created by:

✓ Using the existing prescribed textbook to find relevant context to describe some problem situations;

✓ Putting learners in context situations which they have to solve (relevant for addition, subtraction, multiplication and division);

✓ Providing pictures of problems/situations which have to be solved using ‘word problems’ already in the textbooks under the topic ‘problem- solving’.

- **Level Principle**

This principle underlines that learning mathematics means that learners pass through various levels of understanding (Van den Heuvel-Panhuizen, 2010). As I understand it, the strength of this principle is that it guides growth in mathematical understanding, from the concrete to a symbolic representational form. This principle means in other words that by solving problems learners develop and use models as a bridge between the abstract and the real. By a process of generalising and formalising, this model eventually becomes an entity on its own and is used as a model for mathematical reasoning (Widjaja & Heck, 2003).

Amongst their 10 key principles for effective PD designed to improve teachers' practice, Leu and Ginsburg (2011) also mention the need to recognize that change is a gradual, difficult and often a painful process. Ndlovu (2014:10) states that:

> *'change or progress from one level of understanding to another requires scaffolding by more knowledgeable others or the sequencing of instruction in such a way that new learning carefully builds on previous knowledge'.*

In the envisaged PD participants can be guided how to implement this principle in their teaching as follows: first practising counting (using different strategies, for example string of beads, number frames, buttons), secondly the string of beads can become the empty number line for calculations (addition and subtraction for example), thirdly a double number line for supporting ratios and fourthly a fraction/percentage bar or 'frame boxes' for support working with fractions and percentages.

In the PD sessions, ideas of mathematization (as mentioned with the example above) among learners through practical and integrated applications will be promoted. Participants will experience that it is not always possible to have learners re-invent models on their own. Sometimes, models have to be supplied to learners (such as bead strings for counting/addition) and these models should support the transitions of learners' thinking about more formal mathematics.

- **Intertwinement Principle**

This principle implies that mathematical domains such as for example number, measurement and data handling are not considered as isolated chapters in the curriculum (Van den Heuvel-Panhuizen, 2010). I would like to argue that a major strength of this principle is that it renders coherence to the curriculum, which is also mentioned in the Curriculum of Primary Education in Namibia (MoE, 2005b & 2005c).

In the PD sessions participants will be given the opportunity to discuss this relationship between the different chapters in their current syllabus. They will learn how to apply a broad range of mathematical tools to solve rich context problems with primary school learners. As an example, participants will assist each other in solving rich context problems and will hopefully experience that to estimate the size of a room, does not only involve measurement but also geometry and ratio for example.

- **Interaction Principle**

The importance of this principle is that it points out the important fact that learning mathematics is not only a personal activity, but also a social activity (Van den Heuvel-Panhuizen, 2010).

Participants will be exposed in the PD sessions how to offer learners opportunities to share their (the learners') strategies and inventions with one another. Participants will hopefully experience that themselves in the sessions by listening to what others find out and by discussing these findings the learners will get ideas to improve their own strategies. This interaction will evoke reflection which might enable learners to reach a higher level of understanding (Cheung & Huang, 2010; Cobb & Visnovska, 2008; Ilma, 2011; Kwon, 2002; Menon, 2011; Ndinda, 2011; Van den Heuvel-Panhuizen, 2013).

In the workshop sessions the participants will experience that the significance of this principle is that whole-class teaching, which is also the hallmark of traditional methods, plays an important part in the RME approach to mathematics education. I will emphasize during the PD sessions that collaborative group work could solve problems experienced in overcrowded classrooms as experienced in the Namibian situation. Some of the 10 key principles of effective PD is the logic to afford teachers opportunities for support from their critical colleagues (observations during research lessons) and to discuss challenges and solutions of learning difficulties as a group (Leu & Ginsburg, 2011).

- **Guidance Principle**

This principle implies that learners are provided with 'guided' opportunities to 're-invent' mathematics by finding a balance between 'direct' teaching and the 'freedom' of learning. Teachers have to play a pro-active role in learners' learning (Van den Heuvel-Panhuizen, 2010). The significance of this principle is that participants must be able to foresee where and how they can anticipate learners' understanding and skills that will emerge during the lesson.

During the PD sessions participants will experience how to provide learners with a learning environment in which the process of construction will emerge. Teachers will have to learn from each other ways and means about how to guide learners to better understanding. During the workshops contextual problems that allow for a wide variety of solution procedures will be selected and possible solution procedures that reflect possible learning routes will be analyzed and discussed. Teachers will be guided how to anticipate (for example the mental activities of learners) and how to plan possible teaching trajectories to make the guided re-invention process possible.
For this research the intended learning outcomes for PSMT for PD will determine whether the following has been achieved:

- ✓ Increased understanding of mathematical concepts (guidance principle/guided re-invention).
- ✓ Increased ability to identify misconceptions and errors learners apply when working on real life problems (activity principle/learners' own productions and constructions).
- ✓ Increased ability to identify and apply instructional strategies, RME principles that hold the potential to improve learners' understanding of mathematical concepts (methods/models/level principle).
- ✓ Increased use of instructional methods that allow learners to develop their thinking, share their understandings and discuss problem-solving strategies their classmates (intertwinement principle).

RME motivated me to use an 'adapted' form in the professional development of PSMTs, adapted in the sense that all activities had to be aligned with the Namibian curriculum and in the Namibian context. An 'adopted' form of RME, i.e. in the way

RME is implemented in Dutch schools, having textbooks available that are written according to the RME theory, would not be possible in this study.

The main focus of this study is on RME-based PD through LS. Therefore, to choose RME as the theoretical framework seemed to be the obvious choice.

3.4.8 RME as a Theoretical Framework

Collins English Dictionary (Hanks *et al.*, 1983:576) defines a framework as a

> *'Structural plan or basis of a project'.*

I like to think of a framework as being like a scaffold erected to make it possible to repair parts of a building. A scaffold encloses the building and enables workers to reach otherwise inaccessible parts of it. Therefore, I see the research framework of this study as a basic structure of ideas that serves as the basis for a phenomenon that is to be investigated.

The basic structure for this study will be the RME theory (structural plan) that will enable the participating PSMTs in this research to upgrade their school mathematics subject knowledge as well as their pedagogical knowledge (basis of project). In applying the RME principles in an RME-based PD the need is to understand the phenomena I am studying, namely

> *'What are the experiences of PSMTs who participated in an RME-based PD?'*

The aim with this framework is to enable me to interpret the data and to draw conclusions at the end.

It will be important for participating teachers to meet regularly for the RME-based PD activities I will facilitate, because by getting in contact, advocating, thinking aloud, reformulating and reflecting about mathematical content, RME principles can be learnt. Sánchez (2012) argues that when people are in an interaction, communicative characteristics, such as those mentioned above, are used and applied for the collection of experiences, knowledge and beliefs that influence teachers teaching will come to the front.

The RME framework provides a structure for conceptualising mathematical concepts and designing learning activities for learners. The discovery of principles of RME and the justification thereof might allow for creating ‘new’ knowledge about teaching primary school mathematics for the participating teachers.

It is important for the participants in the PD to realize that their role is to be actively engaged and involved in planning and guiding instruction based on learners’ understanding and performance. Learners’ roles, on the other hand, involve active engagement in solving a variety of meaningful and relevant problems, communicating mathematically, reasoning and making mathematical connections. This requires preparing participants to be able to implement instructional plans through RME principles. This will also serve as a change agent to help other teachers internalise this philosophy.

Aspects of mathematics in the RME-based PD are to focus on solving contextual problems (activity and context principle), communication (guidance and interaction principle), reasoning (guided re-invention principle) and making connections (intertwinement principle). All activities are sequenced in a way that is consistent with the sequence in which concepts and skills develop naturally in learners. Special emphasis is placed on learners’ cognition and learners are not expected to do things that have no meaning for them. This implies that the participant’s role is to assess the learners’ thinking and then to provide appropriate instruction that helps learners to progress to more mature mental functioning through extensive opportunities and to engage actively in appropriate and relevant problem-solving activities. However, since the participants will experience the RME theory for the first time, it might be necessary to make adaptations as the research progresses in order to accommodate questions and requests by the participants.

I maintain that there is a significant difference between the traditional method (mechanistic approach) and RME to mathematics teaching. This is the rejection of the procedure-focused way of teaching (mechanistic, stepwise) in which the learning content (or subject content) is split into meaningless small parts in which learners are offered 'fixed' solving procedures trained by doing a number of exercises, most often done individually. RME has a more complex and meaningful conceptualisation of learning.

In the RME approach learners are considered as active participants in the teaching-learning process, in which they, the learners develop mathematical tools (models) and insights. It is important to note that for RME teaching methods/strategies are offered to create opportunities for learners to share their experiences with their peers. This is an experience the participants themselves might discover during the PD.

I foresee that through the workshops offered during this research study, PSMTs will experience how to use RME principles to improve their instruction. Participants should be able to realize that mathematics is a process, or as Freudenthal stated a 'human activity' but at the same time it is an activity that results in mathematics as a product.

The participating PSMTs will initially teach in ways that are determined by their existing school experience, but also the learning experience they newly encountered in RME principles and LS, that are the basic ideas in PD in this current study. They will bring along knowledge and beliefs that come from 'outside' and 'inside' through contact with me. In the end the main research question in this study will determine the way forward.

As is the case with any new idea in education RME is not to such an extent generally accepted that it is without criticism. Some of these points of criticism will be discussed in the next section.

3.4.9 Criticism against the use of the RME Theory

Currently there are discussions going on between educationalists whether RME solved the inability of learners to perform in arithmetic and mathematics at school. In the different types of schools in the Netherlands, the views on RME are definitely not coinciding with a general view of 'all learners are mathematically literate'. Van de Craats (2007) and Uittenbogaard (2007) have a different opinion regarding the usefulness of RME in mathematics education. It is important to mention that Van de Craats is a renowned mathematician in the Netherlands with a keen interest in mathematics education as well.

The following positive points are mentioned in favour of the use of RME in mathematics education in schools (Van de Craats, 2007):

- ✓ There is a lot of emphasis on ‘content in context’.
- ✓ Good and ‘interesting’ realistic examples are used.
- ✓ Challenging mathematical puzzles are used.
- ✓ Mathematical projects are incorporated in lessons.
- ✓ There is an attractive use of different strategies.

According to Van de Craats (2007) the following points, however, are mentioned against the use of RME in mathematical education:

- ✓ There are just too few systematic exercises for learners to practice (procedural knowledge).
- ✓ There are too many possible strategies demonstrated to solve easy problems. This will confuse learners, especially learners who struggle with the content of school mathematics. Van de Craats (2007) calls them ‘hapsnapmethoden’.
- ✓ Learners cannot build self-confidence to solve mathematical problems.
- ✓ The realistic approach can be disastrous for learners with learning problems.

Wittmann (2005) holds the view that there is a loss in mathematical substance in mathematics teaching when applying RME principles. He refers to the issue of horizontal and vertical mathematization which is a firm part of RME since the early seventies. He claims that the ‘horizontal’ mathematization, which relates to the applied aspect of mathematics, and the ‘vertical’ mathematization, which applies to the pure aspect, are delineated. As RME progressed, this balance became more and more distorted. Wittmann (2005) argues that the influence of RME has an effect on mathematics education research, because now it has lost its connection with ‘pure’ mathematics and instead focuses now on a one-sided orientation towards superficial ‘applications’ and to the testing movement which replaces ‘contents’ by lists of 'competencies'. Step by step mathematical substance, which cannot be neglected in some instances, is pushed into the background and got lost in RME. Furthermore, Wittmann (2005) states that this will result in a kind of 'RME light', which can less and less guarantee a sufficient preparation for future academic studies of learners.

Freudenthal (1991) used the word 'didactics' very often, more than e.g. the word curriculum. For him it was important to focus in school on teaching methods and processes rather than on 'Bildung'. This is exactly what Wittmann (2005) claims is missing in RME. 'Bildung' (German word for education – free translation) entails more than only focussing on the competencies in a curriculum. A teacher should have a 'Grundvorstellung' ('basic ideas' – free translation) of what underlies the mathematical concept to be taught. If a teacher would like learners to make sense of some mathematical concepts, he or she could specify this 'Grundvorstellung' connected to the concept.

Criticism is also raised against the use of the mathematical language in problem situations posed to the learner in a RME approach. A multi-cultural set-up where the learners' mother tongue is different from the medium of instruction used in the classroom will put learners in a situation where the language will hamper their understanding. Interpretation and the analysis of a problem will become a challenge and learners might use a lot of time to first understand the problem, whereby a 'naked' problem (for example to tell a learner straight: 'solve 3 + 5') will enable the learner to solve the problem much faster (Van den Broek & Ros, 2012). This is an important issue that I will have to keep in mind for the duration of the study, since in Namibia learners are from various multi-cultural backgrounds and speak quite a number of different mother tongues. This issue was addressed earlier whereby learners have to apply just the mechanistic approach in solving 'naked' problems.

Van Luit (in Van den Broek & Ros, 2012) states that teachers who do not have sound background knowledge of basic mathematical concepts will pose a threat to learners in RME, because these teachers will not be able to evaluate the methods or the models learners have developed during the lesson. This is another concern I have to take seriously into account, since Lower Primary (Grades 1 – 4) phase participants can be regarded as 'generalists' in my view.

Van Luit (in Van den Broek & Ros, 2012) also points out that if teachers demonstrate too many strategies to learners, they might confuse the learners. However, a teacher should possess the knowledge to solve problems with more than one method. I for example emphasize to my education students that 'there are many roads to Rome' and learners might prefer one strategy above the other.

It is also important to note that if teachers are not able to find suitable context problems, the issue of guided re-invention is lost (Van den Brink, 1989; Van de Craats, 2007). Context is important in RME to give learners a better chance to link to their imagination and world they live in and therefore to invent strategies themselves. Teachers applying the RME approach do not have a lot of practice with similar exercises as for example the teachers who apply the traditional approach. This is a problem, because learners do not get enough practice according van den Brink (1990).

Van der Mee (2008) points out that RME only works for learners in the very first Grades. The reason for this being learners are only requested to solve problems with 'small' numbers and that makes it very difficult for learners to apply the principles in higher Grades where they are requested to solve problems with 'bigger' numbers. Not having a 'proper' strategy at hand complicates mathematical understanding. For this study it is important that participants will have to point out clearly what they have experienced during this RME-based PD in the different school Grade levels.

In the Netherlands research has shown that learners who were trained in RME did not necessarily perform better than learners who were trained in the traditional approach (Hickendorff, 2013). This research points out that girls prefer the traditional approach, because according to Hickendorff (2013), it is more systematic. Boys, on the other hand, prefer RME because they are 'free' to just pin down the answer (doing the necessary steps mentally). In the same research many teachers preferred the traditional approach, because standard procedures in a class could apply – meaning all learners are on the same route to the answer of a problem and this is easier to 'control'. Namibian teachers might be no exception in this regard.

Several aspects of Freudenthal's ideas are still under discussion amongst researchers. His credo inevitably brought Freudenthal into conflict with behaviouristically-oriented psychologists such as Bloom and proponents of the ‘new math’ movement who advocated the development of a curriculum for mathematics as an abstract deductive system (Gravemeijer & Terwel, 2000). Their main criticism of RME is that it is not always possible to proceed from experimentally real situations for the learner to the pure ‘mathematics’ and therefore guided re-invention might be a waste of time (Gravemeijer & Terwel, 2000; Van de Craats, 2007).

To summarize, the reform criticizers who are against the use of an RME approach, recommend that:

- ✓ Mathematics should not be taught in context.
- ✓ Informal strategies in school mathematics should be avoided. They only confuse learners.
- ✓ Progressive schematisation leads to long, unnecessary detour. It is regarded as a ‘waste of time’.
- ✓ The focus should not be on understanding, because understanding comes automatically after training (or after sufficient practice).

It appears that some of these reform critics are of the view that learners in primary school do not need to think. They are serious about the fact that it should be sufficient that primary school mathematics consists of written algorithms. Furthermore, I contend that this chapter provides sufficient information to make it worthwhile to investigate the experiences of PSMTs who participate in RME-based PD.

To summarize, there is no ultimate proof that RME will be a solution to improve performance in mathematics education in Namibia. The use of language in the classroom, the use of context and the willingness and ability of teachers to change their teaching, which were all pointed out by critics as possible obstacles, will have to be carefully addressed in this study. However, I think it is worthwhile to make a start towards changing teachers’ strategies in order to become effective.

This study will report on whether the RME-based PD will/will not bring along change in the teaching of the participants. Beliefs certainly impact on change and it is therefore important to research teachers' views and beliefs in order to address issues concerning beliefs and PD appropriately.

3.5 PRIMARY SCHOOL MATHEMATICS TEACHERS' (PSMTs) VIEWS AND BELIEFS

3.5.1 Introduction

PD cannot be limited to in-depth knowledge of subject content only. In my view it is also important to pay attention to the PSMTs views and beliefs they bring along to the PD activity planned for them.

The following table summarizes what was reviewed in the literature regarding PSMTs views and beliefs:

Views and Beliefs	Views, Beliefs and Change of Beliefs	Factors that influence primary school teachers' views and beliefs
		Teachers' views and beliefs on the nature of mathematics and on primary school mathematics teaching
		The influence of views and beliefs on teachers' attitudes towards teaching primary school mathematics
		The nature and foundations of teachers' views and beliefs
		The role of teachers' views and beliefs in changing and reforming mathematics education
		The role of teachers' views and beliefs in this study
	Efficacy beliefs	Influence of teachers' efficacy beliefs on productivity

Table 3.4: Overview of Views and Beliefs

Many PSMTs may not have had any positive experiences regarding mathematics education. The earlier experiences of PSMTs as learners can possibly be carried forward to their adult lives and these experiences might be important factors in the ways primary teachers regard mathematics teaching. The PSMTs, especially the Lower Primary phase participants, might not have had the subject mathematics up to Grade 12 level, which could also be an indication why this group of teachers might view mathematics teaching differently from their colleagues teaching mathematics in secondary schools. What happens in the mathematics classroom may be directly related to the views and beliefs that teachers hold about mathematics teaching. To fully understand PD, it is therefore necessary to also review the views and beliefs of PSMTs on mathematics.

However, in this study the main focus will be on how the participating PSMTs experienced this RME-based PD and the possible influence it has on their teaching. This study might indicate that previously held views and beliefs regarding mathematics and mathematics teaching of the participants will be challenged for the first time.

For quite some time myths and prejudices about teaching and learning mathematics existed amongst PSMTs. Daniel *et al.* (1993:1) has noted some, namely:

> *'learners have to toil and suffer to learn mathematics; every mathematical problem has only one correct answer; there exists one right way to solve a mathematical problem; inherent objectives of teaching and learning mathematics are found in speed and accuracy with computational skills; speed and accuracy are more readily achieved with competition than cooperation; there is no place for discussion in mathematics; logical and rational thinking are the main skills to foster in mathematics – no creativity and intuition; mathematics is very difficult and can be better understood by a few talented learners; men and boys are more inclined to succeed in mathematics than woman and girls, for males are rational and females are more intuitive and sensitive'.*

Many of these myths and beliefs are present among Namibian mathematics teachers (Nambira *et al.*, 2009).

PSMTs' professional actions and beliefs are assumed as crucial factors for successful transition (Beswick, 2008; Kröger, Schuler, Kramer & Wittmann, 2012; Tella, 2008). This study will address the complex issue about teaching mathematics in the primary school by putting the focus also on the beliefs, views, the intuitive acceptance and the mental processes of these teachers during the PD activities. PSMTs might even have different views and beliefs on mathematics teaching because of the different curricula and different training models they were exposed to.

All the PSMTs in this study will experience RME-based PD for the first time. I am interested in what their existing views and beliefs are of primary mathematics teaching. It will also be interesting to establish the PSMTs' beliefs and views about teaching and learning mathematics after the intervention with RME-principles; how these teachers' beliefs are mirrored in their classroom practice and how willingly they will implement new ideas in their daily teaching during this study.

Mathematics is one of the key subjects in both primary and secondary education in Namibia. Mathematics is about finding solutions to problems. Mathematics educators and researchers have over the years carried out various research projects on factors that are responsible for poor performance in mathematics at primary and secondary schools (Clegg, 2007; Clegg & Courtney-Clarke, 2009; Cobb & Visnovska, 2008; Ferdous, 2012; Ilma, 2011; Tella, 2008). In Namibia these factors range from a shortage of qualified mathematics teachers, poor facilities, a lack of equipment and instructional materials for effective teaching, the use of the traditional 'chalk and talk' method, too large learner-to-teacher ratios and mathematics anxiety, to mention a few outstanding ones. However, I only came across a few studies that considered teachers' views and beliefs as a factor for poor performance in mathematics worthwhile to investigate (Dede & Uysal, 2012; Drageset, 2010).

I would like to argue that teachers bring deeply rooted ideas about the teaching and learning of primary school mathematics to the PD. These ideas can be embedded in the content knowledge and the pedagogical experiences of the participating teachers.

The literature on the impact of PD on teachers' views and beliefs points to the difficulty in overcoming ingrained notions developed during previous experiences (Wilcox *et al.*, 1990). With this study I aim to create situations where these beliefs are faced and re-considered.

Over the last decade there have been calls for teachers to adopt a fresh understanding (which emphasizes the patterning and real-world problem-solving facets e.g. RME) of mathematics and the learning and teaching of mathematics (Nisbet & Warren, 2000). It is hoped that school mathematics will be seen as a search for pattern and order in the world and thus be viewed as a dynamic and evolving subject, which is the main aim of RME. Teachers should believe that the learning of mathematics occurs when learners are actively involved in constructing mathematical meaning (e.g. developing models like in RME) for themselves through activities and discussion.

The importance of the views and beliefs of PMSTs cannot be underestimated. Literature points out that those beliefs also act as filters through which people see the world (Beswick, 2008; Dede & Uysal, 2012; Kröger *et al.*, 2012; Maaβ & Schlöglmann; 2009; Sbaragli, 2006). The result is that teachers' beliefs are considered to have a definite impact on their teaching practice (Drageset, 2010). These authors argue that the more centrally held a belief, the more fixed it is and the more difficult it will be to change. Given the crucial role of the primary school teacher in the education process, it appears obvious to focus this study also on these teachers' personal views and beliefs about mathematics.

The following sections will focus on what is known regarding PSMTs' views and beliefs as well as beliefs on PSMTs' efficacy.

3.5.2 Views, Beliefs and Change of Beliefs

In the literature I have reviewed the theoretical concept of 'belief' has not been dealt with thoroughly because I could not find any generally agreed definition (Boz, 2008; Tella, 2008). I came to the conclusion that there are closely related terms and concepts regarded as similar to 'beliefs'. For example, beliefs are considered as equal to concepts, meanings, propositions, rules, preferences or mental images. In some literature beliefs are seen in a much broader sense, for example as 'mental constructs that represent the codifications of peoples' experiences and understandings' and that shape the teachers' perception and cognition in any set of circumstances (Dede & Uysal, 2012). Before I commenced with this study, I regarded beliefs as one's personal views, pre-conceptions and theories. Tella (2008) argues that beliefs act as 'driving forces' in shaping the structure and content of a teacher's teaching practice in the classroom.

Since I could not come to a 'general' definition I have consulted the *Collins English Dictionary* (Hanks *et al.,* 1983:133) in which 'beliefs' are defined as follows:

> *'A principle or idea accepted as true or real, especially without positive proof'.*

It could also be 'an opinion or a conviction'. Therefore, for the purpose of this study beliefs will be regarded as anything that an individual holds as true. Since PSMTs' views and beliefs on primary school mathematics education could be a research on its own I will only focus on the factors that influence PSMTs views and beliefs, followed by the PSMTs views and beliefs on the nature of mathematics and mathematics teaching.

- ***Factors that influence Primary School Teachers' Views and Beliefs***

Tella (2008) mentions two factors that could have an influence on teachers' views and beliefs namely whether or not a teacher is able to bring about significant change and whether or not the teacher has the ability and skills to enhance learners' learning. This view of Tella (2008) could be valuable because after the intervention it can be determined whether change has taken place and whether learners' performance has improved.

I would like to argue that another factor is how 'open' PSMTs are for intervention programmes. If they are strongly of the opinion that their subject and pedagogical knowledge is adequate it will be difficult to convince them otherwise.

Another issue that might have an influence on PD for PSMTs is what their views and beliefs are on the nature of mathematics and mathematics teaching.

- ***Teachers' Views and Beliefs on the Nature of Mathematics and on Primary School Mathematics Teaching***

The authors Webb and Webb (2004) focus on an in-service Mathematical Literacy programme for mathematics in-service teachers in the Eastern Cape which I thought should to be useful for this study. According to them views on the nature of mathematics can be seen on a continuum from an 'absolutist' viewpoint in which mathematical truth is unquestionable, certain and objective at one pole, to a 'fallibilist' viewpoint, in which mathematics knowledge can be seen as a social construction and is therefore fallible at the other pole.

In an RME-viewpoint mathematics is seen as a human activity. To link with the idea of a continuum, my argument is that learning mathematics can also be seen as a continuum where mastery of skills is at the one pole and pure problem-solving is at the other pole. In the literature reviewed on the theory of RME, the mastery of skills is very important in order for learners to find ways and means to develop own models in which they will develop problem-solving strategies and skills (Freudenthal, 1991; Romberg, 2006) .

Ernest (in Webb & Webb, 2004) mentions three views of mathematics, namely the instrumentalist view, the Platonist view and problem-solving view. These three views differ significantly. The instrumentalists view mathematics as an accumulated set of unrelated but utilitarian rules and facts. These will result in skills that are to be used in the pursuance of some external end. The Platonist view is that of a static, but unified body of specific knowledge. It links to the view of RME that mathematics is there to be discovered and not to be created. The problem-solving view sees mathematics as a dynamic, continually expanding field of human creation, a cultural product, which is constantly being revised and re-constructed. Also here a link with RME can be identified, namely in which so far as mathematics is seen as a human activity and mathematization should constantly be seen as 'guided re-invention'. Ernest (in Webb and Webb, 2004), in contrast, interprets the three views on totally different levels with instrumentalism at the bottom and problem-solving at the top. The above information will definitely play a part in the RME-based PD because participants might have these different views on mathematics in the primary school, albeit of a much less academic (more simplified) nature.

I reason that views and beliefs might have an influence on PSMTs' teaching. PMSTs views and beliefs about mathematics link with their models of teaching and learning (Drageset, 2010). It is maintained that teachers' conceptions of the nature of mathematics stem from their philosophy of teaching and learning mathematics, despite the fact that they may be unable to articulate their beliefs fully, as they are often implicitly held (Askew *et al.*, 1997; Maaβ & Schlöglmann, 2009). Regarding views and beliefs of teachers I found that it is often mentioned that a teacher who views mathematics as a problem-solving activity act, is a facilitator in the classroom and will regard learning as an active construction of understanding as it is the case in RME.

Teachers' views and beliefs cannot be generalized (Askew *et al.*, 1997; Dede & Uysal, 2012; Tella, 2008). These authors argue that teachers' beliefs about their performance capabilities and their ability to accomplish certain tasks through their actions are situation specific. How teachers view 'quality teaching' will depend on how they view 'quality' – for some it could simply imply achieving an average above 50% in assessment tasks (quantitative), for others it could mean that learning for all learners was maximised (qualitative).

It has been established that teachers' beliefs about mathematics and mathematics teaching and learning have a significant influence on their instructional practices (Leatham, 2006; Tella, 2008). These authors are of the view that one's conception of what mathematics is will have an effect one's conceptions of how it should be presented. Handal (2003) discusses teachers' mathematical beliefs and he argues that these beliefs most likely originated from the learning experiences they had in school and which they will then eventually reproduce in their classroom teaching. Handal (2003) also claims that teachers' beliefs may act as a filter through which teachers make their decisions on methods and strategies rather than just relying on their pedagogical knowledge or the curriculum guidelines. I am concerned that current primary school teacher education programmes in Namibia are paying more attention to pedagogical knowledge rather than to consider changing students' beliefs regarding school mathematics education. Therefore, an intervention with an RME-based PD to address teachers' existing beliefs in order to bring changes in their classroom practice is necessary.

My understanding is that according to the RME theory teaching entails engaging learners as active learners to induce positive, comprehensive changes in their pre-existing knowledge, skills and attitudes. This can be achieved by teachers who are able to build on learners' experiences, abilities, interest, motivation and skills (as required in RME). It is for this reason that teachers should view and agree that it is necessary in mathematics education to continuously adjust their teaching strategies to meet the diverse needs of their learners. I would like to argue that PMSTs should have a vast repertoire of instructional strategies and techniques that reflect their knowledge and skills of the subject. From this viewpoint a teacher should accept that it is important to continuously reflect upon, conceptualize and apply understandings from one classroom experience to the next. With this in mind teachers will hopefully realize the contribution RME and lesson study could have towards their professional development.

In the Namibian context the Lower Primary teachers are class teachers, meaning that they have to teach all subjects. This might cause that they do not have the same attitude towards mathematics teaching as their colleagues in the Upper Primary phase, whose major specialisation area during their study was mathematics education. It is important to note how views and beliefs might influence PSMTs' attitude towards teaching.

- ***The Influence of Views and Beliefs on Teachers' Attitudes towards Teaching Primary School Mathematics***

When researching the views and beliefs of PMST it is important to consider their attitudes not only towards mathematics as an academic subject, but also towards the teaching and learning of mathematics in this PD activity. The significance of this research will be important due to the potential influence of these teachers upon learners. PSMTs' views and beliefs influence the formation of attitudes and these in turn will influence their classroom practice (Tella, 2008). Some PSMTs believe they are capable of personal control over the learners' behaviour, thinking and emotions. Effective PSMTs, on the other side, might believe that they can make a difference in learners' lives and believe that they teach in ways that demonstrate this belief. According to Tella (2008) what teachers believe about their capability is a strong predictor of their effectiveness.

The nature and foundation of PSMTs views and beliefs may originate from some previous experiences they have encountered. This possibility is reviewed next.

- ***The Nature and Foundations of Teachers' Views and Beliefs***

An interesting point of view is raised in the book '*Beliefs: A hidden variable in mathematics education*' (Leder, Pehkonen & Törner (Eds.), 2002). The authors state that there is not a joint effort to develop a comprehensive categorisation of all teachers' (primary and secondary school) mathematics related beliefs. In this book the authors, Op't Eynde, de Corte and Verschaffel (in Leder *et al. (Eds.),* 2002) discuss the very basic nature and foundation of beliefs – psychologically held considerations about the world that are accepted to be a true, uncritical acceptance of what we see or hear as products of social life; belief and knowledge operate together; the driving force behind a change in belief is not primarily logical in nature but rather psychological. These authors hold the view that there is no way to judge whether one's belief is true and another one's belief is false but it relates to what one values with respect to others. Beliefs also point to the classification of beliefs as conscious and unconscious beliefs that have a significant impact on teachers' expectations, participation, and contribution in the classroom. The impact of beliefs on cognitive and affective domains leads to practices. However, these authors do not distinguish clearly between primary and secondary teachers' beliefs.

Some sources indicate that beliefs are either derivative or primary (Handal, 2003; Kröger *et al.*, 2012). A derivative belief is a belief that follows from or is derived from other beliefs. They argue that if teachers are of the view that learners need to 'know' certain rules to be able to solve problems, they will do a lot of 'drilling' or learners have to do a lot of memorization of 'facts'. If a teacher cannot provide reason or argues 'it just is', then the belief is described as primary, in other words these beliefs are not held on the basis of evidence. This is an important distinction, for beliefs in this category are held for reasons such as the authority of the source of the information or because they support existing, centrally held beliefs. It is extremely difficult to change these beliefs.

Any reform programme brings changes along. However, change might create fear. How views and beliefs can possibly influence the teachers' role in the PD will be reviewed next.

- ***The Role of Teachers' Views and Beliefs in Changing and Reforming Mathematics Education***

An important aspect in the review of teachers' beliefs is that one must accept the central role of teachers in the changing or reforming of mathematics education. The implementation of RME principles and of attempts to change instructional practice in a professional development programme will only work if teachers are aware of and believe in the positive contribution this programme might have. It is also important to note that in order to implement RME principles and changes in primary school mathematics instruction, teachers must possess beliefs about mathematics and mathematics teaching and learning that significantly differ from the current school mathematics teaching tradition.

It should also be taken into consideration that beliefs can, for example, act as barriers against influence from external factors, such as a professional development on RME principles. Thus, beliefs can preserve the teaching, even if the professional development indicates reasons for change (Drageset, 2010). I hold the view that if beliefs present barriers against learning or development, they need to be addressed. Literature, however, points out beliefs are probably more difficult to change than emotions and attitudes (Drageset, 2010; Tella, 2008).

Whether or not beliefs are open for change depends on how they are held. Beliefs can be held without regard to evidence (non-evidentially) or based on evidence or reason (evidentially). If a belief is held non-evidentially it cannot be modified by introducing evidence or reason (Drageset, 2010). When a belief is held evidentially the teacher will respect other views as reasonable and intelligent. In such cases these beliefs are open for discussion and can be modified by further evidence or better reason.

Reflection which is an important part of lesson study, is regarded as a critical factor for changing beliefs, as teachers learn new ways to make sense of what they observe. On the other hand, beliefs can also serve as affordances, for example, the belief that reasoning and argumentation are the most important aspects of mathematical knowledge may lead the teacher more often to situations where he learns about learners' mathematical thinking.

Wilson and Cooney (in Leder *et al. (Eds.),* 2002) argue that teachers' beliefs are crucial determinants of what they do in their classrooms and therefore PD is important in order to focus on changing their beliefs and practices. Beliefs and practices are related in complex ways and develop and change together which means that PD should address both.

- ***The Role of Teachers' Views and Beliefs in this Study***

Very little information regarding primary school teachers' views and beliefs in Namibia is available. I did not come across a study which focuses on the views and beliefs of PSMTs in Namibia.

Beliefs as pointed out, are a multi-faceted construct which can be described as one's subjective "understandings, premises, or propositions about the world" (Charalambous, Panaoura & Philippou, 2009). Working with PSMTs for several years I experienced that they have various beliefs about themselves as teachers and learners of mathematics, about the manner in which knowledge is acquired, about the nature of the discipline of mathematics and about internal and external factors that affect the learning of mathematics.

Hopefully PMSTs in Namibia will express their beliefs in the interviews that will be conducted with them. The envisaged intervention might put PMSTs, who might hold strong beliefs about the quality and the process of innovation under a lot of emotional strain. Their possibly long held views and beliefs might be challenged and this might create additional stress. Many of the participants might be suspicious of the success RME can bring to their teaching. These teachers might rely more on their own beliefs than current trends in mathematics education. These beliefs, conservative as they might be, will have their own rationality in the practical and daily nature of the teaching profession. The PMSTs who hold behaviourist beliefs can have an influence on the success of RME applied in PD.

I reason that PSMTs with a positive self-image might have a positive influence on learners' learning and might be regarded as being more successful in their teaching. A PSMT who is capable and successful in producing an intended result (in this case 'good' SAT results) is regarded as being efficacious in Namibian terms. The next section will review what is known about teachers' efficacy beliefs.

3.5.3 Teachers' Efficacy Beliefs

Bandura (in Temiz & Topcu, 2013) describes teacher efficacy as a kind of self-efficacy and identifies it as 'beliefs in one's own capabilities to organize and execute the courses of action required to manage prospective situations'. My understanding of 'efficacy' means that a PSMT will be capable and successful in producing an intended result, i.e. in Namibian terms 'good' performance of learners in assessment tasks. This is an important factor which might contribute to the success of this professional development initiative. It is important to note that the PSMT's belief in his/her own capability to organize and execute the course of action required is necessary to successfully accomplish teaching tasks in a particular context.

I maintain that this efficacy belief of a PMST will influence the amount of effort that they will invest in the PD, the duration which they will persist in a given task and the choices they make and their aspirations in facing difficulties and setbacks.

Teachers who have a high level of confidence in their own capabilities will approach difficult tasks or changes in teaching strategies as challenges to be mastered rather than threats to be avoided (Beswick, 2008; Charalambous *et al.*, 2009; Temiz & Topcu, 2013). Temiz and Topcu (2013) further claim that the teachers' efficacy beliefs have an effect on their own teaching behaviour. They are of the conviction that teachers with a high level of teacher efficacy believe that they have the ability to increase the effectiveness of learners' involvement and learning, even if the learners lack motivation.

Research has confirmed that teacher efficacy beliefs have an effect on both the teachers and learners (Beswick, 2008; Charalambous *et al.*, 2009; Drageset, 2010; Temiz & Topcu, 2013). In addition to that teacher efficacy beliefs correlate with learner outcomes and teacher behaviour (Temiz & Topcu, 2013). Research has shown that learners in classes of highly effective teachers (those with a high efficacy belief) performed much better, were more motivated to participate in activities, had a better self-esteem in lessons and had a more positive attitude towards their school work than learners in classes of less effective teachers (Beswick, 2008; Charalambous *et al.*, 2009; Drageset, 2010; Temiz & Topcu, 2013).

PSMTs, who believe that they are effective spend more time helping learners with a variety of activities, identify learner mistakes and spend more time on learner-centred activities (Taylor, Anderson, Meyer, Wagner & West, 2005; Temiz & Topcu, 2013). These PSMTs have confidence in their own teaching abilities and encourage positive learner outcomes. Effective teachers believe that they can make a difference in a learner's life and they teach in ways that demonstrate this belief (Tella, 2008).

A question that arises is 'how do teachers' efficacy beliefs influence productivity'?
In Namibia PSMTs are measured against 'good results'. Therefore, this review will not be complete if the effects of teachers' efficacy beliefs on productivity are not investigated.

- ***Teachers' Efficacy Beliefs on Productivity***

I reason that a positive teacher efficacy belief should relate positively to teacher activity, effort and effectivity. Bandura (in Temiz & Topcu, 2013) states that teacher efficacy beliefs can be related to how much effort teachers put into teaching, their willingness to implement new teaching methods and pedagogical strategies and their ability to meet challenges. This view is important for this study, since the aim is to introduce RME principles to PSMTs in order to enhance their effectiveness. If the participants are open to new ideas and are more likely to adapt to new methods and approaches, their experience in this PD should be positively influenced. On the other hand, teachers with low levels of teacher efficacy tend to stick to the same approaches which are usually teacher-centred approaches.

I understand that self-efficacy can be related to the belief that one is capable of exercising personal control over one's behaviour, thinking and emotions. What teachers believe about their own capability could be a strong indicator of teacher effectiveness. Bandura (in Temiz & Topcu, 2013) view teachers who hold strong self-efficacy beliefs to be more satisfied with their jobs and demonstrate more commitment and are more likely to persist in failure situations. I argue that they might also be more open to apply new strategies to make better gains in learners' performances.

It is important to determine how much the participants believe in their own ability to instruct effectively and whether they have sufficient teacher efficacy beliefs to investigate RME. Therefore, participating PSMTs will be provided with opportunities to engage and practice RME principles and to organize lessons collaboratively to challenge their existing beliefs, views, conceptions and attitudes towards mathematics teaching.

3.6 CONCLUSION

This study attempts to explore the possible contribution of the theory of RME and LS in PD as well as the views and beliefs of fifteen (15) PSMTs in Windhoek. The aim is to ascertain whether participants' views and beliefs of learning have been challenged and whether there are similarities and differences in their teaching before and after the intervention.

Key elements in this review are professional development, lesson study, Realistic Mathematics Education and views and beliefs of PSMTs. This review only attempted to provide the necessary background knowledge to this complex study. It is evident that each one of these key elements could have been a study on its own. Participants in this study have never been involved in an on-going PD before, they have never been exposed to RME and LS and nobody ever asked them about their views and beliefs about primary school mathematics teaching. To be part of an RME-based PD activity is thus a first experience to the PSMTs in this study. Therefore, I had to make sure that the key elements of this study provided me with adequate information to equip participants with the required knowledge and skills to improve their mathematical knowledge and teaching of primary school mathematics.

The choice of primary school mathematics culminated from the fact that it is the foundation for any advancement in an educational system. In the Namibian curriculum (MoE, 2005b & 2005c) the approach to teaching and learning for Grades 1 – 4 and Grades 5 – 7 are described. The theoretical framework, RME, of this study links quite well with the Namibian situation. The prescribed Namibian approach focuses on participation (interaction and guidance principle), contribution (activity and intertwinement principle) and production (reality and level principle). It is expected of Namibian teachers to be able to sense the needs of learners and know how to shape learning experiences accordingly. Teaching strategies must be varied and flexible within well-structured sequences of lessons. The Namibian Mathematics Curriculum (2005b & 2005c) states that mathematical problems should always be exemplified in a context (the reality principle) that is meaningful to learners.

There is no shortage of guidelines for conducting effective PD activities. In this study I would like to include the following in the RME-based PD:

- ✓ Participants being supported to work together – Lesson study
- ✓ Participants gaining feedback from colleagues of their practice – Lesson Study
- ✓ Participants incorporating new ideas into classroom practice – RME principles
- ✓ Participants balancing the requirements of curriculum imperatives and meaningful learning – Professional Development

The literature review focused on what is known to be able to answer the main research question

> *'What are the experiences of primary school mathematics teachers who have participated in RME-based PD?'*

and sub-research questions

> *'How can RME principles contribute to the development of primary school mathematics teachers?'*
> *'What are the primary school mathematics teachers' views and beliefs about mathematics teaching?'*

of this study.

The reviewed literature dealt with research done on the RME theory developed and implemented in the Netherlands, the method of lesson study and the importance of the views and beliefs of teachers on PD. Researchers agree that mathematics should be addressed at primary school level in such a way that it makes sense to learners. It is therefore worthwhile to determine what the possibilities are of implementing such an approach in mathematics in primary schools in Namibia. To my knowledge, RME has not been implemented as an approach for effective mathematics teaching in Namibia prior to this research.

Not every form of PD, even those with the greatest evidence of having a positive impact, is in itself relevant to all teachers (Avalos, 2010). It is therefore important to study, discuss and reflect in dealing with PD on the interacting links and influences of teachers and the educational needs of their learners, the expectations of the education system, teachers' working conditions and the opportunities available to learn through PD in Namibia.

It is important that through this case study PSMTs themselves will become learners of mathematics on the theory of RME adapted to suit the Namibian situation. I would like to reason that in order to effectively teach primary school mathematics, teachers must gain competence and understanding of the mathematics that they are supposed to teach.

In exposing PSMTs to the theory of RME during an on-going PD, the participants will experience learning opportunities very similar to what they will hopefully create for their own learners. These experiences will not only improve the PSMTs' mathematical understanding, but hopefully more powerful conceptions of mathematics teaching as well as more confidence in their own abilities will be fostered. This might lead to more enjoyment in teaching mathematics for primary school learners, especially for those teachers responsible for teaching Grades 1 – 4.

The schematic presentation below gives an idea of the structure which will follow in chapter 4.

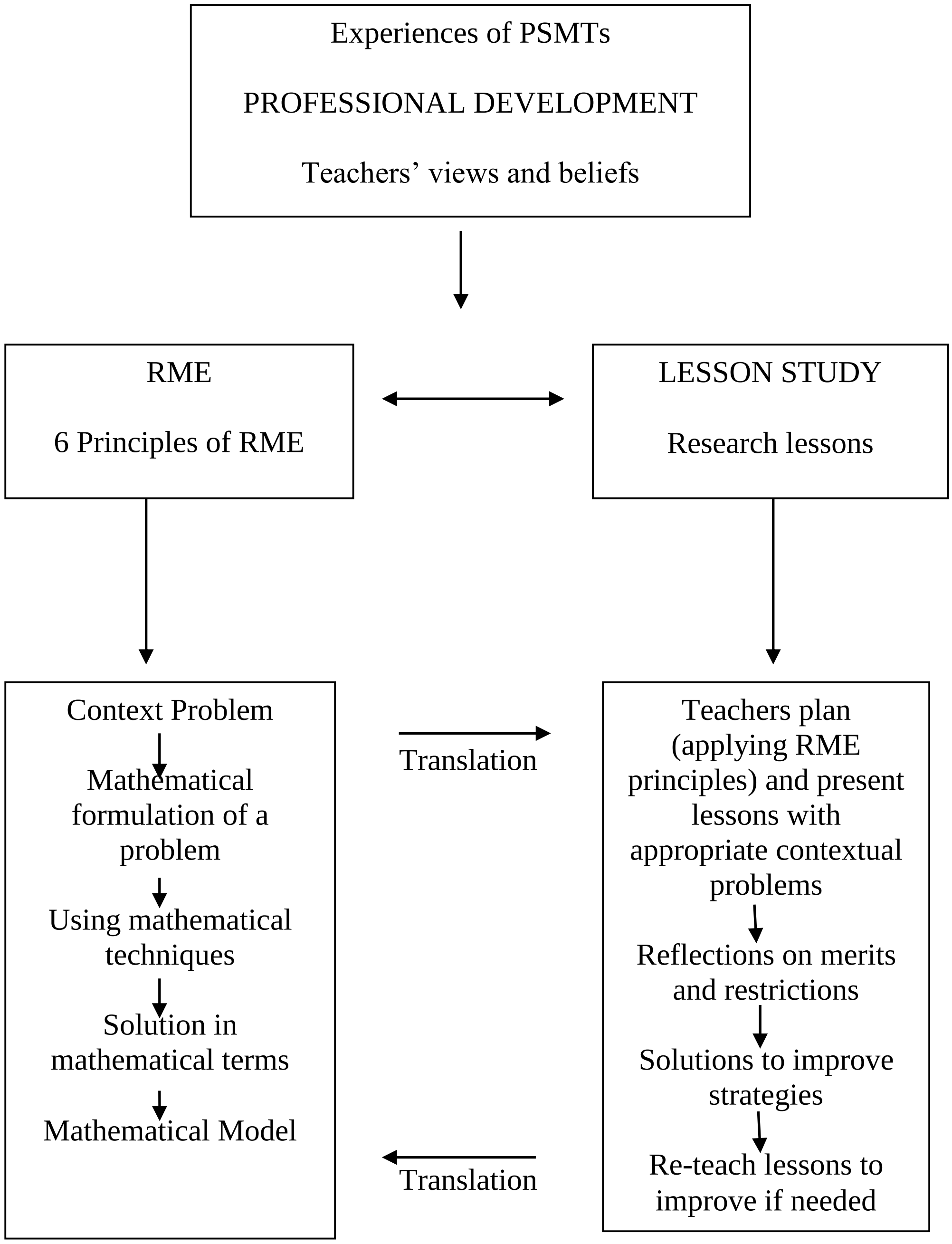


Figure 3.4: Focus of this Study

The schematic presentation is also an indication of the main data category, i.e. experiences of PSMTs participating in an RME-based PD. The research tools which will be used to collect data, i.e. classroom observation, lesson study, workshops and interviews, will be explained in the next chapter.

The next chapter will also comprehensively discuss the intended methodology of this study, such as the selection of the school, the participants, their involvement in the study and the design employed. The reasons for doing the research in the form of a case study will be provided. Special attention will be given to the choice of an ethnographic design.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 INTRODUCTION

This chapter makes an argument for an appropriate research design and methodology in terms of the main research question, which is

> *'What are the experiences of primary school mathematics teachers (PSMTs) who participated in Realistic Mathematics Education (RME)-based professional development (PD)?'*

To put this study in perspective, Chapter 2 described the history of the Namibian Education System with an emphasis on teacher education both in the past and at present. The PD opportunities of PSMTs in Namibia are emphasized especially with regard to the intended new reform of which implementation starts in 2015. The primary school mathematics curriculum is described in order to put the PD in context.

Chapter 3 reviewed literature on RME-based PD, Lesson Study (LS) and PSMTs' views and beliefs, using international trends but also considering local and national trends. The conceptual base of this study was also provided.

This study is about the experiences of PSMTs on RME-based PD and LS at one school in Windhoek, Namibia. Therefore, the purpose of this chapter is to provide a description of the research design and methodology to be used.

Firstly there will be a review of literature on qualitative research methods that relate to answering the main research question. Using the review, I will identify and argue for an appropriate research design. I will also explain why I have chosen an 'ethnographic design' and a 'case study'.

The following section will then provide a description of the context, the school and the relevant experience of the teachers. Ethical issues that have been considered will also be explained. The description of the process of data collection and generation is followed by an explanation of the data analysis. This chapter ends with a conclusion and motivation for Chapter 5.

This study is an in-depth exploration from multiple perspectives of the complexity and uniqueness of PD on RME principles employed through LS in a 'real life' context. It is according to me research-based and evidence-led. Research-based in the sense that this study will involve PSMTs in RME-based PD, i.e. getting research into practice, which will be a first experience for PSMTs to engage with their peers from both primary phases as well as with management members to develop professionally not only their teaching but also their subject knowledge. The experiences of these PSMTs will be reported on and this evidence will lead to inform further research on PD. Therefore, the primary purpose is to generate an in-depth understanding of how PSMTs can benefit from RME principles to generate knowledge and to inform policy development on Continuous Professional Development (CPD), currently envisaged by the Namibian government (UNAM, 2012a). The unique contribution of this case study is that it provides me with a holistic understanding of PD and LS within its social context. It is hoped that this study will offer insights into learning and classroom cultures and provide practical examples of interventions, drawing on a set of workshops and lessons organized during this study.

An investigation of the participating PSMTs' views and beliefs about primary mathematics teaching and whether RME-based PD has contributed to possible growth related to primary mathematics teaching and learning will be done. These PSMTs were part of the process to investigate the events that had contributed to their possible development.

Literature review indicates that research into mathematics education in Namibia in recent years has been driven by learner performance in mathematics and in response there has been a focus of attention on the teacher (Clegg, 2007 & 2008; Clegg & Courtney-Clarke, 2009; Ferdous, 2012). Teacher standards have been formulated (MoE (NPSTN), 2006) and teacher PD is under investigation to be implemented (Ngololo, 2012). There is no doubt that this study can contribute to the developments under way in order to have PD opportunities for all PSMTs in Namibia.

The next section will focus on the research design and will motivate why I have decided on an ethnographic design and a case study.

4.2 RESEARCH DESIGN

4.2.1 Introduction

To be able to choose an appropriate research design, a review of different possible types of designs was undertaken. I have decided that a qualitative research will suit the main research question most effectively.

In order to determine what the PSMTs' experiences are, it is essential to focus on the process and meanings of an RME-based PD to PSMTs. I emphasize the socially constructed nature of reality for these teachers, the intimate relationship between the PSMTs and facilitator (me) and the situational constraints that shape this study.

Denzin and Lincoln (2011) state that qualitative researchers seek answers to questions that focus on 'how' social experiences are created and 'what' gives it meaning. While planning the current study and deciding on a suitable research design, I have asked myself the following questions:

- ✓ How can I understand PSMTs' practices in the light of what I observe and experience?
- ✓ How can I understand PSMTs' practices in the light of what I have reviewed and have information about RME-based principles used in different countries?
- ✓ I reason that the teaching and learning of mathematics should be seen as a human activity and should focus on the learners' every-day life experiences. What are the cultural and intellectual underpinnings that influence the teaching of primary school mathematics?
- ✓ How can I best determine what the experiences of PSMTs are who participated in RME-based PD?

After having reviewed different types of design, I became aware of the 'Ethnographic design' which was used by mathematics education researchers in the past (Bezemer, 2003; Howard, 1995; Kaiser, 2002). This seemed to me to be most suitable for this study.

The purpose of this case study is to share with mathematics education researchers my personal experiences and observations during this ethnographic study.

The next sections more comprehensively explain the reasons for an ethnographic design and a case study. A schematic presentation of the outlay of this chapter provides an overview of this chapter.

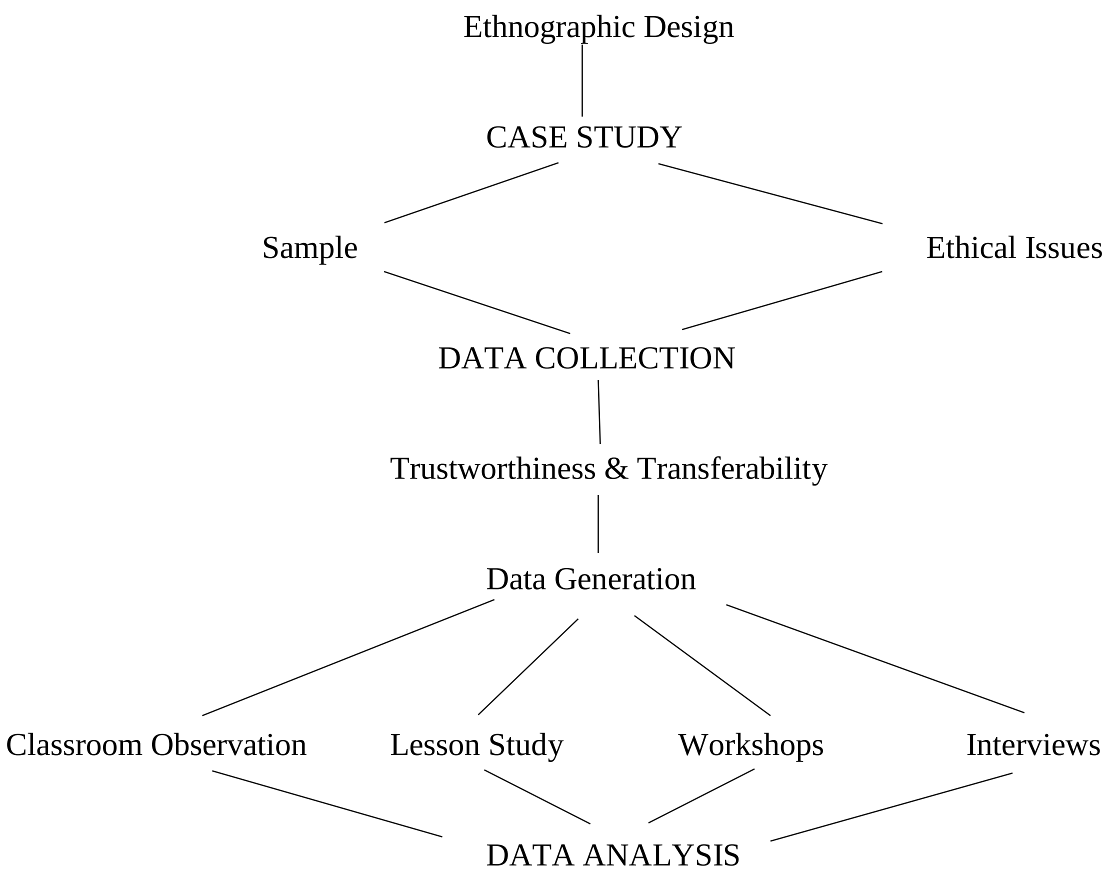


Figure 4.1: Schematic Presentation of the Research Design

4.2.2 Ethnographic design

I have chosen an ethnographic research design for this study, because this type of research with its qualitative methods will provide sufficient flexibility for describing, interpreting, exploring and explaining the process and products of teaching and learning of the participating PSMTs (Hesse-Biber & Leavy, 2011). The literal meaning of the word ‘ethnography’ is ‘writing culture’ (Hesse-Biber & Leavy, 2011). Genzuk (2003:1) uses different definitions for an ethnographic design of which the following seems most suitable for this case study:

> *'When used as a method, ethnography typically refers to fieldwork (alternatively, participant-observation) conducted by a single investigator who 'lives with and lives like' those who are studied, usually for a year or more'.*

To explain how the above statement applies to this study the following:
This study took place over a period of one school year and I have been closely involved in the daily work of the participants, i.e. observing their teaching and planning of various research lessons, i.e. 'lived with'. However, being still the researcher and therefore regarded as an 'outsider', I 'lived like' the participants, because I did not have to report to the school principal.

Hesse-Biber and Leavy (2011) state that an ethnographer is a researcher who 'goes inside' the social world of the participants, 'hanging out', observing and recording the everyday settings of the participants. This statement clearly demonstrates why this method has often been associated with the field of anthropology, in which research is conducted on foreign cultures to capture understanding of the 'native' population (Hesse-Biber & Leavy, 2011).

I reason that the main research question requires an in-depth understanding of the social context (the school) in which the participants, in this case the PMSTs, engage in a particular set of behaviours. This motivated me to use the ethnographic approach, to enable me to get an in-depth understanding of the school culture within which the participants engage in a particular set of behaviours in their everyday task of teaching.

Literature convinced me that ethnographic methods will allow me to understand the reality from the participants' perspectives (Bezemer, 2003; Genzuk, 2003; Hoey, 2014; Howard, 1995; Kaiser, 2002; Mills & Morton, 2013; O'Reilly, 2009). I was looking for a research methodology to investigate teachers' experiences that take place in their classrooms and during on-going PD. One such method that can be used to study this complexity of teachers' experiences and mathematics classroom is ethnography (Howard, 1995). It is a means of learning from participants sharing their story with me. I used observations, lesson study, workshops and interviews to gather data. No similar learning experience by a Namibian researcher who was involved with a PD action was documented anywhere. I realized that I would have to focus on the interpretation of the actions and expressions of the participating PSMTs and that it needed to be meticulously documented.

In this study much observing and recording (journal writing, audio and video recording) of views and beliefs, classroom practices and application of RME principles in lessons took place. Therefore, I understand that in an ethnographic research, as a form of a qualitative approach, the researcher frequently lives with people and becomes part of their everyday environment. For example, every week I spent one whole day at the school, and on the other 4 days I spent normally at least 3 periods at the school, so that it became part of the daily routine and habits, i.e. 'lived with'. I regarded the participants as key informants, because I considered them as most knowledgeable about their school culture and behaviours.

Marshall and Rossman (2011) point out that a qualitative research is pragmatic, interpretive and grounded in the lived experiences of people, in this study being the PSMTs of a school in Windhoek. The five hallmarks of qualitative research as mentioned by Marshall and Rossman (2011) will be covered in this study as follows:

- ✓ This case study is done in a naturalistic setting – the selected school.
- ✓ It draws on multiple methods that respect the humanity of the participants in this study.
- ✓ This case study focuses on context and
- ✓ is emergent and evolving and
- ✓ is fundamentally interpretative.

Three broad principles oriented my approach to ethnography. Firstly, I reviewed that ethnography is a way of 'being, seeing, thinking and writing'. It was for me the way of thinking about my study which could bring together a range of methods under a shared disposition.

This ethnographic disposition lead to the second principle, namely that the approach to this research should be seen as somewhat unconventional, a little exposed. I asked myself the question how I could best become aware of and understand the subjective experiences of others, in this case the PMSTs. I had no idea what to expect and how the PSMTs would experience the RME-based PD. Being at risk in an ethnographic approach, meant to be exposed to the profound complexities of the social and educational worlds of which the ethnographic researcher is part of (Mills & Morton, 2013). The participants bring along knowledge and skills to the PD and that might have an influence on their experiences of this study. Being reflective is a major issue in lesson study, which will also form part of this study, and therefore this approach seemed to link very well to what this study's main research question is all about – the experiences of PSMTs. The participating PSMTs might initially not be willing to share their experiences of reflecting on their own teaching or reflecting on their colleagues teaching, since it is not a normal practice in Namibian schools.

I wanted to comprehend things others take for granted and to make the assumed familiar strange by not jumping to conclusions. This 'comprehend' lead me to the third principle namely empathy, that an ethnographic design also requires. I would like to understand and be attentive to the feelings of the participants on their terms. It might also involve the recognition that a tension exists. This might appear in reactions to questions asked by me or by participants which might be a totally 'new' experience to the participants to be 'open' about themselves and their colleagues. This could let me face emotional and intellectual risks, but it can also bring spontaneous and profound insights to the main research question.

I asked myself the question whether it is possible to be deeply and fully immersed in a situation and at the same time to stand back and try to make sense of it. According to O'Reilly (2009) it is one of the key concepts of an ethnographic approach. Mills and Morton (2013) state that across the world education is all about the struggle to make one's desires and aspiration real and ethnography is the ideal way to access and describe these possibilities and the institutional structures that get built around them. Schooling my ethnographic imagination took time. There was much to read, lots to learn and many mistakes to make during the 'journey' of this study.

My own understanding of 'ethnography' is that it is both a scholarly habit and a moral disposition; quietly attentive, modest, critical and above all empathetic. Thomas (2009) states that empathy in this context is not the easy assumption of shared feelings and experiences, but rather the more difficult task of trying to understand the participants' experiences on their own terms. I have realized that this type of research can be very time consuming and emotionally draining, though it also has its rewards. It will teach me to listen patiently, not to judge and to be open to views and attitudes of teachers.

Applying RME principles through LS makes this approach so useful, because a lot of 'being, seeing, thinking and writing' might happen while planning for the research lessons. Valuable information might be gathered during these sessions. An ethnographic sensibility reminds me of the diversity of lives, experiences and identities shaped and refashioned within the classroom, a fraction of the wider world as Mills and Morton (2013) state it.

I wanted to get an in-depth understanding of the social context, in particular the teaching culture of PSMTs. As a researcher I was interested to get a comprehensive picture of what a daily teaching routine of PSMTs entails, for example how they integrate teaching aids, how they adjust their teaching, how they integrate real life examples in problem solving and whether they follow the same routine in their lessons every day. I was especially interested in for example 'do they make use of teaching aids, how do they involve learners in their teaching, do they do remedial teaching, what extra interesting activities do they plan for their learners?'. This type of research might allow me to get this understanding through direct observation of behaviours (classroom observation) and through interactions with others in the research setting (professional development and lesson study). It might allow me to understand social reality from the participant's perspective (interviews). It might also allow me to explore a range of activities that the participants may even remain unconscious about. I contend that teaching involves creating meaning.

Denzin and Lincoln (2011) state that an ethnographic research is more than a pedagogical technique, because it challenges the researcher to represent interactions to make meaningful interventions. These interventions can produce new understanding and this can then generate new interventions in the form of programmes for implementation on a wider range.

A very difficult task throughout the study was to maintain a balance between familiarity and formalness. Formalness, because I had a dual role, firstly that of researcher, i.e. 'live like' and secondly that of a participant, i.e. 'lived with'. It was important to see and experience things (PD and LS) in a new light and not to take things for granted. The participants had to accept and adapt to an ethnographic researcher, being me, which might have caused its risks and discomforts. I had to repeatedly explain my role in this research and might have possibly appeared sometimes too exposed and disoriented. It was also about coping with confusion and the unpredictable effects of linking concepts to unfamiliar ideas. Therefore, the decision to use an ethnographic design was based on the fact that it involves to reflect openly, to engage and to be critical of the everyday life of PSMTs.

The sub-research questions of this research are related to a number of different factors

- ✓ *How can RME principles and LS contribute to the professional development of the primary school mathematics teacher?*
- ✓ *What are the primary school mathematics teachers' views and beliefs about mathematics teaching?*

To be able to find answers to the above questions there might be a variety of perspectives on the same question within the same setting. There might have also been a dynamic interplay between me and the participants in identifying and making sense out of all these different realities. I can adhere to the following characteristics of an ethnographic research design as Creswell (2003) mentions them:

- ✓ Qualitative research occurs in a natural setting. (An ethnographic research is a qualitative research design). This study's focus is on a primary school in Windhoek.
- ✓ The data that emerge from a qualitative study is descriptive. The activities in the classrooms of the participants will be clearly documented before and after the intervention. This will be done by keeping field notes and having interviews with participants.

- ✓ The focus of qualitative research focuses on the participants' perceptions and experiences. The views and beliefs of participants will be documented, analyzed and discussed before, during and after the intervention.
- ✓ I am particularly interested in how the participants interpret and implement RME principles in daily lessons and whether the PD has significantly influenced their views and beliefs.
- ✓ Objectivity and truthfulness are critical. In this study I seek believability based on coherence, insight into actions of participants and trustworthiness through a process of verification.

Long-term engagement in the field setting, in this case the selected primary school, will be the primary source of ethnographic data. During the whole study, I have filled a dual role, namely as a participant and as a researcher. In order to be able to develop an understanding of what it is like to live in the circumstances I had been the participant in the life of the setting while also maintaining the stance of an observer in order to be able to describe the experiences with a measure of 'detachment'.

For me gaining access to the research setting was critical in determining the type of data I need and the process of how I would collect the data. Hesse-Biber & Leavy (2011) state that gaining access to the participants is critical in determining the type of data you have in mind to collect and also how difficult or easy the process will be. My aim was to establish relationships with the participants in order to find a way into the daily class activities and into the close-knit teaching community of the particular school. On the other hand, I was aware of the danger or tension between getting too close to those in the setting and at the same time maintaining the role of researcher, which involves a degree of detachment. Finding a balance between the two is crucial. Hesse-Biber & Leavy (2011) state that an ethnographer participates in the research setting in varying degrees. There could be tension in wanting to get too close to those in the setting and at the same time being a researcher.

In this study detailed accounts of planning, presenting and reflecting of research lessons were collected and transcribed. As Creswell (2003) mentions, the methods of data collection are ever growing, and they increasingly involve active participation by participants, but it also required sensitivity towards the participants from my side.

Throughout the study I have been aware of the fact that I should not get too much involved in other day-to-day challenges participants had to cope with.

I came to the conclusion that ethnography relies heavily on up-close, personal experience and possible participation (in this case study workshops and LS) and not just observation (Thomas, 2009). Genzuk (2003) states that ethnography enhances and widens top down views and enriches the inquiry process, taps both bottom-up insights and perspectives of powerful policy makers and generates insights by becoming engaged in the process of envisaged change. I could not find any information regarding mathematics education researchers in Namibia who wrote down and shared their research process experiences regarding an on-going PD with PSMTs. Therefore, by documenting my findings through a RME-based PD I may inform others, in this case the Ministry of Education, in an attempt to derive instructional innovations (PD and LS) from such an analysis.

An ethnographic study takes a lot of time and needs careful planning. My responsibilities at the University of Namibia and simultaneously paying attention to my research resulted in the decision to involve only one primary school in the near vicinity of the University as a case study. An explanation of the characteristics and usability of a case study follows.

4.2.3 Case Study

A review of recent case studies regarding RME-based PD convinced me to undertake the ethnographic study in a case study context (Bezemer, 2003; Fauzan *et al*, 2002; Hadi, 2002; Kaiser, 2002). An ethnographic study requires that I have to be involved with the participants in their environment. On the other side a ‘case study’ has the advantage that I can focus on one case, i.e. one particular school environment.

I found many different ‘definitions’ about what a case study is. However, I could distinguish some common denominators on which most case study researchers agree (Gerring, 2004; Hesse-Biber & Leavy, 2011; Merriam-Webster, 2009; Yin, 2009). These are:

- ✓ The case study should have a ‘case’ which is the object of study.

- ✓ The 'case' should be a complex functioning unit, be investigated in its natural context with a multitude of methods (e.g. classroom observation, interviews, and field notes) and be contemporary.

Merriam-Webster's dictionary (2009) defines a case study within the abundance of definitions of 'case study' and reads:

> *'An intensive analysis of an individual unit (such as a person or community) stressing developmental factors in relation to environment'.*

This definition provides much detail which I could relate to the current study. I analyze the definition for this study as follows:

- ✓ In this definition 'case study' focuses firstly on an 'individual unit' which in this case is the participating school.
- ✓ Secondly, the definition stipulates that a case study is 'intensive'. I argue that since this research comprises detail, richness, completeness and variance (RME-based PD and LS) of one school, it qualifies as a case study.
- ✓ Thirdly, a case study stresses 'developmental factors' and this means that a case study typically evolves in time, in this study one school year, has a string of concrete and interrelated events, PD and LS, that occur at 'a time and at a place' that constitutes the case when seen as a whole.
- ✓ Lastly, the 'relation to environment' I regard as being in context. In this study it will be the experiences of PSMTs during RME-based PD and LS at their school.

Gerring (2004) states that since many academic attempts to clarify what 'case study' means, it is better to stay with clear definitions like that from Merriam-Webster rather than with more loaded academic definitions. However, Yin (2009) places more emphasis on the method and the techniques that constitute a case study. Yin (2009) states that to refer to a research as a 'case study' means that its method is qualitative and involves a small number of participants and that the research is ethnographical, clinical, participant-observation or otherwise in the 'field'. This study will focus on ethnography and I will be in the 'field' for quite some time with the participants.

Therefore, within this case study I will keep to the definition of Merriam-Webster (2009) and the description of Yin (2009).

Given the main research question and its context, the current study has an exploratory and descriptive character. The main research questions starts with 'what' and this type of question is as Yin (2009) states, an indication that the question is a justifiable rationale for conducting an exploratory case study research. This study aims to explore what the experiences are of PSMTs who participate in RME-based PD. Another aim with this study is to discover how LS and the RME approach were experienced during the PD in terms of improving the knowledge and skills of PSMTs at the particular school in Windhoek. The reason for deciding on a 'case study' method is explained in the following paragraph.

The exploratory case study helped me to describe and explain the unique opportunities which focused on the social interactions with the PSMTs during classroom observations, interviews and workshops which I facilitated. The developing meanings that participating PSMTs attach to each other and how they interpreted each other's acts are part of this study. This case study's focus is on the 'case', namely that PSMTs did not have opportunities in the past to partake in PD. The 'study' will try to distinguish the possible existence of multiple realities, the possibility of different and sometimes contrasting views and the possible diverging interpretations of events and conditions the participants in the study might have had.

In reviewing different case studies, I put special focus on those written regarding Indonesian RME-based PD activities. The reason is that there exist many similarities between teachers, as well as between the teaching conditions in different regions of Indonesia and Namibia. Teachers in Indonesia experience challenges in designing context rich learning experiences for learners. As Fauzan, Slettenhaar and Plomp (2002) and Hadi (2002) state in their case studies, teachers are viewed as the key actors in education innovations. The Namibian situation is no exception to this fact. In the concept of RME learners should be given opportunities to develop their reasoning and logical skills through exposure to real life (contextual) problems. In Indonesia, as in Namibia, RME is a 'new' concept for PSMTs and research is needed to investigate whether and how it can be translated to be realized in the Namibian context. The

Indonesian researches (Fauzan *et al*, 2002; Hadi, 2002) alerted me of all the challenges that I had to take note of. In this study no PSMT in Namibia has experience with teaching RME-based lessons and the case studies reviewed, portrayed a similar scenario. However, the review of literature in Chapter 3 indicates other countries' experiences regarding RME-based PD as well. PSMTs in Namibia need to be well trained to meet the challenges any reform will bring along and I reason that on-going PD could be one possibility to meet these challenges.

I also studied other case studies regarding PD. One such a case study is for using Interactive Whiteboard Technology (IWT) in the primary mathematics classrooms (Serow & Callingham, 2008). I could draw some inferences from it, because the focus is on primary mathematics teachers' PD acquiring new teaching skills. This case study reports about on-going PD for a year with teachers who have never used IWT, which is very similar to the situation in the current situation in my research where PSMTs are not informed about the RME approach.

To summarize, I have used an ethnographic case study design because I wanted to examine a contemporary issue. This case study concentrates on a RME-based PD for PSMTs, looking at it in depth in a 'real life' context. I will not try to generalize from it, but a primary purpose is to generate in-depth understanding of how PSMTs experience PD to generate knowledge and skills in order to be better prepared for the 2015 reform in Namibia. My choice of a case study with ethnographic characteristics was influenced by the fact that it would give the PSMTs a voice, as they are the ones who are directly influenced by any PD necessitated by an educational reform.

A case study is expected to capture the complexity of a single case and therefore only one Namibian primary school's mathematics teachers are involved in this study. General information about the school, the participating PSMTs and how the sampling was done is provided in the next section.

4.3 SAMPLING

This research is based on qualitative principles, which implies it is concerned with in-depth understanding. A qualitative research is usually working with small samples, because it aims to look at a 'process', in this case it is PD, or the 'conceptions' (views and beliefs of participants) individuals have about their given social situation (Denzin & Lincoln, 2011; Hesse-Biber & Leavy, 2011; Olsen, 2012).

An ethnographic case study implies that it would require much input and time from my side. The main difference between a case study and other designs is that it focuses its attention on an individual case and not on the whole population. Cohen, Manion & Morison (2007) state that this type of sample is selective and biased and cannot claim to represent the whole population. However, for this case study I believe that because of the amount of data gathered from this sample, one school in Namibia, would adequately indicate what the experiences of PSMTs are with regard to PD.

Entry into the selected school was carefully planned and discussed with the director of Education of the Khomas Region. I had a separate meeting with the principal of the selected school. During this meeting I clarified the purpose and aims of this study. The principal was very keen to participate, but she was adamant that all PD activities must adhere to the prescribed Namibian school syllabi. It was therefore important for planning purposes to adhere to the sequencing of topics in the syllabus.

The school is situated in a western suburb of Windhoek and is in the near vicinity of my work station. This school was chosen for the logical inferences that could be drawn from it. My involvement at the previous Windhoek College of Education with the Hoogeschool Rotterdam, Netherlands, influenced my decision to involve this school in this study. The Windhoek College of Education signed an agreement of cooperation with the Hoogeschool Rotterdam (HR) in the Netherlands. It was important to involve a primary school in the cooperation agreement, since HR planned for their students to do an internship at the selected primary school. The principal of this school accompanied me once to Rotterdam to experience what RME is all about. We visited various primary schools in Rotterdam and she could form an idea of what RME principles entail. Therefore, the participants in this study represent a purposeful sample.

In the meantime the Colleges of Education merged with the University of Namibia and the cooperation with HR came to an end. However, while conducting the current study at the school, six students from HR volunteered to do their internship at the school. They taught for eight weeks at the school. These students also took part in the PD arranged for the afternoons and contributed with their experiences regarding RME gained during their study at HR. The participating teachers regarded these students as an extra source of information for the days I could not attend their lessons.

Seventeen teachers participated in this study on a voluntarily basis. They are responsible for teaching Grades 1 – 7. In Grades 1 – 4 you have class teaching, whereas the teachers who are teaching Grades 5 – 7 are regarded as primary school mathematics subject teachers (specialists). The participants' teaching experience ranged from three to 31 years teaching experience. The biographical data regarding age, years of experience, Grades taught and type of teacher training is indicated in the table beneath:

Participant	Age	Gender	Years Teaching experience	Teaching qualification (Acronyms page vi)	Teaching the following Grades
1	26	F	4	BETD	2
2	27	M	4	BETD	6&7
3	30	F	7	BETD	1
4	33	F	10	BETD	5
5	33	F	10	BETD	4
6	35	F	11	BETD	2
7	36	F	14	BETD	2
8	37	F	12	BETD	3
9	39	F	19	BETD & HDE	4
10	40	F	0	BETD	2
11	40	M	18	BETD	7
12	40	F	4	DE	4
13	43	F	14	FDM	2
14	46	F	26	HPEC; BETD; SPTD	1
15	48	F	23	DE	Special Grade

16	52	F	29	HDE	5
17	52	F	31	HDE	4

Table 4.1: Biographical Data of Participants

The table should be interpreted as follows:

- The columns provide for each participant the age, the gender, number of years of teaching experience, the highest teaching qualification and the different primary school Grades in which mathematics is taught.
- The rows (across) provides the data of each participant.
- The BETD qualification (as indicated in some cases) is regarded as the minimum qualification for entry into the teaching profession in Namibia. It is a three year tertiary qualification.
- The HDE is a four year tertiary qualification.
- The FDM is a one year diploma in Mathematics after a Diploma in Education (DE) has been obtained.
- The qualifications are quite on par with those at an average primary school in Namibia, which should give validity to my findings.
- All abbreviations of qualifications will appear in the list of acronyms on page xv.

The school has an enrolment of 1057 learners, of which 15 learners are classified as ‘special learners’ meaning these learners need remedial teaching. There are 35 permanent employed teachers, including the principal and 4 Heads of Department (HOD). Two of the HOD’s and the principal also took part in the current study.

The school further has on its establishment also a ‘special class’ teacher, two secretaries and 8 cleaners. Every year the school receives more requests for learners to be enrolled for Grade 1 than what they can accept. In 2009 another five additional classrooms already had to be built to take care of the growing number of learners looking for enrollment.

Before independence this school was part of a Roman Catholic Church school. This Roman Catholic Church school was administrated by the previous Coloured Administration before independence. The Bishop of the Church at that time wanted the school to be under the control of the then National Education, an option that was possible at that stage. Since some teachers were not happy about the decision of the Bishop of the Church, division was inevitable. One group of teachers stayed at the Roman Catholic Church school and the other group moved to another school that was initially called "Primary School No. 5" at that time. This particular school was hosted on the school terrain of another educational institution and two school shifts per day were planned to fit in lessons for all learners. This was not an ideal situation.

The then Coloured Administration built a new school in 1989. This school was inaugurated on 4 May 1990 and had an initial enrollment of 270 learners and 16 teachers. Since 1990 the enrollment numbers have increased tremendously. For 2015 it is expected that the number of learners will again increase and the current management is already considering tents to accommodate the extra number of learners. This school fully partakes in extra mural activities and has developed into a well-known primary school in this part of Windhoek.

The significance of this case study will be in the way it distils the accumulated experience and knowledge I gained in a RME-based PD through LS. This case can be used to illustrate the range of possible dynamics or also the complexity of the situation, since Namibia is embarking on Continuous Professional Development (UNAM, 2012b).

In order to be able to do the research, certain ethical issues had to be taken care of before, during and after the research. The following ethical issues are considered central and relevant to the conduct of an ethnographic research.

4.4 ETHICAL ISSUES

After reviewing several sources regarding ethical issues before, during and after the study, I interpret 'ethical issues' as ethical considerations that are guided by a search for deeper understanding, as well as the cultivation of a curious, compassionate frame of mind (Bresler, 1996; Creswell, 2003; Genzuk, 2003; Hesse-Biber & Leavy, 2011).

Therefore, in order to conduct this study, two central ethical issues came to my mind, namely the representation of truth and confidentiality.

The representation of truth relates to a fundamental assumption of the ethnographic design. The literature review (Bresler, 1996; Creswell, 2003; Genzuk, 2003; Hesse-Biber & Leavy, 2011) indicated that truth and reality are perspectival, contextual and multiple. Observations, interpretations and their articulation are shaped by the situated knowledge, beliefs and commitments of me as the researcher. However, confidentiality in my view, concerns the product and the dissemination to members within and outside the research setting. I realized that I had to take special care about ethical issues in this ethnographic case study and that made me aware to what Bresler (1996) mentions, namely that the classroom community and societal contexts are more than abstract variables. This implies that I, the researcher, have to commit myself, while using ethnographic methods, to focus upon ethical considerations.

The review informed me that the underlying assumption of the qualitative paradigm necessitates different types of ethical considerations (Bresler, 1996). I interpret them as:

- ✓ Teaching and classroom life are complex phenomena and cannot be reduced to one variable.
- ✓ The context of this study indicates that the reality is shaped by many factors, e.g. the understanding of an issue always involves the understanding of its relevant context.
- ✓ The social reality is constructed culturally and individually.
- ✓ It will be difficult to stay objective all times. Therefore, subjectivity should be accepted, examined and negotiated rather than suppressed. I will be situated within a social reality. Therefore, I have my own values and also some kind of subjectivity, meaning that I carry with me my own emotions and prejudices.
- ✓ Interpretation and finding meaning will take a lot of time and effort. Any casual explanations, control and predictions are impossible. Interpretations are constructed and multiple and an activity might be interpreted in different ways by different participants according to their relationship to the ‘issue’ under investigation as well as their personalities and values.

From the above, I understand that I have to 'distance' myself from the classroom situation in such a way that I will report the findings as they are and not how I experience them. To stay objective at all times, means I will have to take into account the cultural and individual differences of the participants. I will have to apply different tools to gather data to ensure objectivity. By analysing the data obtained from these tools might therefore help to report the findings as truthfully as possible.

I realize that there are close links between ethical concerns and issues around participation. Being an ethnographic research, a number of ethical concerns before this study started, had to be taken care of. Before the start of any data collection and PD activities, the most important task was to make my research goals clear to all participants and to gain informed consent to this study. I took care of the following before the commencement of the study:

- ✓ Requested formally permission from the Ministry of Education in Namibia to carry out the research as soon as the proposal was accepted.
- ✓ Talked to participants (principal and teachers) about the envisaged research.
- ✓ Informed participants how the data will be collected.
- ✓ Ensured anonymity and confidentiality of participants at all times.
- ✓ Provided information on all aspects of the research and its possible consequences.
- ✓ Ensured participants the right to withdraw at any time.
- ✓ Fully revealed my identity and background as a researcher to the participants in all phases of the proposed research.
- ✓ Explained the purpose of this study and its procedures in detail and obtained informed consent of all the participants.

Cohen *et al*., (2007) indicate that a researcher must take into account the effects the research might have on participants. A researcher should always act in such a way as to preserve the dignity of the participants. This I did during the current study by:

- ✓ Respecting participants' rights and dignity and interests.
- ✓ Demonstrating social responsibility and obligations.
- ✓ Striving to be objective and honest.

- ✓ Informing participants that they could withdraw at any time but could still attend the RME-based PD during the afternoon sessions.

When I completed my data collection I reported the procedures with as much accuracy and integrity as I could. I reminded myself constantly about the ‘representation of truth’ and ‘confidentiality’. The way in which I address these issues will affect the process of conducting the ethnographic research, namely the data collection and analysis. Eventually this might possibly shape the ‘voice’ and ‘form’ of the intended product. Confidentiality will be ‘triggered’ by the product, its publication and dissemination.

The review (Bresler, 1996; Cohen *et.al*, 2007; Creswell, 2003; Genzuk, 2003; Hesse-Biber & Leavy, 2011) made me well aware of ethical issues that should be taken care of during the study. I ensured that all involved parties had given me informed consent to continue with this study.

In the next section I explain the main procedures used for the collection of data.

4.5 DATA COLLECTION

4.5.1 Introduction

Methods of data collection should be the means to find the answer to the main research question of this study. Since an ethnographic methodology deals with multiple realities that are constructed, the issue of ‘telling the truth’ is problematic. I seriously considered the question ‘whose truth’, i.e. my ‘truth’ or the participants’ ‘truth’? Marshall and Rossman (2011) claim that in determining the validity of qualitative data, the researcher is concerned with the trustworthiness of the data. Lincoln and Guba (1985) suggest several strategies that can be employed to ensure credibility, dependability and transferability. I am positive that all the strategies were employed purposefully in the current study. However, before data generation can be explained I would like to clarify the importance of issues such as trustworthiness and transferability for this study.

4.5.2 Trustworthiness and Transferability

The first strategy (Lincoln & Guba, 1985) encourages the researcher to be in the research setting for a long period of time. My research was conducted over a period of ten months (one school year excluding examination sessions and holidays) beginning in January 2014 and concluding end of November 2014. Participants experienced four cycles of LS and thirteen workshops over the course of the study.

The second strategy (Lincoln & Guba, 1985) is to be a constant observer. In this ethnographic case study, the participants became familiar with my daily presence in their classrooms. Classroom observations took place according to a regular schedule. I have normally been at the school the first four school periods of every morning as well as a whole Thursday. This happened consistently throughout the study. I recorded classroom observations comprehensively in my journal and constantly referred to them when reflecting at the end of a subject topic we handled during the workshop sessions.

In order to ensure for credibility the third strategy (Lincoln & Guba, 1985) requires a peer debriefing. Throughout my study I regularly asked the participants for their input. The first few minutes of every workshop session a debriefing session was held. Except for that, I consistently interacted with my supervisor. I had meetings with him and his valuable insight helped me to reflect on my observations and findings in the context of this study.

The fourth strategy (Lincoln & Guba, 1985) is to practice triangulation while generating data. Triangulation helps to ensure the rigor and usefulness of this qualitative research. A variety of data resources are used in this study and will be described in the next section. I paid close attention to each of the strategies suggested and can therefore believe that this study holds in itself high standards of rigor.

Lincoln and Guba (1985) use concepts like ‘credibility (confidence in the ‘truth’ of findings), dependability (showing that the findings are consistent and could be repeated), confirmability (a degree of neutrality or the extent to which the findings of a study are shaped by the participants and not researcher’s bias, motivation or interest) and transferability (showing that the findings have applicability in other context)’ instead of older terms like 'reliability, validity, objectivity and ability to generalize. In this study I am convinced that these concepts are applied. In addressing credibility I will demonstrate in Chapter 5 that a true picture of the experiences of PSMTs participating in RME-based PD is being presented. For transferability I provide sufficient detail of the context, since this is an ethnographic design and the reader will be able to decide whether this case is similar to another situation with which he or she is familiar and whether the findings can justifiably be applied to the other setting. However, meeting the criterion of dependability I address the fact that PD is a necessity in Namibia and PSMTs are in dire need for PD. This study is a first and can serve as a motivation for future researchers to repeat similar studies in other regions in Namibia. Confirmability is addressed in that sense that the findings in Chapter 5 emerge from the gathered data and are not my own predispositions.

A case study cannot be seen as generally transferable, because the collected data most of the time comes from 'one' case, in this study one primary school (Thomas, 2009). However, in this study I have tried to collect and develop descriptive data of the context in which this study was conducted. The next section provides a comprehensive description of how the data was collected, as well as the setting and process of research. Therefore, any experienced reader (e.g. a mathematics teacher) should be able to work out how the findings of this research could possibly be transferred to their context.

I am aware that I cannot claim to determine the exact context for transferability, but by providing a detailed description of the particular context and how data was generated I argue that transferability will be more easily facilitated. The research tools to collect the data were workshops, classroom observations, LS and interviews. The tools will be discussed in the sequence above.

4.5.3 Data generation

Yin (2009) states that case study evidence may come from six sources, i.e. documentation, archival records, interviews, direct observation, participant-observation and physical artifacts. In this research I only use three of Yin's (2009) mentioned sources, being interviews, direct observation and participant-observation. The other three may be more relevant to other fields of study. However, the title and main research question of the current study focus is on professional development (PD) and lesson study (LS). For this reason, I added additional sources not mentioned by Yin (2009) namely workshops and LS (direct and participant-observation are part of LS). I regard LS and participant-observation in this case as one source, since the planning for LS and the following observation of the implementation thereof was handled as a 'unit'. I use workshops and LS as research interference tools, while classroom observation and interviews are used as data collecting tools. In this study I will use only the term 'classroom observation' which includes classroom observation of the participants before and during research lessons. A research lesson, at the heart of the LS process, is the actual classroom lesson that was planned collaboratively by participants but presented individually.

The first method was by conducting workshops (PD) that I have facilitated. The workshops had a dual purpose; firstly participants acted as 'learners' in order to illustrate to them as learners how the RME approach could increase their own subject and pedagogical knowledge and for some topics we planned LS activities (research lessons). Since the topic of this study's focus is on RME-based PD it is important to reflect on these activities as well. All PD activities were in the form of 'workshops'. The review (Brodie & Shalem, 2011; Clegg, 2007; Forde *et al.*, 2006; Good & Grouws, 1987) points out that 'workshops' are not the most conducive form of conducting PD. However, in this case, it was a series of workshops continuing over a period of one school year. The participants were involved in deciding which content/topic in the school syllabus should be addressed in each following session. It was a very good decision to include the participants, because it created a feeling of 'I am part of this process' and 'my own problems/challenges are addressed'.

The second method was classroom observation. It was important for me to observe the participants before LS cycles took place as well as during research lessons. The reason for this was that I hoped to obtain detailed information about how participants conduct their lessons before any PD activities have taken place and the possible influence the PD might have on the participants' teaching thereafter.

The third method was participant-observer and LS, in order to be involved in and in the same vain detached from the topic of this study. This 'participant-observer' is a kind of schizophrenic activity, in which, on the one hand, I try to learn to be a member of the group by becoming part of it and, on the other hand, I try to look at the scene as an outsider in order to gain a perspective not ordinarily held by someone who is a participant only. However, in this study the second and third method is recorded only as ‘classroom observation’. The findings will clearly distinguish between similarities and differences before and after the intervention has taken place.

However, it must be accepted that PSMTs’ actions only form part of the practice. Behind any action is a system of decisions and these decisions reflect teachers’ knowledge-in-practice, according to me. This cannot be captured through observation only, it is necessary to go beyond that and LS can provide an answer to see how participants’ pedagogical content knowledge and the richness of their interactive decisions have effects in their classrooms.

The fourth method was collecting data through conducting interview sessions. This was a way of learning about participants’ subjective views and beliefs about mathematics teaching and their experience of RME-based PD and LS. The possibility to get information about activities beyond my immediate experience, such as relevant events at school or events at other schools, will help me to better understand the complex issues of this study.

In the process of collecting the data, the four methods could possibly have been utilized together. Each one can be useful for providing a different perspective on the topic. I have tried to utilize these methods flexibly, in an attempt to maximize opportunities to view the scene from many different perspectives and comprehend it holistically. Eisenhart (1988) states that in an ethnographic research more perspectives will contribute to a more complete picture of the scene of interest.

I have used the following four methods: workshops, interviews, classroom observation and lesson study. A comprehensive explanation of these methods follows.

- **Workshops**

Literature has convinced me that short workshops are not actually regarded as the ‘best’ method of conducting PD (Brodie & Shalem, 2011; Clegg, 2007; Forde *et al.*, 2006; Garet *et al*., 2001; Good & Grouws, 1987). The 'workshop' sessions are generally explained as 'once off' learning opportunities. However, I contend that an important aspect in the dissemination of RME is to provide PD for PSMTs through a series of workshops as Merilainen and Pietarinen (2002) suggest. Therefore, my objectives with the workshops were that PSMTs are empowered to implement RME principles in their classrooms. Therefore, to be able to do this, there is a need for PSMTs to study what is actually accomplished during the workshops.

Another aim of the workshops was to change the type of relationship the participants had with each other and with me. It was important that the participants would view themselves as active partners in the discovery process of RME principles and LS. The reason for this was that Chrzanowska (2013) states in her article that if participants are actively involved, not just reactively, workshops have the potential to be more creative and generate more buy in to the envisaged research.

During the workshops the participants could thrive on differences and diversity, especially when planning research lessons (through LS), instead of seeing their teaching skills as problematic. Chrzanowska (2013) also states that workshops have team building benefits which are so essential to LS. Through the use of democratic techniques in this study I tried to balance out differences in power and roles. In this case study all PSMTs of the selected school, including the principal and HOD's, took part and the different managerial persons did not have an influence on the execution of tasks assigned during the different workshops. The workshops also offered flexibility, which allowed for movement, trying out different techniques, exploration of new principles (RME) and extensive stimulus (planning research lessons for LS). Being an ethnographic research, the outcome of these workshops could not have been manipulated.

Well before the first workshop was organized, I clarified the needs with the principal of the selected school. Together with the principal, ideas for the workshops were generated and developed. The principal helped with her presence at the workshops to buy in participants into this research. The participants were, however, also included in development and refinement of plans and actions that had to be taken for all LS activities.

I did extensive and detailed planning before every workshop session in order to be equipped with a resource to handle a wide range of techniques to cope with unexpected situations. One of the main aims of this research was that participants had to be introduced to the principles of RME. This was a totally new concept for all participants, except for the principal, who had observed lessons of teachers applying the RME theory in Rotterdam. Participants have to learn mathematics by mathematizing the subject matter through examining 'realistic' situations. This means that experientially real context for learners that draws on their current mathematical understandings had to be determined. As time went on, I found it easier to plan ahead, because the setting and participants became more familiar.

Being an ethnographic researcher, I was very aware of the fact that I had to be even-handed, consistent, sensitive and enthusiastic as well as empathetic all the time. During the first workshops it was difficult for me to be neutral, not to form opinions and not to act too autocratically. I was aware of the fact that it is expected of a good facilitator and researcher to stay at all times task-oriented. I aimed to lead participants towards understanding, clarified issues where questions arose, listened patiently and tried to integrate participants' ideas where possible.

In this case study I designed and managed the process, but made it very clear to all participants that it was the group who would be responsible for the content that emerged from the workshops. This gave the participants a sense of ownership and responsibility of their role in this study. At the beginning I could not determine what the outcome would be, neither could I predict the outcomes, but for this ethnographic design it was very valuable information that would arise during data gathering. The participants were also asked to elaborate on their expectations they had on the different workshops after each session.

Regarding the planning of the workshops, the main aim was to develop local instructional theories with RME as the global perspective. After each instructional activity participants tried to implement the newly acquired RME principles and I observed and recorded the research lessons. Afterwards the participants and I engaged in retrospective analysis that led to refinement and revision of the conjectured learning trajectories. Participants were responsible for more than one class per Grade in the

Upper Primary phase, which made it easier to do the refinement as soon as possible. Lower Primary participants planned to take the refinement up in a follow-up lesson. The workshops mainly concentrated on the participants so that they could experience what it means to incorporate RME principles into their daily lessons and to stay within the prescribed national mathematics primary school syllabus.

During the workshops attention was paid to:

- ✓ The guided re-invention principle, whereby participants were guided to construct at least some of the mathematics context for themselves in order to be able to guide learners in their prescribed lessons.
- ✓ The didactical phenomenology, whereby the participants and I have analyzed practical problems applicable to learners' experiences as possible starting points for the re-invention process and
- ✓ The construction of mediating or emergent models of learners' informal knowledge and strategies in order to assist learners in generalizing and formalizing their informal mathematics (the participants were in a sense the learners).
- ✓ The engagement of participants in activities with their PSMT colleagues in order to develop relationships amongst each other to create a 'working group' of PSMT. To achieve this aim LS served as the tool.

Zulkardi (2014) describes Streefland's three levels construction principle, which I applied through the different sessions: These levels are:

<u>The local or classroom level</u>

In this level, lessons were designed with participants that were based on the principles of RME and the focus was also on horizontal mathematization. Samples of lessons will be attached as appendices. During the workshop sessions teaching aids and materials were introduced into the learning situation. Opportunities for carrying out own productions were always provided. During all sessions attention was paid to questions like:

- ✓ whether the intended material developed links to reality,

- ✓ whether the material developed will serve as a source and an area of application (care was given whether the starting point was always from meaningful context),
- ✓ whether intertwinement with other strands has been taken care of,
- ✓ whether producing tools in the form of symbols, diagrams and context models were taken care of,
- ✓ whether we stayed within the prescribed Namibian mathematics syllabus. This was an important issue, since the principal and I had an agreement that the prescribed school syllabus would be followed at all times.

In applying this level with my participants my intention was to give them the experience of the principle of interaction. I felt that the participants themselves had to experience the value of discussions, negotiations and collaboration. By doing this, the participants would experience the next level.

The course level

On this level participants were applying and using the material they had developed. Through LS it was determined whether the mathematical and didactical essence of the planned worked was achieved. The cycle of LS enabled participants to kind of more ‘formalize’ what they have developed by applying the next level.

The theoretical level.

All activities that had taken place, e.g. the design and development of lessons, the research lesson presentations and deliberations afterwards were used for constructing a kind of model which could be applied for future professional development.

In this study the workshops aimed to promote and connect the participants into a learning community. It provided participants with opportunities to interact with colleagues and also to talk about specific subject matter (RME principles linked to curriculum content), about learners’ learning (learners creating their own models), about teaching and it ensured collaboration by facilitating conversation among participants. This in turn led to shared experiences and a shared investment in thoughtful development of selected subject matter.

Each workshop will be described in detail under 'description of data collection'. In this research the main research question made me decide to visit the PSMTs classrooms to investigate teachers' practice.

- **Classroom observation**

There are different forms of ethnographic observations (Hesse-Biber & Leavy, 2011). The term 'observation' is usually associated with the sense of sight (Whitehead, 2005). Since it is an ethnographic case study research I raised my senses sight and hearing to take in stimuli from all sources of the classroom environment. I viewed this process as one in which I am responding to inquiries about the study's participants. I did not go into the observation period with fixed questions for which I pursued responses to at first. However, when research lessons served, my focus of observation changed to 'did the PD have a possible effect on the participants' teaching?'

During my thirty year teaching career I have experienced that what participants say is often contradicted by their behaviour. I realized that what I observe are actually answers and the process of this observation period would be to find questions to those answers, which would most likely be found during the interviews with the participants. Therefore, classroom observation can be a way to control what people reported about themselves during interviews and focus groups. The reason for classroom observation (observing the participant) was that I could approach them in their own environment.

During the classroom observation period I drew up a schedule of participants to be visited. The main aim of observing the participants was to visit the classroom and to record as much information as possible. I wanted to establish what was going on in the classroom. I especially needed information obtained through observation to be able to answer the question 'how can RME principles be incorporated into the daily lesson plans of the participants'? Directly after the observed lessons I recorded what I have observed in the classroom, including a holistic recording of events of behaviour and resources in the classrooms.

During the whole process of research I remained aware of the fact that the research had to be an objective exercise. I was very cautious to note down what I had observed and not what I wanted to interpret out of it. The filtering out of biases took me some time and practice. I acknowledged the fact that I would need to be prepared and willing to adapt to a variety of uncontrolled situations and settings during this research. For the sake of data collection I had the aim to observe the participants as they were engaged in activities that would hopefully occur in much the same way if I were not present. The observation of such context could provide a means of finding out about teachers' views and beliefs as expressed actively within the classroom. An objective for the observation period I derived from Whitehead (2005) was to be also able to discern the real from the ideal, the tacit from the explicit and the back from the front.

The classroom observation was an important part in the sense that I shared as intimately as possible in the views and activities of the participants. In the setting I tried to develop an 'insider's' view of what was happening. In doing that, I felt part of the group. The challenge, however, was to find a balance between participation and observation, so as to become capable of understanding the experience as an 'insider' while simultaneously observing the experience from a distance. This might have helped me in discerning patterns among certain events and to explain those patterns and their significance to the readers.

The planning and observation of research lessons is a main aim in the process of LS. Therefore, research lessons played an important part in data generation and will be described next.

- **Lesson study (LS) – planning research lessons**

LS is next to PD an important component of this study, because through the process of LS the participants implemented the RME principles acquired in the PD activities. The LS process involved all PSMTs who participated in this study and we met regularly to discuss and plan the research lessons. Some of the workshop sessions were also used for the planning of research lessons. This happened after sufficient sessions of RME principles were experienced and acquired by the participants. The lessons were for this reason not sequentially organized. However, participants indicated when they were ready to plan a research lesson. LS required from the researcher, being me, and the participants to use the following process to develop their research lessons:

- ✓ Apply learning objectives and competencies for the lesson study and plan a lesson accordingly.
- ✓ One of the participants has to present the lesson.
- ✓ All participants have to participate to reflect, evaluate and refine the lesson (if necessary).
- ✓ Then the lesson needs to be re-taught if necessary.
- ✓ The above-mentioned steps can be repeated in order to refine the lesson.

My aim with LS was to promote a process whereby participants experience gradual and incremental professional growth through collaborative development of lessons. In doing that I claim that teachers can build a bank of useful resources that will enrich teaching and learning of primary school mathematics in their school. These resources can eventually also be shared with mathematics teachers at other schools.

In this study I consider 'participant-observer' as being involved in a variety of research activities over an extended period of time (Hesse-Biber & Leavy, 2011). Since I will be involved in facilitating the planning of the research lessons and observing the lessons when taught, it might enable me to observe the participants in a setting which will facilitate a better understanding of certain behaviour. This process should enable me to clarify my findings through member checks, formal interviews and informal conversations. By keeping consistent and organized throughout this type of observation, I should be able to give detailed feedback to facilitate the development of a narrative that explains various aspects to the reader.

While planning for this type of data generation, I realized after a discussion with the principal that a 'complete' form of LS could not be handled throughout the research. The participants indicated that it would not always be possible to attend each other's research lessons, due to big classes and very few 'teaching free' periods of participants. Therefore a slightly simplified form of LS would serve.

This type of data generation allowed me to check definitions of terms participants used during my subsequent interviews with them.

- **Interviews**

Ethnographic interviewing is a type of qualitative research that combines observation and directed one-to-one as well as focus group interviews (Mai, 2009). In an ethnographic design participants are interviewed in their natural setting, while they are performing their usual tasks, asking them questions about what they are doing and why. Questioning participants in their environment can provide important details of their views and beliefs as well as bring certain behaviour to light (Kleve, 2009).

An interview as such is very useful and important, because I could

- ✓ ask questions about issues that were not clear to me,
- ✓ listen instead of talk,
- ✓ take a passive rather than an assertive role,
- ✓ express verbal interest in the participant,
- ✓ show interest by appropriate eye contact and other non-verbal means.

Before every interview session, the participants were informed about the following:

- ✓ How long the interview should take.
- ✓ The type of questions to be expected.
- ✓ That privacy and confidentiality would be respected at all times.
- ✓ That at any time a participant could withdraw from the interview session.

An interview is a particular kind of conversation between the interviewer (researcher) and the interviewee (participant) that requires asking pre-determined questions and listening to the answers (Hesse-Biber & Leavy, 2011). It is a process of a meaning-making endeavour embarked on as a partnership between the interviewer and his/her respondent. Ideally, the degree of division and hierarchal difference between the two collaborators is low, as the researcher and the researched are placed on the same level (Kleve, 2009). This is a very important issue that was often clarified in the course of this study. My aim was to observe and to ask questions and take note of answers where necessary and not to evaluate or criticize the teaching practice of participants (Kleve, 2009).

Hesse-Biber and Leavy (2011) mention that an interview is a kind of knowledge-producing conversation between the researcher and the participant. The interviews mainly focused on the professional development participants underwent as well as on their views and beliefs of teaching mathematics in primary school. The aim of using interviews was to create a meaning-making partnership between the participant and me. I wanted to understand primary school mathematics teaching through the perspective, experience and language of the participants.

In the planning of the interviews I had to consider the following:

- ✓ How can I get the participants start talking?
- ✓ How can I overcome the problem of being an active listener while also being in the role of interviewer?
- ✓ Will the participants be open and honest towards certain questions?
- ✓ What will the participants get out of these sessions?

Questions were drafted and will be discussed under ‘description of data collection’. These interview questions provided for ‘targeted’ data, because specific questions were asked (Hoey, 2014). Although, much information was also derived from informal talks and discussions after classroom observation. I allowed participants to talk and elaborate on issues experienced during LS without limitations and without having a specific agenda in mind. These spontaneous and everyday conversations contributed valuable information to this case study. These conversations encouraged me to be open to possibilities and to imagine new ways of thinking that could be worth of in-depth considerations. Through this approach I came to realize that the neglected experiences from the day-to-day life of the participants could bring real insight into the powerful meaning of change that is necessary for teachers to increase their performance.

Interviews, individual as well as focus-group, were conducted for the purpose of obtaining information from the participants about their mathematics teaching, about their views and beliefs about teaching and learning mathematics and also for the purpose of validating the whole research and its findings. Before I started with the observation period I had a pre-interview session with some participants. Having realized that individual interviews were very time consuming, I later changed to focus-group interviews.

The literature review indicates that focus group interviews are recommended because it handles a whole group and it is focused (Hesse-Biber & Leavy, 2011; Kleve, 2009). In this research I made use of three focus-group interview sessions – the first one was with the Lower Primary phase participants, the second one with the Upper Primary phase participants and the third session included the principal and Heads of Department (management) who participated in this research.

According to Krueger (1994) focus-group interviews are often useful in obtaining information which is difficult to obtain by using other methods. This method seemed to be very useful, because it gave me the possibility to intervene in the conversation and pose questions to probe what a participant had said. It gave also the participants the opportunity to engage in mathematical talk which they might never have experienced before. Participants also had the opportunity to construct meaning of RME principles experienced in the PD by talking about a topic of particular interest.

The aim of having focus-group interviews was to provide me with information about teachers' views, beliefs and practices which went beyond what was obtained through classroom observation and PD. Data obtained from focus-group interviews will also be valuable to triangulate and support other sources of data.

I reflected regularly on my experiences, what is called in ethnographic design 'researcher introspection'. After every session, I noted down important conversations, questions that were asked or comments that were made. The reason for this was that I was strongly aware of the fact that classroom observation and interviewing are always contextual and might possibly never be quite under control. In the quest to increase knowledge and understanding of the research I always tried to search for a more complex understanding by having an open, curious and compassionate frame of mind. In doing so I hoped to gain the support and trust of all participants.

The next section will describe the data collection tools that were applied in this study. They are classroom observation, workshops, Lesson Study and interviews.

4.5.4 Description of data collection

Data collection and data analysis proceeded simultaneously. It meant that I had to write down what was observed after every PD activity, classroom observation and interview sessions. I tried to make sense out of what was going on in the participants teaching.

The analysis of the field notes lead sometimes to new questions and making new observations and interactions in the setting. I started immediately after the first meeting an introductory session with the participants, with classroom observation. Therefore, a description how the data was collected follows.

- **Classroom Observation**

The collected data through classroom observation was used to improve the design of the individual and focus group interviews. During the first part of the observation I collected information regarding class size, setting, classroom management, desk arrangements, date and time as well as the teaching strategy applied. I regarded the data which I gathered through classroom observation as a check against the participants' subjective reporting of what they believe and do. This enabled me also to develop a familiarity with the milieu to understand the breadth and complexity of this study. Lessons were not all audio-taped, because some participants were not happy about it. Taped lessons, however, made it much easier for me to reconstruct lessons observed as well getting the factual information. However, tape recording classroom observations posed also limitations and weaknesses. Silent activities or silent answers given by learners could not be recorded. At the start of the observation period I also had some problems in operating the tape recorder. Visual accounts of the participant interacting with learners were also not possible. Another disadvantage was that it was very time-consuming to document the data.

Classroom observation started in February 2014 when I observed participants' teaching before the process of lesson study started officially. The classroom layout was such that learners were at all times aware of my presence. I completely acted as an observer without interfering in the teaching process at all, did not comment on actions, but also did not ask questions, e.g. why certain issues were addressed as they were. On request of the participants I did not make use of any video-recording. This role allowed me to study a setting without interfering with the day-to-day operations, thereby limiting the possible bias (or reaction) that might have resulted from my presence and possibly changing the very nature of social relationships in the settings. It had though its drawbacks. I could not clarify meanings and ask questions concerning activities in class that were not readily understood. The question in my mind always remained 'is my understanding or observation shared by the participant?'

The learners did not know my role in the class; I was just introduced as a 'visitor'. At the beginning learners were very hesitant to accept this fact, but when they realized that I did not give any attention to them they started to act normally. I also tried to write down my observations immediately after the session, because taking notes the whole time during the presentation would have distracted the participants' attention from the class. I was not at all 'visible' to them in the end, because of the low 'profile' I kept. The reason for this was that I really wanted to understand the diversity and teaching practice of the different participants. However, I developed a form which helped me to capture main issues during a lesson. The reason for developing this form was to serve as an aid to more easily transcribe the observed lesson after each observation. During the observation of the classroom activities I just ticked or made short comments on the form.

Before I started with this type of data collection, I showed every participant the form I had developed to pin down shortly my observations during the class presentation. The participants gave their consent that the form could be used. The form was as follows:

Participant No: Date: Time:	
OBSERVATION	**COMMENTS**
1. The classroom • Number of learners: • Organization of classroom	
2. Professional Disposition • Demonstrates enthusiasm • Demonstrates flexibility – adapts easily	

to changing circumstances • Is sensitive and responsive to the needs of the learners • Communicates effectively and accurately in Afrikaans/English (mother tongue Grades 1 – 4), verbally and in writing	
3. Response to learners • Recognizes and values individual and cultural differences in learners • Gives assurance and support • Gives constructive feedback to questions asked • Can manage big class groups • Controls physical environment to maximize learning, e.g. desk arrangements • Gives individual guidance during activities	
4. Actual teaching • Presents teaching in a sequenced/ conceptually clear manner • Lessons/activities reflect mastery of content • Lessons/activities reflect learners needs, interests and capabilities • Lessons/activities relate learning to real-life situations and context • Sticks strictly to textbook • Monitors learners' learning and adjust teaching • Makes clear transitions from activity to activity • Engages learners in active learning • Maintains learners as focus of learning activities • Links content to other subjects	

Table 4.2: Classroom Observation Form

After each classroom observation, I wrote descriptive notes about the lessons. I also noted down my thoughts and impressions about what happened during the lesson. This served as a type of self-reflection. The classroom observation was followed by lesson study and the observation of the research lessons. The description of this data collection tool follows.

- **Lesson Study**

The part of 'participant-observer' started at the beginning of March 2014 when the participants and I started to plan research lessons through the process of lesson study (Hesse-Biber & Leavy, 2011).

Along the continuum and moving towards more team-spirit in this study, I have been actively involved in the planning of the research lessons for several weeks. Later on I have been involved in the planning sessions on a more limited basis. A tape recorder was used from time to time. This recorded natural conversations and there was no undue awareness of the recorder. This happened during the phases of lesson planning and the discussions of which teaching aids should or could be used.

It was at this stage that the process of lesson study started when learners were informed about my role and that we might video-record lessons and that other teachers might sit in the class as observers as well. Once again, at the beginning learners were very hesitant to act naturally. This was soon overcome. This role was problematic in the sense that with the demand of 'researcher role first' the participation part took up a lot of my time and energy. Mills and Morton (2013) point out that participation, if necessary at all, is a means to an observational end, rather than integral to the research strategy in itself. Since LS was a totally new concept for the participants, I regarded it necessary to partake as a participant in the planning stage as well. The importance of not losing one's detachment and scholarly identity was always present and had to be taken care of.

An advantage of this type of observation is that as an observer, I was able to 'see' and 'hear' what participants could not. As I observed the participants teaching the research lesson, I could note the change of interaction of the participants with learners as well as the interaction between learners themselves which might not have been the case in the classroom observation at the start of the study.

Since I expected participants to attend research lessons and observe their colleague, I developed an easier form which they could use to write down what they have observed. The form is as follows:

Observer role:
Descriptive notes about lesson observed (record important issues)
Reflective notes (record your feelings and thoughts about what happened during lesson presentation)

Table 4.3: Participant: Research Lesson Observation Form

The planning of research lessons was a very difficult exercise. I expected it, since it is a totally new experience to participants.

During the PD session, the second Thursday afternoon after teachers had resumed duties in January 2014, I planned to introduce the concept of LS to participants as explained in Chapter 3 (pp. 91 - 93). This was necessary, because to plan the research lessons I had to clarify my role as researcher. Since I have the theoretical background knowledge of the process of LS and the participant had none, it was necessary to assume that I would have an interactive role with them in the first cycle. However, LS was introduced much later, since participants needed time to find ‘their way within the PD activities’.

I assumed that the role of active participant in and facilitator of the LS process is allowed in an ethnographic design (Hesse-Biber & Leavy, 2011). I also made it very clear to the participants that I consider myself not an expert in LS, since I lack some personal and practical experience.

Participants were initially not very eager to participate in LS. I accepted that a lot of motivation and interaction from my side would be required. A lengthy discussion with participants indicated amongst others that they were afraid of being observed by their colleagues – these participants were used to be 'alone' in their classrooms. The biggest fear of the participants was that they might 'fail' the lesson. It was quite clear that participants did not understand the concept of LS – I had to convince them that if we would experience challenges, there is always the fourth stage of LS namely to 'adjust and re-teach' the lesson. Having used the word 'we' they realized that I will be there and we were 'in it together'. After I discussed this issue with the principal, we decided that we should allow some time for participants to get used to the idea, but that planning should already start, since she was very enthusiastic about the implementation of the concept of LS.

In planning the research lesson I had to play an important part as the facilitator. Finding a topic for a research lesson was no real problem, since participants had to stick to the national syllabus. The learning objectives are spelled out in the syllabus, but building a lesson 'around' the topic was a more difficult issue. Participants had problems in finding realistic examples for the topic we had decided on. I assisted with teaching aids and all of a sudden the motivation of participants changed and all members took part actively. Some suggested changes to the teaching aids, some had very good ideas about how to implement these aids and all of a sudden they experienced themselves as a professional community. Finding a volunteer to teach the research lesson was not an issue at all after the initial hesitance.

However, there were anticipated difficulties that were raised during the process. These difficulties involved

- ✓ time constraints – three hours are not adequate
- ✓ getting all participants to be involved and enthusiastic about the planning of a lesson
- ✓ participants being reluctant to try out new strategies
- ✓ participants being reluctant to share ideas and experiences
- ✓ participants observing me, as the researcher, as another imposition on their already crowded day.

Unfortunately, two participants did not want to be part of LS, though they made it clear that they would take part in all activities regarding preparing the research lesson. Reasons for their withdrawal will be discussed under ‘data analyzes’.

Participants could not attend each other’s research lessons, because classrooms had very limited space in order to put two classes’ of learners together. This would have enabled participants that at least two colleagues could have observed each other’s research lessons. Participants had at the utmost three ‘free’ periods in a week during which they could have observed each other. However, the timetable was such that some colleagues had at the same time ‘free’ periods, meaning that they could not observe each other’s lessons. The Lower Primary phase participants were responsible for one class each, which was a challenge for adjusting the teaching if necessary. The Upper Primary phase participants were responsible for four mathematics classes each per year group (e.g. Grade 6A, 6B; 6C and 6D). Re-adjustment of teaching, meaning making adjustments to presented lessons, could have been taken care of much more easily.

The observation of each other’s’ lesson was resolved in that presenters were allowed to report back at the start of every workshop session. I attended all research lessons and added information if needed.

Future planning of research lessons from the second cycle onwards went much more smoothly. The planning sessions for the four cycles of LS are discussed under ‘workshops’.

- **Workshops**

The workshops started the first week after the teachers resumed their duties in January 2014. The teachers had to be at school four days before learners resumed their classes. On one of these afternoons time was set aside to inform the participants of the intended research. In this research exercise the ‘workshops’ were regarded as the PD for PSMTs. The duration of the workshop sessions was in the range of three to four hours.

Before the commencements of the workshops, I requested the Heads of Department to provide me with topics which seem to be a challenge in primary mathematics education. A long list was provided, consisting of almost all topics in the syllabi, but we agreed on the following topics: number concept, fractions and problem-solving (i.e. in the context of the participants named 'word problems').

The following table presents an overview of the content of the workshop sessions:

Nr	CONTENT	Nr	CONTENT	Nr	CONTENT
1	Introduction and overview of study	6	'Number concepts: 'Counting'	11	Fractions
2	Information: Lesson Study and Knowledge Quartet	7	Planning Research Lesson 3	12	Planning Research Lesson 4
3	Theory of RME Number Concepts 'Counting'	8	Multiplication Tables	13	Reflection on PD and RME
4	Planning Research Lesson 1	9	Reflection on PD		
5	Planning Research Lesson 2	10	Levels of questioning & SAT		

Table 4.4: Content of Workshop Sessions

A description of each workshop follows.

<u>Workshop 1</u> (Appendices applicable: A (p.414), C (p.419), D (p.420) & F (p.424))
<u>Getting started: Introduction and overview of the envisaged workshops</u>
The aim of the first workshop was to introduce the intention with this study and to give an overview of what participants could expect to learn by participating in the study.

This workshop's activities can be broadly summarized as follows:

- ✓ Providing an overview of what will happen over the next three school terms.
- ✓ Providing an opportunity to critically discuss with participants their participation and willingness in this research.
- ✓ Explaining what the two main issues of this research are: Realistic Mathematics Education (RME) and Lesson Study (LS)
- ✓ Providing an opportunity to experience the use of one RME principle. The other principles were to be experienced in the follow-up sessions.
- ✓ Providing the envisaged schedule of future workshops and a timeline of research lessons through the process of LS.

I facilitated the workshop. The principal welcomed me and informed the participants (staff members teaching primary school mathematics) that she had given her consent that this study could be conducted at her school, because she was convinced that teachers and the school community at large could benefit from this envisaged PD. The principal also elaborated on the importance that staff members should avail themselves to these PD activities, since the performance of learners at that school needed improvement. There was room to improve teaching skills in order to enhance performance skills of the learners. She mentioned the performance of learners in the Namibian National Standardized Achievement Tests (SATs) that were conducted in 2013. These national tests are assessments that provide diagnostic information regarding learners' achievement of key learning competencies in the mathematics syllabus of Grade 5 and 7 (MoE, 2014a). The outcome of the SATs include a report of each school to assist PSMTs to diagnose the challenges learners experience mastering key skills and competencies specified in the national syllabi.

I then informed the participants about the following issues (Appendix D, p. 420):

- ✓ Participation in this study was voluntarily. Participants names would at all times be protected (anonymously). All information would be handled confidentially.
- ✓ Participants might have taken part in other PD activities offered at the school. I stressed the fact that this PD will focus on the need to learn together (LS), to actively engage with colleagues and to build on existing knowledge and

experiences. All workshop sessions would therefore have a strong element of participation if they were to work properly.

- ✓ There would be a strong focus on learning something 'new' – how to incorporate RME principles into their lessons. Therefore, there would be a lot of discussions and demonstrations of how to prepare and come up with teaching aids for different topics in the school curriculum. In order to make this task easier, a range of teaching material and handouts would also be provided.
- ✓ Participants were encouraged to take notes in a diary. This would help them to reflect about the sessions later and also to pose questions about issues that were not clearly addressed. The notes could also provide contributions which they would like to discuss during or at the end of the study period.
- ✓ This PD was a training programme that provided opportunities to practice various skills, not only during the workshop sessions but also during normal class periods. Engaging in the workshop sessions was very important, because all sessions would 'build on' each other – they were interlinked.

The 'participant consent form' was discussed and handed out (Appendix A, p. 414) Participants were asked to go through the form again in their own time and sign if they agreed to participate in this study or should contact me should something not be clear. Once again it was made very clear that participation was on a voluntary basis. I informed them that they had a week to decide whether to participate or not. The principal wanted all PSMTs to participate and she made it very clear that she would appreciate if all PSMTs could attend the PD activities (in this case the workshops conducted every Thursday afternoon from 14:00 – 17:00). Two participants withdrew immediately from the research, because they did not want to be observed and interviewed. However, these two participants indicated that they would attend all workshops and lesson planning sessions on a voluntary basis.

The ethical considerations for this study were then discussed and participants were ensured of the following:

- ✓ Names of participants would not be used in the final draft of the thesis. Special coding of data would be used instead (Appendix C, p. 419).
- ✓ Notes, interview transcriptions, transcribed notes and any other information that could identify a participant would be stored on a pass-word protected personal computer which would be kept in a safe at my home.
- ✓ A participant could request to read information, view video-recordings and consult any other data gathered during the study at any time.
- ✓ In any publication that may result from the research no personal details of participants would be used.
- ✓ All material gathered would be destroyed when no longer needed for this research.
- ✓ Most important, I assured them that this research would not harm or exploit them among whom I do the research.

After supplying this information participants were thanked in advance for taking part in the study.

Before we adjourned I introduced participants to a tangram (Appendix F_1, p. 424). The experiences of this exercise will be discussed in Chapter 5.

<u>Workshop 2</u> (Appendices applicable: G (p.426), H (p.428) & S (p.488))
<u>Lesson Study (LS) and the Knowledge Quartet (KQ) (Rowland, Turner, Thwaites & Huckstep, 2009)</u>

For future workshops it was important for me that all participants are acquainted with the ‘rules and regulations’ of attending these sessions. Guidelines, determined by the participants, on how to go about during our workshop sessions where formulated. This should enable us to work together in a productive and harmonious atmosphere. These guidelines were also important to be remembered for future workshops, because we needed to work in a way that would be fair and respectful to everyone’s needs and contributions.

The workshop guidelines were written down on a flip chart and kept for future workshops to serve as a reminder. These guidelines were:

- ✓ Be a participant – everyone has a contribution to make – do not think that it might be regarded as 'invaluable'.
- ✓ Critique but do not criticize.
- ✓ When you give feedback always do it in the affirmative.
- ✓ Have fun.
- ✓ Immediately indicate when you do not understand.
- ✓ Allow colleagues time to speak and to express themselves.
- ✓ Confidentiality – no personal information shared in the workshop should be repeated outside the workshop.
- ✓ Appreciate each other – see this as an opportunity to learn from each other.
- ✓ Try to attend all session.

The aim of the second workshop was to refresh participants' pedagogical knowledge regarding school mathematics education. I explained to participants that we would have to agree on a set of key issues a PMST needs to know in order to function efficiently and effectively in a mathematics classroom. By requesting this I hoped to determine some of their views and beliefs about primary mathematics teaching.

Participants came from a broad spectrum and with different qualifications. I needed to ensure that everybody was feeling comfortable which I argue would then lead to successful learning. I divided the participants into groups, which meant participants teaching the same Grade were in one group. The majority of teachers were trained at different institutions and might not have had the same pedagogical content background knowledge.

A summary on the power-point presentation was used to facilitate the workshop as follows (Appendix S, p. 488):

- ✓ List some of the "things" you think a Lower and Upper Primary mathematics school teacher (PMST) needs to know in order to teach mathematics.
- ✓ Do you remember some categories of teacher knowledge? List them.
- ✓ What is the role of the mathematics teacher content-related knowledge in the classroom?
- ✓ What is the influence of 'wrong' concepts of content conveyed?

- ✓ What is the influence of positive experiences in primary school mathematics for the future of the learner?

Participants wrote down their ideas and after thirty minutes the groups had to share their suggestions. A summary of the answers to all questions were then drafted on the chalkboard and each group commented on the suggestions. Participants were asked to check their own list and to comment whether they thought that an important issue which appeared on their list had been left out. This took quite some time and a valuable discussion developed. For many it was a first experience of this kind of professional development. This session took almost two hours. I had to cut the discussion, because I wanted to still do the Knowledge Quartet (KQ) (Appendix G, p. 426)

The KQ was regarded as important for me, since it has the dimension of knowledge, transformation, connection and contingency which links very well to the RME principles, e.g. the use of the reality principle (connection), the activity, level and intertwinement principle (knowledge and transformation) and the interaction and guidance principle (contingency and connection). It also links to the 'views and beliefs' of PSMTs in that sense how they view teaching practice. I presented a 'lecture' on what is regarded as the KQ, since no participant was familiar with this concept.

A discussion then followed about what 'The Knowledge Quartet' is and why it is regarded as important. I allowed time for questions and comments. This was a totally new concept which participants heard for the first time.

This workshop was planned for two hours but in the end we finished only after three hours and LS was not even addressed. Before we adjourned I asked participants to solve a contextual problem (Appendix H, p. 428).

Workshop 3 (Appendices applicable: I (p.429))

'How to design Realistic Mathematics Education (RME) lessons'

I intended to develop RME lessons together with the participants as developed by Streefland (1991) in Zulkardi (2014) using the three level construction principle as was described earlier, i.e. the local or classroom level, the course level and the theoretical level (pp. 187 – 188).

It seemed to me that since RME and LS were totally new concepts to the participants, the use of these three levels could help participants to put theory into practice with my guidance. The aim of this workshop was therefore to prepare for what is meant by implementing RME principles through the process of LS (planning research lessons).

Number concept is a very important concept in the Namibia national mathematics syllabus. My emphasis in this workshop was to demonstrate what it means to think of number concepts in RME terms. The following aspects were attended to:

- ✓ What is counting? Are there different kinds of counting? Why is counting important?
- ✓ The structure of numbers up to 20 (increased for higher primary school Grades)
- ✓ Operations – in this workshop only addition and subtraction for numbers up to 20 were applied.
- ✓ I had several teaching aids prepared and teachers acted as learners in order to see how to apply them if they should choose to use them during a research lesson. This was a totally 'new' experience for teachers and it was quite a surprise to me. The comments and reactions of participants will be reported on in the next chapter.

Workshop 4 (Appendices applicable: J (p.432), K (p.435) & R_{4-5} (pp. 476-477))

Lesson Study and the planning of the first research

This workshop was conducted a week later than the previous one and the objective was that participants should get to know what LS entails and why they could benefit from this experience. This was an important session to take place, since the main aim was to implement research lessons, after a workshop session that handled topics being a challenge to participants. I used a power point presentation to explain to the participants what LS entails.

I presented this in the form of a brainstorm session to plan how and when participants would present a research lesson. A challenge was that participants could not attend colleagues' lessons, as well as the re-adjustment of a lesson for the Lower Primary phase participants. The re-teach phase (refine taught lesson) was a challenge, because the Lower Primary phase participants were responsible for only one class and the scheme of work was such that they had every day another topic to present. Therefore, LS should be seen in this study as a slightly simplified version. It was agreed that the person who presented a lesson would have a discussion with the whole group the same afternoon or as soon as possible thereafter, but at the latest at the next workshop session to discuss her/his lesson and the way forward for a topic.

It was problematic to decide when to put time aside to plan topics which had to be presented in the following five days. Due to time constraints and the fact that the majority of Upper Primary phase participants were involved in extra-mural activities, e.g. preparing for athletics competitions, the first research lessons were only planned for Grades 1 – 4. However, the Grade 5 – 7 teachers helped with the planning lessons for 'counting' for Grades 1 – 4. After this first planning session, participants from the Upper Primary phase were eager to get involved in LS. To find a suitable time was a big challenge. It was eventually decided that research lessons for the Upper Primary phase would be planned during break time. This in the end did not realize because of the time constraint. Therefore, all participants decided to present the planned research lessons by adapting the number range prescribed for each Grade.

Participants discussed how to implement the number frame and 'friends of five' and 'friends of ten'. Participants agreed that each learner should have a number frame and at least twenty counters of the same colour. Participants came up with very innovative ideas on what could be used as counters. Teaching aids for subitizing (recognizing small numbers without counting) were discussed and it was decided that the participants would use the 'buttons' and flashcards I had used as a demonstration during the workshop. Example of these will be taken up in Appendices R_4, p. 476 and R_5, p. 477.

The first research lesson was planned for the following Thursday morning for Grades 2 and 3. The syllabus topic was discussed along with having long term goals for learner learning in mind. All participants, regardless of the school Grade they were responsible for, helped in selecting the research lesson, helped in anticipating what learners might think and how learners would react to the lesson. In planning the lessons the participants and I agreed that the following rules should apply:

- ✓ Learners should be given a contextual problem that related to the lesson topic as a starting point.
- ✓ Interaction activities must be included, learners should be given clues or be guided individually or in their small groups if need be.
- ✓ Learners should get the opportunity to compare their results/answers in order to stimulate a class discussion. Teachers were quite skeptical about this point but willing to try it out.
- ✓ Learners should find their own solutions. Discovery was encouraged. If some learners would use shortcuts to answers, for example, they would write down answers only, but they should be prepared to explain their way of thinking.
- ✓ Participants must always have more than one problem in the same context available.

This workshop was adjourned after three hours.

<u>Workshop 5</u> (Appendices applicable: <u>K_2 (p. 441) & M (p. 456))</u>

<u>Feedback of presented research lesson, the planning of the second research lesson and mathematization</u>

This workshop started with the discussion of the outcome of the first research lesson. The objective of the workshop was to help participants appreciate and realize the importance of LS and the role it can play in developing them professionally.

One of the main objectives of this workshop was to summarize what is meant by ‘mathematization’. The participants were asked to discuss in their group what they thought ‘mathematization’ meant and how they implemented it in their daily lessons. The groups reported back and after the discussion the Upper Primary phase participants left the group (they had to attend to other important issues) and only the Grade 1 – 4 participants continued to attend the workshop.

The next research lesson was then planned. This lesson's focus was on computation strategies for addition. It was decided that the different participants from the different school Grades would plan their topic (the same topic for all different Grades but on different levels) as a research lesson and afterwards discuss planning. I served as 'resource' and participants asked for a lot of guidance, especially on the level and activity principle. The focus during the planning was on how best to incorporate RME principles. Grade 1 participants did not plan a research lesson, since they were still busy with 'familiarization' – the learners were not yet busy with mathematics, especially the aspect of mathematization which we have discussed earlier.

This session took very long and the planning could not be completed. Participants decided to continue during break times on the following days. I could not attend all sessions but a day before the research lesson I was briefed on what was planned and how the research lesson would be conducted.

Workshop 6 (Appendices applicable: R_1 (p. 473), R_2 (p. 474), R_4 (p. 476), R_5 (p. 477) & R_7 (p. 479))

Feedback on second research lesson and continuation of 'counting'

As with the previous workshop participants reported back on their research lesson. A discussion on the reflections followed, as well as the way forward. It took at least an hour, because every participant reflected rather comprehensively.

The objective of this workshop thereafter was to continue on the concept of counting in 2's; 3's; 4's and 10's. This was requested by the participants, because they had experienced uncertainty about it. The aim was that by the end of this session participants should understand how to incorporate RME principles (activity, reality, level, intertwinement and guidance) into their mathematics teaching. I formulated several questions for this topic which participants had to discuss in their groups and had to report back on after 30 minutes:

- ✓ Why is counting in 2's; 3's; 4's, 5's and 10's regarded as being important?
- ✓ What is the difference in teaching Grade 2, 3 or 4 these counting competencies?
- ✓ How do learners acquire skills to be able to do these important activities?

- ✓ What are 'nice' activities you have used in the past for these counting activities?
- ✓ How did you guide learners who experienced difficulties in activities where they had to count in 2's; 3's; 4's, 5's and 10's in the past?

Unfortunately participants had so much information to share amongst them that I had to stop them after an hour. It was then decided that the discussion of the above questions will be done at our next workshop since it was already 17:00 and participants had to attend to other issues.

Workshop 7 (Appendices applicable: K_3 (p. 445) & R_6 (p. 478))

Report back on questions of previous workshop and planning of third research lesson

The questions raised in the previous workshop were summarized in the groups and then representatives (groups decided on a representative for future workshop sessions) of the groups reported back.

The objective of this session was then introduced as being 'How can I address odd and even numbers in the lower primary phase?' This session was attended only by Grade 1 – 4 participants.

I gave a short presentation on the topic 'odd and even' numbers. The presentation was not only didactical in nature, but I also used it also to invite participants to a discussion on the topic 'odd and even numbers'.

Participants were then requested to think of relevant and suitable teaching aids which could be incorporated in a research lesson including RME principles. The representatives of the groups reported back after twenty minutes. I then discussed some teaching aids that I had prepared and distributed among the participants. A lively discussion followed. The planning of a research lesson followed and we went over our planned time of two hours for this workshop.

During this workshop it was decided that only one participant would present a research lesson per week, since the report back sessions took a lot of the time available.

Workshop 8 (Appendix applicable: R_3 (p. 475))

Report back on third research lesson and multiplication tables

The presenter of the research lesson reported back and shared her experience with the group. All participants (Grade 5 – 7 participants as well) took part in this workshop. Unfortunately the video recording that was made could not been shown because of a power failure.

The objective of this workshop was to find a way how to focus on skills of learners to learn the multiplication tables. In the prescribed Lower and Upper Primary mathematics school syllabi a topic 'mental mathematics' is prescribed. I prepared and planned the following questions regarding the objective:

- ✓ How do you start your lesson when you are doing multiplication?
- ✓ What are the basic mathematical concepts to master multiplication?
- ✓ Why are multiplication tables important to master?
- ✓ Which strategies are involved in multiplication?
- ✓ How do you 'build up' the multiplication tables? What is e.g. the order of mastering multiplication tables, do you do 2x; 3x; 4x tables, or do you do 2x and then first 4x tables before you do 3x table? How do you find ways to connect logically? Explain your answer.

I planned to do group-work for half an hour, but it took an hour before the groups were ready to report back. By the end of this session, participants reflected on how they used to handle multiplication tables in their teaching.

After the discussion I provided two examples of multiplication charts and we had a lively discussion about which one would be more suitable. Participants used it to reflect on their past experiences. Due to time constraints no research lesson was planned.

Workshop 9

Reflection:

Since we normally went over our planned time for the previous workshop sessions, I decided that this workshop would be used for reflection of what had been learned so far. At the start of the session I informed the participants of this decision. Their reaction was very positive. We used the chalkboard to summarize the experiences of the groups. Several participants wanted to share their experience individually. Participants participated freely and all experiences were captured. This session took two hours.

Workshop 10 (Appendices applicable: O_{1-3} (pp. 459 - 465))

Levels of questions and Standardized Achievement Test results

The objective of this session was to help participants understand the different cognitive levels of questioning. The SAT results of 2013 were distributed and an aim of this professional development was to increase the performance of learners in these tests. I used a power point presentation to update participants' pedagogical knowledge regarding Bloom's taxonomy and the different cognitive levels used to set up a balanced examination question paper.

I tried to incorporate how assessment in terms of RME could be implemented into the current examination system in primary schools. I used de Lange's (1995) five principles of assessment as a guide to lead the participants to how purposeful assessment should be conducted:

- ✓ The primary purpose of assessment is to improve one's teaching and learning. This means assessment should measure learners during the teaching-learning process.
- ✓ Methods of assessment should enable learners to demonstrate what they know (rather that what they do not know). It is important to have problems that have multiple solutions with multiple strategies.
- ✓ Assessment should operationalize all the goals of mathematics education – as it is prescribed in the Namibia National Curriculum. All three levels of cognitive thinking should be included.
- ✓ Assessment tools should be practical.
- ✓ Objective tests and mechanical tests should be reduced by providing learners with tests in which can be determined whether they understand the problems.

At the end of the presentation I prepared a worksheet with different mathematics questions and participants had to indicate the levels of the questions (Appendix O_3, p. 464). It was a group activity (same Grade participants were in one group). Participants were not quite sure of what was expected of them. After I had done two examples they continued.

The feedback session was summarized on the chalkboard. It took quite long, because disagreement on the levels of questions was very obvious. At the end we recorded all possible answers. I summarized the session and participants requested another session on this topic. I promised to focus on this topic before all question papers were due for the end of year examination session.

In reality this session did not quite link to RME principles, but I thought it important, because in Namibia the performance of learners is judged by the outcome of examination results.

<u>Workshop 11</u>(Appendices applicable: Q_{1-3}, (pp. 459 – 465))

<u>Fractions</u>

From middle of April until middle June no workshop or research lessons took place due to test weeks and school holidays.

The objective of this workshop was to develop an understanding of fractions (common, mixed and decimal). I handled this session in the form of a brainstorm and not as a didactic session. I wanted participants to have their understanding stretched beyond the 'textbook' and wanted answers to questions like:

- ✓ What is a fraction?
- ✓ How do you introduce the concept of a fraction?
- ✓ What is the relationship between fractional parts and a whole?
- ✓ Where do we use common fractions in everyday situations?
- ✓ How do you teach computation of fractions?
- ✓ How do you manage to move over from fractions to decimals?

Participants were overwhelmed by the number of questions and requested that half of the questions should stand over for the next session.

After the representatives reported back, I had an activity planned for them. It was playing 'domino' with fractions. Again, the time planned for this activity was not enough, but some participants managed to finish the game in their respective groups.

Workshop 12 (Appendices applicable: K_4 (p. 449), P_2 (p.467) Q_2 (p.471) & Q_3 (p.472))

Fractions, measurement and planning of fourth research lesson

The objective of this session was to complete the session on fractions and start with the introduction of how to teach measurement according to RME principles.

I prepared and planned different handouts on fractions, especially worksheets for learners which included questions on different levels of difficulties (Appendices P_2, p.467; Q_2, p.471 & Q_3, p.472). Participants asked that we should rather do several questions on the worksheet for them to use it in their class teaching. Several questions on the worksheets were brainstormed for participants to experience what it means to implement the reality, activity and level principle on a worksheet. This was a good opportunity for participants to experience an activity like this.

After this the participants were requested to plan a research lesson on the topic 'fractions'. An active and productive session was ended after three hours. However, the topic 'measurement' was not introduced.

Workshop 13 (Appendix applicable: U (p. 491))

Reflecting on implementation of RME principles

The objective of this workshop was to determine what participants have learnt so far regarding the implementation of RME principles.

The numbers 55; 17 and 38 were presented. Participants were asked to find a 'topic' for the lesson as well as to develop a lesson plan for these three numbers. Since all Grade 1 – 7 participants were present, the numbers for Grades 5 – 7 were increased to 155; 17 and 138.

Participants immediately went to task. They worked in groups for their respective Grades they were responsible for. They soon came with very interesting lesson plans which they wanted to demonstrate. Quite a different number of strategies were displayed and I had the feeling that participants enjoyed working together and were proud of their ideas. It was very impressive. The different strategies the participants displayed will be discussed in the next chapter.

As usual participants wanted to learn also something ‘new’. I prepared something on ‘how to develop additive thinking’ (Appendix U, p. 491). Participants immediately had an idea, since from the start of the PD it was emphasized that they should focus on conceptual understanding as well as on addition and subtraction at the same time. In giving the following problems participants had to consider possible strategies of how to give guidance to learners to solve these:

- ✓ Maria has some marbles. She gave three away. Now she has 8 marbles. How many marbles did Maria have to start with?
- ✓ Toivo has 5 marbles. Simon gave him some more. Now Toivo has 8 marbles. How many marbles did Simon gave him?
- ✓ Timo has 9 marbles. Johannes has 3 more than Timo. How many marbles does Johannes have?
- ✓ Tobias and Olivia had together N$100,00. They bought sweets and fruit juice. How much money did they had left?

For Grades 3 – 7 the number range was increased. The first three problems were handled and a lengthy discussion followed on what is regarded as a ‘transparent’ and a ‘hidden’ problem. The last question provided some difficulty. Questions like the following were asked:

- ✓ Did you not forget to add something?
- ✓ What is involved in answering this question?
- ✓ Why it is important to include these types of problems?
- ✓ Can you find other situations like the above which might generate opportunities for learners to discuss problem solving?

During all workshops that were conducted a lot of discussion took place. Participants often stayed after sessions to ask questions to get more clarity on issues. I wrote down a lot of information regarding these questions and answers of participants. Valuable information about their views and beliefs about mathematics teaching were provided.

- **Interviews**

Many questions were raised after an observation session or during informal talks with participants during break time or while waiting for classes to start. During focus group interviews three questions at the utmost could be asked, due to time constraints. It has been important for me to study participants' views and beliefs about teaching and learning primary mathematics and also what I observed them doing in their classrooms.

I reason that in order to understand participants' teaching practices from the participants' own perspective, understanding participants' beliefs with which they understand their own work is important. According to literature a teacher's beliefs are influenced by his/her practice and the interactions in the classroom are in turn again influenced by the teacher's beliefs (Kleve, 2009).

In order to collect data for triangulation purposes the following questions were drafted for individuals to elaborate on:

- ✓ What are your expectations of attending the planned professional development?
- ✓ Explain what you enjoy about teaching primary school mathematics.
- ✓ Elaborate on what were the reasons to become a primary school mathematics teacher.
- ✓ In case of your own teaching, are there particular issues why learners struggle with certain topics?
- ✓ Elaborate on your views about what primary school mathematics entails.
- ✓ What are you reading for your own learning to ensure professional development?
- ✓ In case of your own teaching, what do you regard as "being successful"? Give examples.

The following questions were drafted for focus groups to elaborate on:

- ✓ Elaborate on professional developments you have attended, if any, before this one.
- ✓ What do you think is the main purpose of teaching primary school mathematics?
- ✓ Which topics do you find difficult to teach? What do you think are the reasons for that?
- ✓ What is your experience (if any) regarding the prescribed syllabus? Is there a recommendation you could make regarding improving the syllabus? Explain.

The answers to these questions are comprehensively discussed in Chapter 5.

The description of data collection provides the outcomes of this study that can be evaluated. This evaluation can serve to draw conclusions about the experiences of PSMTs of the PD that was offered in this study. The results and findings of the gathered data will be reported on and discussed in the next chapter.

4.6 DATA ANALYSIS

Howard (1995) states that in an ethnographic research there are three broad categories, i.e. descriptive, reflective and analytical, to analyze the data gathered. In this research it was done accordingly.

The descriptive part of data refers to the recordings of the site, the geography of the location and the description of the participants. This was discussed under the sub-section 'sample'.

The reflective category served throughout my stay at the research site. The notes generated from classroom observations, workshops, interviews and informal conversations were reflective to generate an overall impression and to generate results and findings.

The analytical category refers to the initial interpretations linking all gathered data to lead to initial interpretations and findings. These categories originated from an investigative perspective based on the constructions by myself.

In this study the PSMTs' experiences partaking in an RME-based PD is the unit of analysis. The main focus of this study was on RME-based PD in which Lesson Study served the purpose to plan research lessons collaboratively and for participants to present these lessons individually. Classroom observation as a data gathering tool served the purpose to record the similarities and differences in teaching before and during the intervention. The workshop sessions addressed mathematization and the process of lesson study and therefore it is important to analyze what the experiences of the PSMTs were before, during and after the intervention. The analysis of the interviews will be a tool to verify the findings of this study. The analysis of these experiences is demonstrated in the following schematic presentation:

PROFESSIONAL DEVELOPMENT

↕

Experiences of PSMTs

↕

Classroom Observation:

Similarities and differences in teaching before and during intervention

The role of mathematization

↕

Lesson Study:

The influence of collaboration, collegiality and reflection on own teaching

↕

Workshops:

Mathematization, RME principles and planning of research lessons

↕

Interviews:

Views and beliefs before, during and after intervention

Figure 4.2: Schematic Presentation of Unit of Analysis

The arrows linking the different components are always pointing two-ways, illustrating the effect one research tool had on the other one. All tools contributed to analyze the experiences of the PSMTs partaking in this complex study.

In the next chapter the findings will indicate what the experiences of the participants in this RME-based PD were. These experiences were influenced by partaking in workshops as a PD activity in which participants were for the first time exposed to the process of Lesson Study and the RME theory. The analysis will also indicate whether the views and beliefs of these participants regarding primary school mathematics teaching were challenged or not.

4.7 CONCLUSION

I used a combination research instruments, such as classroom observation, workshops and interviews. Previous research studies on professional development, RME and LS found the combination of these instruments to be effective (Buhari, 2011; Hurd & Licciardo-Musso, 2005; Sembiring *et al.*, 2008; Sembiring *et al.*, 2010). This ethnographic study required from me to collect text-rich data, which will be analyzed in the next chapter.

It was very time consuming for participants to attend to all RME-based PD activities. In this study the availability of time was a crucial factor to success. The contact hours in the workshop ranged from at least two hours up to four hours per session.

The next chapter will indicate whether and to what extent it has shown positive effects on the PSMTs learning. It required from me, the researcher that time needed to be effectively planned and the content purposefully structured in line with the needs of the participants.

I claim that if the PD is purposefully directed and focused on content and pedagogical knowledge, it should result in positive experiences for the participants attending such on-going PD activities. In this study the activities were aimed at helping participants to better understand both what they teach and how learners acquire specific content knowledge and skills in mathematics.

The interpretation involved that I had to attach meaning and significance to what I had observed and experienced. By providing a detailed description of the research design, I intentionally focused the readers' attention on the complexity of the process of PD.

In the next chapter I will present the findings of this study. The findings will answer the main research question, which is

'What are the experiences of PSMTs who participated in RME-based PD?'

and the sub-questions, which are

- *'How can RME principles and LS contribute to the PD of the PSMT?'*
- *What are the PSMTs 'views and belief about mathematics teaching?'*

CHAPTER 5

FINDINGS

5.1 INTRODUCTION

In the previous chapters issues like the Namibian Education System, a summary of the literature consulted for this study and the intended research methodology were discussed.

The reader might expect this chapter to be called ‘analysis’. However, the literature consulted (Denzin & Lincoln, 2011; Patton, 2002) explains that qualitative analysis transforms data into findings and that the challenge of qualitative analysis lies in making sense of a huge amount of verbal data. I was involved in an ethnographic case study in which I analyzed my relationship with the participants as well as discovered some insights about myself and the experiences of Primary School Mathematics Teachers (PSMTs) of Realistic Mathematics Education (RME) in Professional Development (PD). I therefore prefer to call this chapter ‘findings’.

In this chapter I will report on the actual findings of my own analytical procedures and processes. In putting forward these findings, I accept the possibility of some subjectivity, since I might have had my own perceptions of some issues during this study. However, I have tried my best to avoid personal bias in order to reach accurate findings that eventually will lead to valid and relevant recommendations. Therefore remarks by participants are often quoted because ways they experienced the process at the different stages are of vital importance.

This study contains the results of experiences PSMTs had with RME-based PD and LS in 2014. However, since both concepts, RME and LS, are not familiar to PSMTs in Namibia, the aim therefore is to look for possibilities to introduce and integrate these approaches in future PD activities in Namibia.

I argue that PSMTs' experiences are to quite some extent influenced by existing, long-held 'subject knowledge', 'views and beliefs' and 'ways how their learners learn mathematics'. Their experiences are also influenced by their understanding of LS.

The findings should provide the necessary information and viewpoints to answer the main research question, which is:

> *What are the experiences of primary school mathematics teachers' who participated in RME-based professional development?*

The sub-questions of this study should also be answered. They are:

- *How can RME principles and LS contribute to the professional development of the primary school mathematics teacher?*
- *What are the primary school mathematics teachers' views and beliefs about mathematics teaching?*

The second sub-question will also address how participants view the experiences they encountered with RME principles and LS during this study.

The main emphasis of this study was on implementing RME principles in participants' classroom situations. Therefore, the emphasis focused to a lesser extent on LS due to a time constraint. Participants requested that the PD they participate in should also consider challenges they experience in the classroom. This reminded me of the participants' perspectives such as work context.

Patton (2002:431) states that

> "*The moment you cease observing, pack your bags, and leave the field, you will get a remarkably clear insight about that one critical activity you should have observed… but did not. Analysis brings moments of terror that nothing sensible will emerge and times of exhilaration from the certainty of having discovered ultimate truth. In between are long periods of hard work, deep thinking, and weight-lifting volumes of material.*"

The above quote is an exact description of how I experienced it coming to an end with the data collection and starting with the analysis part of my study.

In this chapter rich, detailed and concrete descriptions are provided to share the experiences of the participants in RME-based PD and LS with the reader. The aim in analysis and reflection is to draw conclusions about the experiences of PSMTs on professional development and the possible contribution of this study to the participants' teaching.

The actual PD in this study happened during the workshop sessions. However, in these workshop sessions time had to be set aside to plan for research lessons. In the process of LS a research lesson is regarded as a lesson that is collaboratively planned, but presented individually.

Literature (Chauvot & Turner, 1995; Drageset, 2010; Leder *et al. (Eds.),* 2002; Tella, 2008) prepared me for the fact that participants will bring along their own views and beliefs to the PD. These might be challenged or not. Therefore, this study would not be complete if participants were not allowed to elaborate on questions, which might portrait their views and beliefs regarding mathematics education, which is an important contributing factor.

From the main and sub- research questions it is evident that RME and LS were utilized to collect data to derive at findings regarding PSMTs' experiences of PD. The following illustration should put the findings of the data generation into perspective.

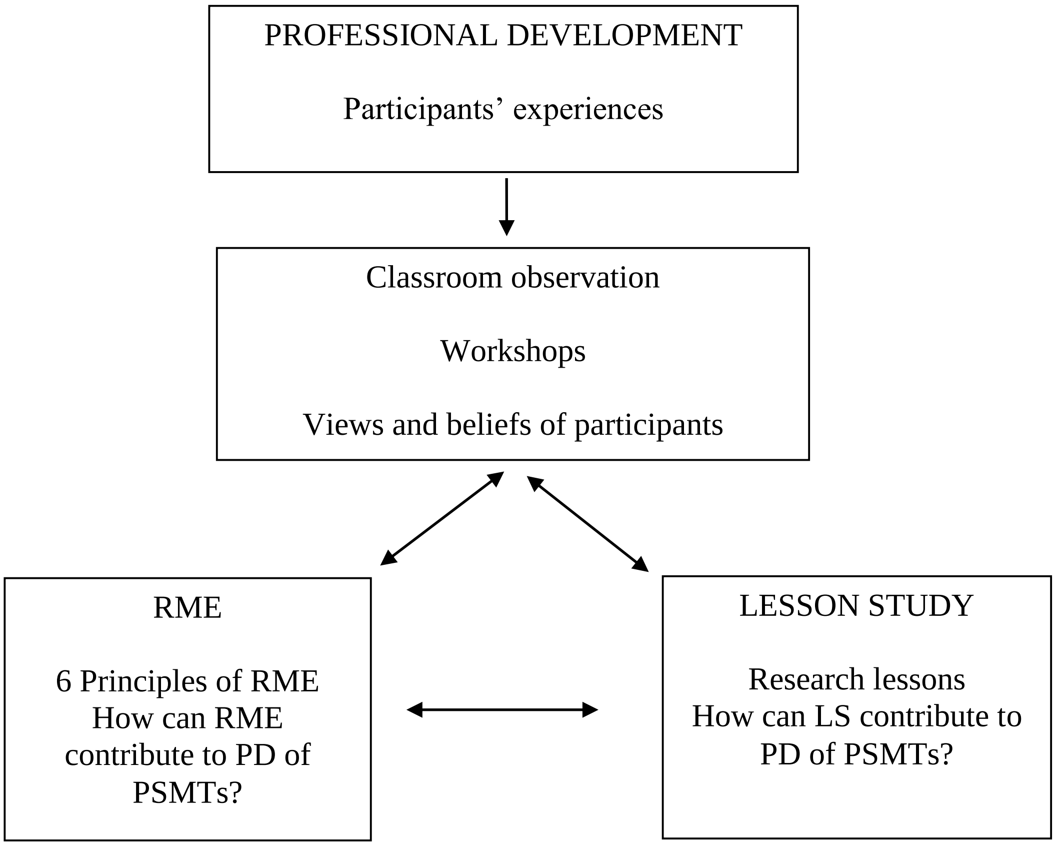


Figure 5.1: Presentation of Findings

The above illustration explains the unit of analysis, i.e. the experiences of PSMTs participating in PD. Participants had their views and beliefs regarding primary school mathematics teaching already before the start of this study. Participants experienced RME and LS for the first time. These two concepts were applied in the workshop sessions. Participants experienced for a first time to collaborate with colleagues across the two primary school phases, i.e. Lower and Upper Primary school phase. Therefore, the two-way arrow between RME and LS indicates that the learned RME principles were applied and implemented through the process of LS. Some workshop sessions were set aside to plan collaboratively research lessons, which participants then taught individually. The two components, RME and LS demonstrate the link, the two-way arrow, to the classroom observation and workshop sessions. Classroom observation served as a tool to indicate whether participants' teaching changed or not during the intervention (workshop sessions) and whether the PD challenged participants' views and beliefs regarding primary school mathematics teaching.

The findings of this study will indicate the PSMTs' reflections upon their own classroom experiences when applying RME principles in their teaching. It will also clarify their experiences of the contribution of LS towards their own PD. Therefore, the findings will be presented in the form of vignettes of PSMTs teaching in the spirit of RME.

In 'Vignette 1' the findings of different stages in the participants teaching are presented. This will inform the reader whether the RME-based PD contributed (or not) to teacher learning. 'Vignette 2' reports on the findings of PSMTs' experiences with respect to LS and RME. This is necessary to place the findings of this study in context. LS and RME were new concepts for participants. In 'Vignette 3' findings on PSMTs views and beliefs regarding teaching, before and in the spirit of RME, are elaborated on. These vignettes of PSMTs teaching in the spirit of RME are followed by the limitations and verification of this study.

The findings of this study will determine the recommendations and future development of PD activities in Namibia.

5.2 Vignettes of PSMTs' teaching in the spirit of RME

This study's focus was on participants' experiences in PD regarding RME principles and LS. Therefore, the findings will be presented in different sub-headings to guide the reader through the different stages in participants' teaching and their experiences they encountered in the workshops and with the process of LS. These findings will then be complemented by means of the views and beliefs of mathematics teaching participants elaborated on during interview sessions.

5.2.1 Vignette 1: Different stages in PSMTs' teaching

To have an overview of this sub-heading the following illustration is provided to guide the reader.

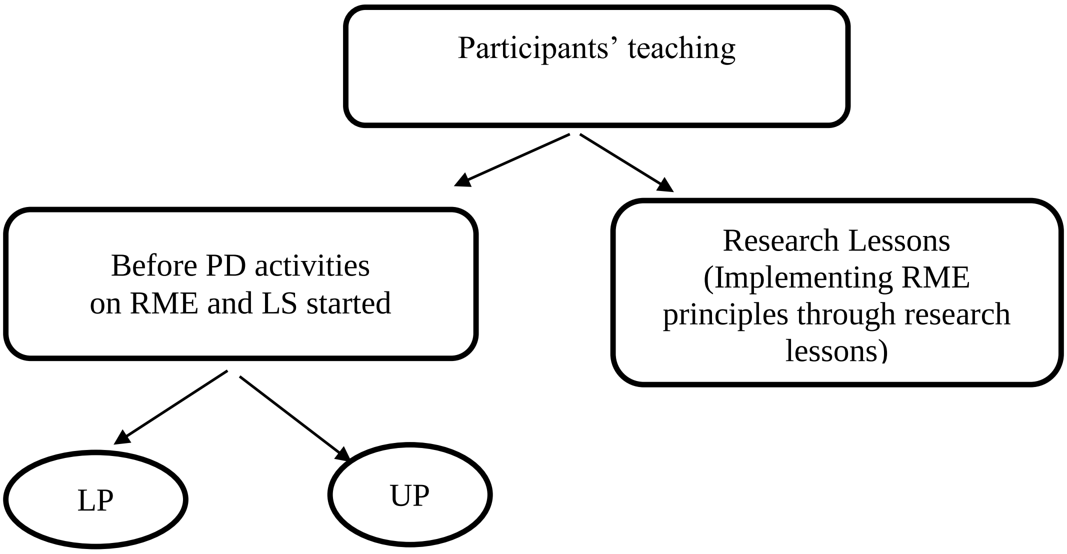


Figure 5.2: Overview of Participants' Teaching

In this sub-section the findings of participants' teaching is reported on before as well as whilst they have been involved in RME-based PD and LS. The reason why I have observed participants' teaching before the workshop sessions (PD activities) started, is to have an idea of how participants approached their daily teaching before any intervention had taken place. The classroom observation whilst the intervention took place served the purpose to determine whether participants' teaching was significantly influenced by the PD.

The observation covered a full 'normal' day of a participant. The observation might also point out why some topics seem to pose particular challenges to the participants.

- **Findings emerging from participants' teaching: Before the intervention started**

Participants planned all lessons before the intervention started individually. It was not required of participants to write out the planning of lessons.

I will present the teaching of the Lower and Upper Primary phase participants separately. The reason is that the participants' way of teaching, levels of teaching and especially the teaching structures are significantly different in the different primary school phases. The teaching structure for the Lower Primary phase will be described first.

In Grades 1 – 4 the participants are class teachers, i.e. they teach all subjects in that phase. In this phase participants may be flexible concerning time and can re-arrange periods as they need, i.e. they could teach more periods mathematics on a specific day, while on the next day no mathematics lessons were offered. In this study this principle was practiced by participants when LS was implemented. It was very useful, because participants did not feel pressured by time. However, participants mentioned that they would not prefer to have a day without a mathematics-lesson. The National Curriculum for Basic Education (MoE, 2010) provides guidelines for timetabling in the different school phases.

In contrast, in the teaching structure for Grades 5 – 7 participants are regarded as subject teachers, i.e. in Namibia they usually do not teach more than two subjects per phase. The Upper Primary phase participants are usually responsible to teach mathematics to all class groups per Grade, i.e. they repeat a lesson for different classes in a specific Grade. In the Upper Primary phase fixed periods are allocated to subjects, including mathematics. For the Upper Primary phase the participants utilized the double period allocated on the timetable to implement LS.

At first the participants were not comfortable with my presence in their classroom. One reason for this was that many of these participants were my former students during their BETD studies and possibly felt 'threatened' and that they might have disappointed me. I explained my role as researcher and that the basic aim was not an evaluation of anybody's teaching skills. After getting used to my presence the participants relaxed and the situation changed for the positive. They acted more naturally and with confidence. It enabled me to observe what really took place in the classrooms.

I want to find answers to the question whether RME principles and LS offered in PD can contribute to PSMTs own learning, knowledge and teaching of primary school mathematics.

Another point of consideration was to determine whether the participants benefitted from RME-based PD and gradually included it in their teaching practice, and with what degree of effectiveness.

The observation of participants' teaching started in the last week of January 2014 and continued up to the end of October 2014. The findings of the Lower Primary phase participants' teaching before the intervention starting off are discussed first.

<u>Lower Primary (LP) phase participants' teaching</u>

- **LP Participants' classroom management**

The number of learners in the classroom for Lower Primary was in the range of 40 – 49 learners. There were three English- and one Afrikaans-medium class for each year group. The classrooms were neat and in front of every Grade 1 classroom was a clean carpet. The tables and desks for Grades 1 and 2 were arranged in groups of four in three classrooms. In another classroom the arrangement was horizontal rows from side to side of eight benches each. Still other classrooms (Grades 3 and 4) had vertical rows from front to back of eight benches each. Therefore, every classroom had at least six rows of eight benches. I regarded the arrangement of the horizontal rows as very crowded with limited possibility of movement between the learners. Obviously a few of these arrangements make provision for discussions (e.g. group work) amongst learners.

These classroom arrangements did not change noticeably during the course of this study.

The participants did not give the impression that they have fixed rules for class room behaviour. On the one hand three to four learners were allowed to leave the room to go to the toilet. Each time the participant was asked for and granted permission to go. I experienced it as being quite disturbing. The participant handled these situations as normal practice.

On the other hand authoritarian discipline (characterized by strict obedience) was handled throughout a lesson period. Participants mentioned that strict discipline helped them to cope with the big groups. Many of the participants put greater emphasis on classroom management than on transferring of knowledge. This created the impression of teacher-centredness. Participants did not allow enough time for questions to be asked. Time was a crucial issue, because several times participants made the comment that by allowing learners to ask questions and to argue time was 'wasted'.

Participants tried to speak very slowly, especially in the English medium classes, because the majority of the learners' mother tongue was not English. However, most of the participants also do not speak English as their mother tongue. Their limited knowledge of mathematical terminology in English made it difficult for them to engage learners in terms of the meaning of the mathematical terms or symbols. In some cases the participants switched code to the mother tongue of the learner, i.e. if the participant is fluent in this mother tongue as well. By switching code the participants might have argued that learners might have a better understanding of the mathematical concepts because the participants were drawing on their beliefs and knowledge about what constitutes 'good teaching' peculiar to their context.

- **LP Participants' behaviour: Response to learners and teaching**

All lessons had the same routine. A lesson started by the learners greeting the participant and myself followed by a prayer. Then the learners had to count. Grades 2 started to count from zero to twenty, later up to fifty, Grades 3 counted from zero to fifty and Grades 4 started counting in two's or three's always from zero to fifty. Learners did not count individually, they chorused the counting activity. The participant then introduced the new topic by saying:

> *Today we will do .... Please pay attention. You have to look carefully what I am doing otherwise you will not be able to do your homework.*

The participants continuously presented the lessons in a similar mechanical ('step-by-step'/'stepwise') way. Learners were not allowed to ask questions while the participant presented the lesson content. At the end the participant asked some questions to test understanding *Do you understand?*
and learners chorused *Yes.*

However, the participant did not ensure with additional questions whether the learners really understood. Since the active involvement of the learners in the class was very limited there was little opportunity for the participant to respond to learners' answers.

Most of the time learners were requested to take the information down in their 'neat' exercise books.

Learners did neither ask questions nor were they involved in activities during the presentation of the participant. After presenting the lessons learners were involved in 'activities' which were based on the lesson presentation. For example, learners were introduced to the number 'eight'. The participant demonstrated several times how to write the numeral 8. Learners had to repeat the drawing imaginarily in the air. Only much later they were given an activity sheet with dots on which they had to complete in a certain order to get the numeral 8. Lessons were very rigid and learners were only allowed to do the activities after the lesson presentation. The activity was given to be completed as homework if it was not completed in the lesson time. Participants had difficulty to move around in some classrooms because of limited space.

I observed that the majority of lessons were presented abstractly in a mechanistic, stepwise, way. For example the numeral 8 was the topic of the lesson. The focus was on the symbol 8 only and not so much on the meaning behind the symbol, maybe because of time pressure. Learners had to imagine the content without having a concrete idea of what the context was about. The participant demonstrated the numerical symbol '8' abstractly and later on how it can be presented pictorially. Another example, learners counted from one to ten by heart, i.e. rote counting. They did not even have counters in front of them – no rational counting was done. The participant did not distinguish between rote counting and rational counting at all. Rational counting implies that learners have counters available and counting is done in the following way: The learner has some counters in the hand; putting one counter down saying 'one'; putting the next counter down saying 'two' and so forth (one-to-one). This was the case with most of the topics that I observed.

The Grade 3 and 4 participants focused very much on working in a stepwise (in this study also referred to as 'mechanical') way:

Step 1 is…..Step 2 is… Good, you have paid attention. Well done.

Learners chorused what each step was. Learners were also assigned routine duties in the classroom – one had to distribute the exercise books, they were collected after every lesson to stay in class, some had to clean the chalkboard regularly, while another one had to note down names of learners who did not 'behave'.

The participants had teaching aids available but did not use them in every lesson, apparently because of time pressure:

> *We have to push, otherwise we will not finish.*

This comment I heard very often and this is the reality of time pressure common to school mathematics teaching I realized very soon.

<u>Summary of findings emerging from LP participants' teaching before the intervention started</u>

To summarize, the teaching in general was very mechanically (stepwise). No attempts were made to attract the interest or attention of the learners. There was no link between the content and the learners' reality. Although the participants had some teaching aids available they did not use them consistently and efficiently. The efficient use of teaching aids would have implied that they become a tool to help the understanding of mathematics concepts for all learners. Instead activities were done, for example learners sang songs; recited rhymes and did exercises while doing counting activities without any clear purpose or use of teaching aids. Participants might have used these rhymes and songs for example as pedagogical ways of connecting mental and visual representations with symbolic, numeric representations. Most of the participants did teaching in these ways. However, these activities usually did not supplement the learning because no clear move from the concrete to the abstract stage with understanding and confidence occurred. This created the impression of teacher-centredness and 'stepwise' control over the learning process. The use of context relating to learners' everyday experiences (RME: reality principle), involving learners in challenging activities (RME: activity principle) and involving learners in their teaching (RME: interaction principle) was not observed at this stage. Participants created very few opportunities for learners to be guided to reach a correct solution to a problem (RME: guidance principle). In fact these learners in early Grades had to remember 'steps' how to solve problems.

To distinguish between the practices of the participants in the different phases in primary school I describe the findings of the Upper Primary phase participants next. This will enable the reader to relate to the need to involve all PSMTs in primary school simultaneously in future PD projects.

Upper Primary (UP) phase participants' teaching

- **UP Participants' classroom management**

The classroom organization was very similar to what I have observed in the Lower Primary phase. The classrooms were also arranged either in groups of four desks or long vertical rows of ten desks each. Class sizes ranged from 40 – 48 learners. Classes appeared to be very overcrowded. The participants apparently were used to it as they did not regard it as a problem.

Participants handled strict discipline. Learners were reprimanded several times if they were noisy. This was quite disruptive for some learners and it also influenced the 'flow' of the lesson. One easily lost 'track' of the lesson. However, the strict discipline ensured that the participant had the class 'under control'. As in the Lower Primary phase discipline almost appeared to be more important than the conveying of knowledge.

- **UP Participants' behaviour: Response to learners and teaching**

Learners had to greet the participant and me before the start of a lesson. Normally the period started off with the 'correction of homework'. A participant is usually responsible for more than one class group. With the first group the participant was doing the homework together 'with the learners' meaning learners had to answer questions like: *What do we have to do first?*

Again, the instance of stepwise control and teacher-centredness was also visible here. Homework was done step by step. For the next groups the homework simply remained on the chalkboard and had to be marked against the chalkboard without explanations. Marking homework took up at least half of a period. At the end the participant asks:

Do you all understand now?

Learners, chorusing: *Yes.*

The participant did not ensure whether individual learners in fact did understand. As in the Lower Primary phase the presentation of the lesson followed the same pattern every day. The observed participants all demonstrated the same instance of 'stepwise' control and teacher-centredness.

The participants tried to implement the idea of a lesson introduction but they mostly did it ineffectively. They demonstrated enthusiasm by trying to motivate the learners at the beginning of each lesson. Normally they involved the learners for a few minutes in a discussion to attract their interest and attention. This usually was about what happened the previous day that was of interest or what the results of the last soccer or netball games were. That made learners pay attention although they could not effectively link it to the day's new topic.

The use of English as medium of instruction was problematic. It posed a severe challenge to several learners, especially in Grade 5. In Namibian schools Grade 4 is seen as a transition year utilized to gradually change from mother tongue instruction to English as the medium of instruction. Therefore, the participants quite often had to switch codes and use the learners' mother tongue – i.e. when the participant was able to speak it – to explain a mathematical concept.

Mostly attempts of the class to be involved were interpreted as lack of discipline or not paying attention. Participants' 'body language' discouraged learners to feel free to ask questions. Instead of directly responding to the learner's questions the lesson content presentation was repeated by the participant.

Very little individual guidance was given during the presentation of the lesson, because learners were not allowed to make remarks or ask questions during lesson presentation to indicate problems. This demonstrated that participants were teacher-centred orientated.

The following is a direct quote from an observation of a Grade 6 class:

> *Ok learners, today we will do conversions of common fractions to decimal fractions. Please pay attention to what I am doing otherwise you will not be able to do the homework.*

The participant demonstrated two different examples from the textbook. While solving the conversions the participant talked and wrote simultaneously. Learners repeated the 'steps' by chorusing. The participant responded by saying 'good' and continued with a next problem. Afterwards the question followed: *Do you understand?*
Learners, chorusing Y*es*.

Sometimes the participant noted that some learners were not responding. The participant then demonstrated another example in the same procedure as above. After the repetition and the chorusing of 'yes' louder than the first time learners were instructed to open their textbooks and to solve some exercises:

> *In the same way I just did it on the chalkboard*.

This was the procedure followed for all lessons.

Learners have to answer 'yes' or 'no' questions. Sometimes learners were asked to do examples on the chalkboard – if a learner was not able to come with a solution, another learner was called to do the chalkboard to continue or to correct the previous learner's attempt. Very little guidance was provided for a learner who obviously experienced difficulties or to guide the learner in conceptual thinking. Although repetition was done regularly participants seldom gave additional or supplementary guidance to learners.

Learners write many short tests in order to determine whether they have mastered the content. In cases where the average of the test results was below 50% the participant might spend another period on the same topic. The practice of writing short tests to determine understanding is questionable since the tests often do not really test understanding.

Learners' performance in this phase appeared to be very good considering the Grades achieved in tests. Participants are very satisfied with their teaching, because they would say:

> *The term test results demonstrate that we have achieved our aims and objectives*.

The term test results were above average for the classes I observed. The reason for that was given by a participant as:

> *You see, it is important that learners are taught rules. They can apply them in the tests, because they know them by heart. I am very strict during my presentations as you might have observed.*

Participants are pressured for time and they tend to follow the sequence of the textbook. However, the topics in the textbook do not follow in a clear conceptual and sequenced manner.

Mathematization, which is an essential factor in RME, was not observed. Learners had limited opportunities to 'unpack' the mathematics. An example to demonstrate that mathematization did not really happen as can be demonstrated by the following example.

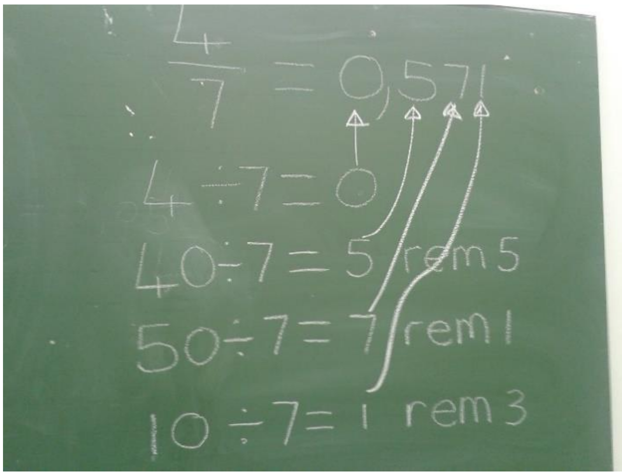
The procedure to convert a common fraction to a decimal was taught as follows:

Participant:	*Convert 4/7 to a decimal fraction*
Participant:	*Step 1: 7 goes into 4?* (It should actually have been 4 divided by 7?)
Learner:	*Zero times*
Participant:	*Write zero comma - 0,*
	Step 2: make the 4 forty and divide by 7 - 40/7
	Therefore 7 goes into 40? (Actually 40 divided by 7?)
Learner:	*5 times – write 0,5*
Participant:	*Step 3: there is* (are) *how many left?*
Learner:	*5*

Participant: *Make it 50 and divide by 7- 50/7*

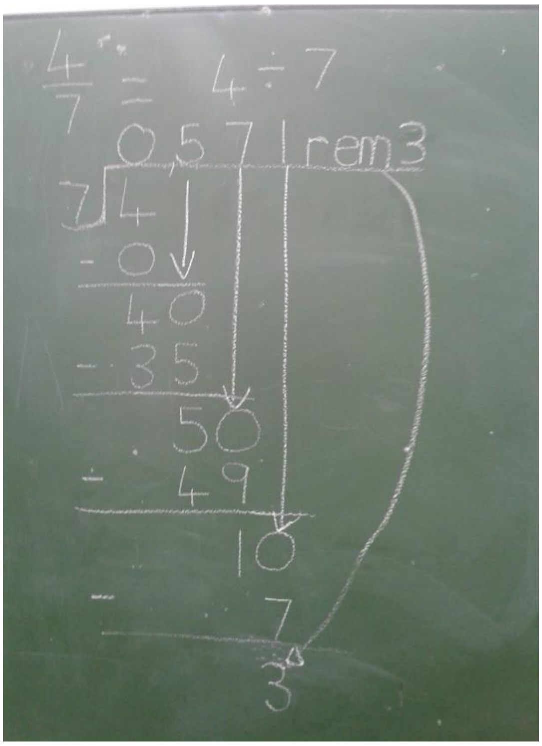
Participant: *Step 4: The process starts all over*

The chalkboard work looked like



Explanation on chalkboard: Convert 4/7 to a Decimal Fraction

The seventh fractions are rational numbers and are in fact repeating decimals. I think the participant realized it and stopped after the third decimal place after the comma. From the above it is evident that the learners' involvement in 'doing mathematics', (i.e. mathematization) did not happen. It was done through a step-by-step (stepwise/ mechanical) procedure expected and enforced by the participant. The participant realized that some learners did not follow and he then used long division to convert the common fraction. The same procedure as above was followed.



Another Explanation on Chalkboard: Convert 4/7 to a Decimal Fraction

The participant demonstrated that the / sign means division which is correct. However, he did not demonstrate with an 'easier' fraction like for example 1/4 which becomes one divided by 4. Using 'long division' the participant would have derived at an answer of 0,25 which is equivalent to 25/100. If the participant would have used this as an example, he could have applied mathematization – 'unpacking' the mathematics. I missed the link to equivalent fractions, when participants were busy with the topic 'decimal fractions'.

Problem solving is for example a separate topic and is done in isolation. The majority of learners experienced severe problems in solving the so-called 'word problems'. The lessons I observed that were planned for problem solving always started by the participant saying:

> *Today you have to pay attention – we will do a difficult topic*.

This statement obviously immediately discouraged the majority of learners to actively participate. The textbook was the only resource participants used. In some cases problems in the textbook could easily have been adapted to make these problems more concrete and real to life for learners. This supports the point about the lack of learning opportunities for PSMTs. These teachers should be provided with PD activities which pay attention to their needs they experience in their classrooms.

A participant responsible for Grade 5 for example asked learners to solve the following 'word problem':

> *'Mother baked 84 biscuits. She wants to put them into packets to sell. If she puts 12 biscuits into each packet, how many packets can she fill?'*

Learners had to read altogether the problem twice. The numbers 84 and 12 were underlined – no reason provided. Four learners had to show how they solved the problem on the chalkboard. The answers follow:

Learner A: *12, 24, 36, 48, 60, 84 = 6 packets.*

Learner B: *(took very long to answer) 84 ÷ 12 = 7*

Learner C: 84 – 12 = 72, 72 – 12 = 60, 60 – 12 = 48, 48 – 12= 36, 36 – 12 =24, 24 – 12 = 12, 12 – 12 = 0

Leaner D: (12) (12) (12) (12) (12) (12) (12)

12 + 12 + 12 + 12 + 12 + 12 + 12 = 84

The participant asked: *Whose answer is correct?*

Some learners shouted out after quite some time: *B*

Participant: *Yes correct. Can you see class you have to divide 84 by 12 and the answer is…*

Learners, chorusing*:* *7*

The participant did not even discuss the other three learners' answer.

This is one of many similar incidents happening daily in participants' teaching. It clearly demonstrates that participants experience challenges in guiding learners to find a correct solution. The three learners, A, C and D, could have been easily guided towards 'unpacking' their mathematical thoughts and deriving at a correct answer. Especially learner D was, while drawing his 'packets' silently, counting on like 12; 24; 36; 48; 60; 72; 84. Similar to what A did. Though learner D was displaying his answer as 12 + 12 + 12 + 12 + 12 + 12 + 12. When I asked the participant why she did not discuss the other learner's solution the well-known comment of:

I have to finish in time

Language competency obviously plays an important role in problem solving. Some learners were not able to completely understand what they have read. Participants always requested the learners to read the problems at least twice but this was done by the class as a whole, reading together. The participant explained some important (difficult) words without the learners being actively involved in the choice of words and then asked individual learners to solve the problem step by step.

I acquired a better understanding of what was happening in the classroom and to have empathy with the challenges the participants have to face every day. To handle a class group of more than 40 learners with a variety of mother tongues is surely no easy task.

<u>Summary of findings emerging from UP participants' teaching before the intervention started</u>

To summarize the classroom observation sessions before the intervention took place I observed that the participating PSMTs, in their daily practice, perform their lesson in a fixed sequence, i.e. opening - demonstrating how to solve an example – exercise out of the prescribed textbook – closing by giving homework. The lessons were dominated by the normal 'chalk and talk method' and the authority totally in the hands of the participant. In the Lower Primary phase participants had some activities and teaching aids planned for the learners, but in the Upper Primary phase learners where not involved in any relevant activities to discover a concept. Lessons were dominated by the participant and learners were passively listening. Very little time for mathematical thinking and reasoning was made available for learners. Mathematization, the ‘unpacking’ of mathematical matter did not feature. For example when doing the so called ‘word problems’ no attempt was made to give learners a chance to discuss how they arrived at their solutions (RME: activity principle). Very little learner involvement in participants’ teaching was observed (RME: Interaction principle). The possible reason for this might be that participants prefer strict routines which probably gave them confidence and a sense of security.

The emphasis of observation then shifted from individual planning to group planning. This was quite important, since the process of LS started by the participants planning a lesson together in groups and individual participants presenting at least one of these lessons. The first evidence of change in the participants’ way of teaching should become evident at this stage. The presentation of the research lessons started after the fourth workshop, first week in March 2014 (Appendix E, p. 422).

- **Findings emerging from LP and UP participants’ teaching: Implementing research lessons**

The planning of the research lessons were normally conducted during workshop sessions set aside for the process of LS. Sometimes the planning of a lesson could not be finalized during an afternoon session and then the completion of the lesson plan depended on the time available during break time. However, the findings of the participants’ teaching the research lessons will be done first (though the planning happened first) to put the study’s findings of participants’ teaching before and during the intervention into context. The reason is to be able to distinguish more easily between similarities and differences of participants’ teaching before and during the intervention.

The first research lessons (Grade 2) were presented from 10 – 14 March 2014, the second research (Grade 2 & 3) lessons from 17 – 26 March 2014, the third (Grade 2 & 3) from 7 – 12 April 2014 and the last (Grades 4 – 6) from 6 - 10 October 2014. A complete schedule of the workshops, indicating in which research lessons were planned is to be found in Appendix E (p.422).

Overall, participants planned four research lessons and I observed eight of them. These research lessons (Appendices K_{1-4}, pp. 435 -453) were not sequential, because we had to stick to the 'normal' routine of the participants.

I observed four Lower Primary phase participants' research lessons and two Upper Primary phase participants' research lessons. For the Upper Primary phase I observed two different class groups of each participant. Due to timetabling constraints it was not possible to observe more. Chapter 4 points out that a decision was taken that from research lesson number three and onwards only one participant presented a planned lesson. However, I continued observing participants on their request during this study.

In this sub-section I will not distinguish between LP and UP participants teaching, because the lessons were planned collaboratively for a specific Grade and even if the lesson was planned for Grade 2 for example, all participants taught the lesson as they stated '*to get the experience'.*

The following is a summary reflecting on research lessons of the participants.

- **Participants classroom management**

Some presenters of the first research lesson (Grade 2) (Appendix K_1, p. 435), i.e. a lesson the participants planned collaboratively and presented individually, experienced difficulties in getting learners involved in doing the activities as they guided them through the lesson. Learners were not used to be actively involved in a lesson (RME: interaction principle). The learners seemed to be very 'unruly' as one participant mentioned. Learners were running around, talking, some not paying attention to instruction given by the participant and some learners just sat passively doing 'nothing'. However, this changed after some time when learners realized that they had to find a solution to a problem they had never done before (RME: activity principle).

The classroom management of the participants (Lower and Upper Primary phase) changed. They acted more than a facilitator (facilitating learning; RME: guided learners to re-invent) during the lesson and not anymore as the 'instructor' (transferring of knowledge). Learners were not as quiet as before, but it was a positive learning atmosphere. Learners engaged with each other and worked in groups.

- **Participants' behaviour: Response to learner and teaching**

First research lesson (Appendix K_1, p.435)

At first learners had difficulty in comprehending what the participants expected of them. Previously learners chorused all counting activities. In this first research lesson it was quite different; learners were asked to continue counting where a previous learner was stopped. All of a sudden learners paid attention because the participant asked learners randomly to continue. Especially the backwards counting was for some learners a challenge if they had to count backwards individually. The participants were quite surprised that the exercise regarding the sequences was solved by learners very fast. Working in groups forced learners to talk to each other in solving the exercise. A first experience for learners and for participants was in 'allowing much more freedom' to solve problems. The contextual problem was correctly solved by learners without a lot of guidance from the participants' side (word problems were regarded as 'very difficult'). The solution to the problem:

> '*There are six groups in total. There are three learners in a group. How many learners will be in a group if 12 learners join the class?'*

Learner A: *Easy – if there are six groups and one learner joins each group there are four learners in each group. If another learner joins there will be 5 learners in the each group, because 6 + 6 = 12.*

After the lesson the participant came to me and said:

> *'I would have solved the problem regarding the learners joining differently. I would have divided 12 by 2 and then added 2 learners to each group. No wonder learners struggled in the past. The learner solved the problem so logically and that for Grade 2! Unbelievable!*

Participants of the other class groups reported back similar 'successes'. One participant mentioned that the problem about:

> *'Mia's sister is 17 years old. How old was she six years ago?'*

the learners solved the problem by counting backwards' 16; 15; 14; 13; 12; 11. In the past they would have asked 'what do we have to do – add or subtract?' Participants gave learners opportunities to display their answers.

Second research lesson (Appendix K_2, p. 441)

In the second lesson, terms like horizontal, vertical and diagonal were totally new to them and a 3x3 square was something they had never used before (Appendix L, p. 454).

The participants wrote the information necessary for completing the 3x3 square on the chalkboard, for example that the numbers one to nine had to be placed in the square in such a way that they will always add up to 15, horizontally, vertically and diagonally. Each number might be used only once.

Some learners were very fast and thought they had a 'solution', but at a closer look and with the guidance of the participant they realized they had made a mistake and had to start all over. In general the mathematical mental skills of learners were not good. However, one learner managed to find a correct solution and it excited the group tremendously. These group members started to explain to their friends what they had done. In the end many different solutions were demonstrated by the learners. It was a first time for learners to demonstrate their own produced solutions to their peers and that engaged learners actively in the teaching process.

The following demonstrates how effectively the participant handled the responses of the learners.

Quite surprisingly for the participant a learner said

Learner X *Madam, I see now that 2 + 5 + 8 = 6 + 5 + 4 = 7 + 5 + 3. The 5 has to be in the middle.*

The filled-in square looked like:

8	1	6
3	5	7
4	9	2

Immediately another learner argued

Learner Y *Not true. 8 + 1 + 6 = 15 and 5 is not even included.*

His square looked like:

4	9	2
3	5	7
8	1	6

The boys in class got excited about the possibility of different correct solutions. For me it was interesting how the participant handled the situation. She said:

> *Both of you are correct. But remember learner X points to the diagonal and middle row of the 3x3 square, whereby learner Y points out to the last row of the 3x3 square (She used one of the 3x3 squares of the learners to demonstrate).*

In this incident the participant was able to guide learners, guided re-invention (RME principle), in the sense that she observed, listened and monitored learners as they worked on the problem. She asked questions that helped learners to see connections or to derive at generalizations ('five is always in the middle').

Learners were purposefully and actively involved in the lessons, an experience learners had to get used to at first. Learners were eager to find their own solutions to realistic context problems.

<u>Third and fourth research lesson (Appendices K_3, p. 445 & K_4, p. 449)</u>

The third and fourth research lessons had similar experiences as above. Learners enjoyed the research lesson on odd and even numbers (research lesson 3). While planning the lesson the majority of participants were sure that a lot of guidance would be necessary to give an answer to

> *'if I add two odd numbers will the answer always be even?*

Learners had no problem in answering and by checking on their ten frames they quickly added 1 + 3; 3 + 5; 5 + 7 and they immediately came to a conclusion. The participants were able to guide learners who experienced challenges.

In the fourth research lesson the participants had to give a lot of guidance. Learners experienced difficulties in finding the answer to ½ + $^{1}/_{5}$. By letting learners discover which 'fraction strip' (Appendix P_3, p. 468) could be used to find an answer and the teacher demonstrating that for example ½ and ¼ can be both be used by *'only one strip, i.e. the quarter strip' (sic)* (strip divided into quarters). It took not long and learners used the strip that was divided into tenths.

The sequence the lessons followed in the research lessons can be described as opening – learners doing an activity normally in groups of 4 – learners presenting their solutions – learners discussing the solutions and participants posing a new contextual problem – closing by the participant summarizing the solutions to questions.

<u>Summary of findings emerging from participants' teaching implementing research lessons</u>

To summarize the findings of the research lessons presentations I can state that participants were able to structure their lessons by emphasizing learners' learning. It was a very difficult start because learners were used to be given information and instructions and not to elaborate on or discuss their answers. However, being involved in the PD, participants were able to engage learners to explain their thoughts, or comment on the responses of the learners or even facilitated a discussion (interaction principle).

However, some similarities in the classroom observation before and after the intervention were still evident. The Lower Primary phase participants still used songs and rhymes to start off but they at least ensured that they linked in a way to the day's new topic. The Upper Primary phase participants continued to handle very strict discipline during their presentations. A reason for this might be that the participant felt 'more secure' in having not so much noise in the classroom. These participants also demonstrated the same confidence in their teaching than previously.

Participants started to present lessons in a logical order. For example addition and subtraction were not done in 'isolation', but concurrently. The participants were able to still use the examples in the textbook even though not necessarily in the same sequence as the textbook. Estimation in the Upper Primary phase was applied where possible and not only in one topic. Learners became skilled in 'checking' the correctness of their answers by comparing each other's solutions. Mathematization and mathematical talk became 'normal practice' in the classroom. These differences in the teaching of participants were evidently brought about through the process of LS. Samples of worksheets developed by participants are to be found in Appendices P_2, p. 467; R_6, p. 478; R_8, p. 480; R_9, p. 481; R_{10}, p. 482 and R_{11}, p. 483.

Learners were very excited during the research lessons and remarked

> '*We are doing again the different mathematics (sic) today*'.

Learners participated actively in research lessons. What was interesting to note was that participants had indicated some of these learners before the lessons as 'trouble makers' but then these very same learners often acted as group leaders during the research lessons. Participants were very surprised about this occurrence. It was also evident that although the classroom organization was 'not disciplined' according to the participants the fact that learners argued, discussed and worked together to reach solutions for problems in a purposeful manner was experienced as a 'highlight'.

In the next section the findings of participants' difficulties with respect to RME principles and LS are presented.

5.2.2 Vignette 2: PSMTs' experiences with respect to LS and RME

To have an overview of this sub-heading the following illustration is provided to guide the reader.

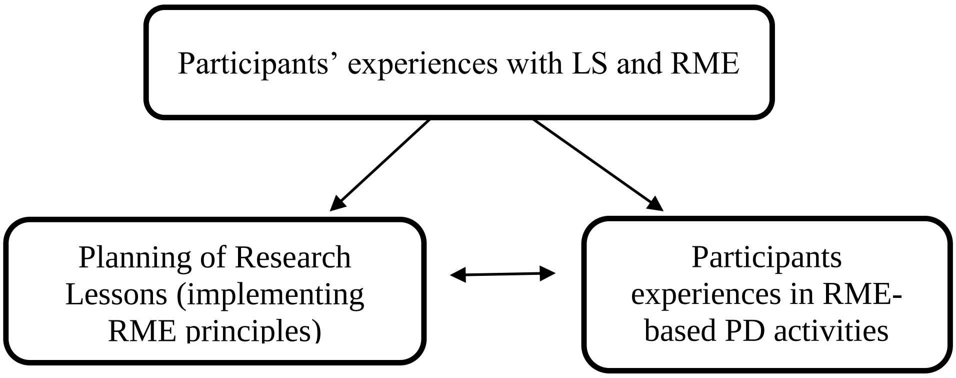


Figure 5.3: Participants' Experiences regarding LS and RME

The planning of RME research lessons might be influenced by the participants' experiences in the workshop sessions. The two-way arrow indicates the relationship between the two.

In this sub-section the findings of participants' experiences with respect to LS and RME are reported on. The experiences in planning research lessons are reported on first, because the process of LS was a new concept that participants came across during this study. Some workshop sessions were utilized to plan research lessons. The reasons why I present the findings on the planning of research lessons separately from the workshop sessions, is that participants experienced for the first time to plan collaboratively, i.e. all participants irrespectively of being in the Lower or Upper Primary phase, planned a lesson. I argued that for future planning for PD activities these experiences of participants would be valuable. The experiences of the participants might point out whether it is recommendable that Lower and Upper Primary phase participants should be involved to plan research lessons together as a group of primary school mathematics teachers.

The findings of participants' experiences regarding the workshop sessions will be discussed after this sub-section. The reason why I present the findings in this order is that the professional development regarding RME was also a new experience to participants. It was a comprehensive study in which participants were exposed to new concepts with the aim to develop professionally. The workshop sessions had to be arranged in such a way that participants could implement what they have experienced so far regarding RME in their research lessons. The aim of the workshop sessions was to expose participants to RME principles which might help them in their teaching. The findings of these sessions might point out whether it would be worthwhile to expose participants to on-going RME-based PD.

- **Findings emerging from participants' experiences in planning research lessons**

In this section an overview of the findings of the research lessons and not so much about the actual content is provided. Appendices K_1 – K_4, (pp. 435 – 453) will indicate the content of these lessons. The reason for doing this is to focus the attention on the participants' experiences they encountered in implementing research lessons. I argue that '*Experiences of PSMTs in PD*' is the main unit of analysis.

The first research lesson was planned for Grade 2 and the topic was 'Counting'. The second research lesson was planned for Grade 2 and 3 and was for the topic 'Computation'. The topic for the third research lesson was 'Odd and even numbers' for Grade 2 & 3. The last research lesson was planned for Grade 4, 5 and 6 and was for the topic 'Fractions'. The research lesson planning was quite an issue because to find a suitable time when all participants could attend was problematic and for this reason four workshop sessions were utilized.

- **The process of Lesson Study (LS) in this study**

In this section the findings of LS also reflect on the participants' discussions and my initial role as participant in the planning of the first two research lessons.

In the process of LS research lessons play an important role because participants get the opportunity to demonstrate the knowledge, skills and strategies they have obtained in the workshops. In this study a research lesson is regarded as a lesson that participants planned collaboratively but presented individually. In the process of LS reflection on the lesson forms an integral part. In the situation of this study it was not possible for participants to observe each other's lesson presentation because during school time classrooms could not be left without a supervisor. All participants commented and reflected on their presentation of research lessons individually and since I attended most of these lessons I could share in their experiences.

The process of LS was slightly adapted for this research. My focus was more on the planning of a lesson as a group and then observing a participant presenting the lesson before reflecting on it. LS was a new concept to the participants. Another reason for adapting the LS is the fact that finding a suitable time for all participants was problematic. We had to make use of Thursday afternoons which was originally reserved only for PD activities. Therefore, only one lesson was planned and not a number of lessons, as the original intention was, for the following week.

Participants from Grades 1 – 4 are responsible to teach all subjects. Therefore they have to prepare for quite a number of subjects and had limited 'free' time. The Grade 5 – 7 participants in this study were mainly responsible to teach mathematics only but two participants had to teach another additional subject. The Upper Primary phase participants are responsible to teach more than one class per year group.

- **The experiences of participants' planning of research lessons**

The first number of classroom observations revealed that participants use the textbook in their daily lessons as only resource. Participants do the same examples in the same sequence as they appear in the textbooks as well as their tests are drafted out of the textbooks.

The initial research lesson's planning was a 'learning experience' for the participants and for me. I never expected that participants would find it so difficult to plan a lesson as a team. Nobody was willing to take the initiative and start working. It was quite an awkward situation. I was forced to act as facilitator and get the group eventually motivated and starting to plan. The topic for the first lesson was decided on in the previous workshop. The Namibian syllabus provides the learning objectives, approaches and basic competencies. This made the first hurdle easy to cross. Since it was a first research lesson, the group of seven participants (five participants from Grade 1 – 4 and two participants from Grades 5 – 7) decided that participants from both phases should plan a lesson for Grade 2 together to get the necessary experience. The Upper Primary phase participants agreed that they would assist since some of their colleagues were not present. Participants argued that:

> *If we know the process, the second cycle will be easier.*

Participants also decided that since there were three groups teaching through English medium of instruction and only one Afrikaans group in the Lower Primary phase it would be more practical if all research lessons were planned in English. The participant of the Afrikaans group agreed to translate the lessons. The only part of the whole process that was conducted in Afrikaans was the delivery of the research lessons. Language proficiency was a problem and participants often switched between English and Afrikaans as they felt more comfortable in expressing themselves in the latter which all participants could understand.

During planning for the first cycle the topics for all research lessons were decided upon. Without directly having been instructed that they had to implement RME-principles one participant took the initiative and asked

> *Which RME principle will we use in each topic?*
> *Is it possible to use all principles in one lesson?*

After a slow start initially it was quite a surprise experiencing participants to become so motivated and enthusiastic. I guided them by advising them to consider the following questions before they start:

- ✓ Is the topic rich in mathematical content and valuable?

Here the participants used what I explained to them in the workshop. They used the different meanings a number could have for a learner in a different context. They could e.g. take the number 15. This number can be used in different contexts – with the emphasis on contexts – for example ‘he is 15 years old’; I have N$ 15.00; I have to be at home by 15:00.

- ✓ What is the mathematical level for the specific Grade?

Although the number range increases for Grade 3 the group preferred to stick to the same number range since it was a first lesson.

- ✓ Can we include ‘problems’ (exercises) which include mathematical features that will lead to further mathematical development?

Here they argued that addition and subtraction could be included.

Although participants initially had strong differences of opinion they eventually agreed to develop their lesson plans according to the following steps:

- ✓ Note down a ‘problem’ and list possible responses that might come from learners.
- ✓ Ensure that the ‘problem’ is clearly stated. (However, strong disagreement of language use existed amongst participants. (RME: Interactivity principle))
- ✓ Devise a strategy that learners could apply to understand the ‘problem’. (RME: Guidance principle)
- ✓ Ensure that it is a challenging but realistic problem. (RME: Context and models)
- ✓ Set a possible ‘time frame’ e.g. how long each activity could take.

In planning the first research lesson participants wrote down all ‘instructions’. The reason for this was that they experienced this process as a ‘new’ way of doing. A complete lesson plan, according to them, would ensure that they would not get lost. The participants developed a lesson in which ‘counting’ moved over to ‘calculation’ as they also titled their lesson. Participants were very eager that the first lesson should be developed in detail because some of them remarked:

> *In future it will save us a lot of time*.

However, planning follow-up research lessons went much more smoothly. Participants used the same format as above. Those participants who had not been present the first time felt ‘left behind’ and asked many questions. One participant said:

> *If you want to learn something make sure you attend all lessons. We cannot waste our time now to explain everything again*.

From this planning session onwards participants really made an effort to attend the planning of research lessons. However, participants were involved in primary school extra-mural activities in the afternoons and finding another suitable time to slot in was not possible, so regular attendance of all participants remained a challenge.

The Upper Primary phase participants were also actively involved in the planning of the research lesson. It was an unforgettable experience for both Lower and Upper phase participants. Each planning session took at least three and a half hours and comments from participants afterwards were:

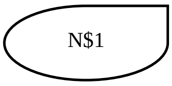
> *That was great.*
> *All lessons should be planned together.*
> *I am afraid that I will mess up in my presentation.*
> *We have to also plan lessons for Upper Primary – this is great. I will teach this lesson as well tomorrow.*
> *I cannot belief how much we can assist each other. I always find it difficult to find extra problems. My colleagues are my source from now on. We did not even have a textbook here this afternoon.*

The last comment was especially interesting since participants tended to be very text-book-bound. In the planning of the lessons it was interesting to note that one participant tried to pin a RME principle to each step. This was a totally new experience for the participants. The principal called me one morning and expressed her satisfaction saying that it was not only a learning experience but also a motivational exercise for all PSMTs.

The planning of research lesson for Grades 3 – 6 experienced minor challenges in the sense that deciding on the relevant level for content took quite some time before detailed planning could start. In the end participants decided that the content would be the same but the number range for each year group should be as prescribed in the national syllabus. The research lessons were always planned for a double period.

While planning a lesson, participants were involved in discussions. These discussions were valuable because for the first time participants engaged each other in mathematical talk. An example follows.

Participants realized that knowledge of the meaning of numbers in a specific context is an element of basic numeracy. They argued that by giving them a 3x3 square, which is relatively an easy exercise for a first experience learners' mental skills would assist them in completing the task. In Grade 2 learners should be aware of different strategies to count, for example counting on or ‘making a full ten’. Participants felt that by giving a realistic problem to learners they used the example they did in one of the workshops. Realistic in this sense that it should relate to learners’ everyday experience. This example related to ‘bags of money’, e.g.



(numbers 1 to 9) and each ‘bag of money’ must be placed in the 3x3 square that the sum will always derive at N$15, horizontally (rows), vertically (columns) or diagonally. Participants were quite sure that learners would be successful with this activity because using ‘money’ related to learners’ everyday experience.

Participants had many suggestions how to demonstrate the solution to learners. One participant had a challenge to complete the 3x3 square for example. A colleague took her completed square and did not cut the rows but the columns into separate strips. Every column added up to 15, she demonstrated, using the other colleagues’ rows that also added up to 15 and then suddenly the participant screamed with excitement:

I have it, I have it and she put the separate rows together to ‘get the square’.

Almost all participants made the following remark at the end of the session

> *Yes, I agree now some problems can have more than ONE* (emphasis on ONE) *correct answer.* (Appendix L, p. 454)

<u>Summary of findings emerging from participants’ experiences planning research lessons</u>

To summarize the planning of research lessons participants started with a problem in which learners were confronted with an exercise to develop mathematical insights. For example for the second research lesson the participants ensured that the principles, the activity (e.g. learners had to solve a 3x3 square;), the reality (e.g. learners were given a bag with play money), the level (learners had to go through various levels of thinking – what is ‘horizontal’, ‘vertical’ and ‘diagonal’ in a 3x3 square; knowledge, application), intertwinement (this topic could have served under the topic ‘money’), interactivity (learners could work in groups) and the guidance principle (interactive involvement of the participant) were adhered to. Participants, with involving me as a ‘resource’, developed research lessons with enthusiasm and commitment.

The next section will present the findings on the reflections of the research lessons.

- **Findings emerging from participants’ experiences regarding reflections after presentations of research lessons**

Reflection after a lesson plays an important role in the process of LS. The participants experienced for the first time to reflect critically on their lessons in the presence of their colleagues.

The presenters of the research lessons whom I have observed, as well the others who presented the developed lessons, reported back comprehensively before the start of a next PD activity. It was interesting to note that participants ‘opened up’, they were quite critical about the outcome of the lesson. I had the impression they wanted to hear whether their colleagues experienced similar challenges.

The report back sessions took very long but it was these events that participants found very useful. It was a first experience to them to report ‘to each other’. One participant said

> *For the first time I share my experiences, good and bad, with my colleagues, not only in the same phase but across all phases. The good about it, we do not criticize each other we listen and think about better ideas and solutions to challenges.*

However, an important issue of concern to the participants was that:

> *RME lessons take too much class time. We will never finish the syllabus.*

This issue arose quite often. Sometimes it might have dominated the positive experiences participants had in their classrooms.

The participating PSMTs' views and beliefs regarding mathematics teaching were nevertheless influenced by the PD activities in this study. This becomes evident from the following quotations:

> *I see my role in the mathematics classroom now differently. I listen to learners, especially if they solve their problems differently as I have explained it to them.*

> *I realize now that memorization (*multiplication table) *and automatisation (*to 'see' that a 3 + 7 or 4 + 6 will always result in ten – 'friends of ten'*) represent different aims, though the mental processes used are for me the same.*

> *Learners need 'short-cut' calculation strategies.*

> *Learners have to know number bonds ('friends of') and their multiplication tables by heart. No issue about it anymore.*

Due to a very high teaching load it was not possible for the participants to observe each other's lessons which hindered the process. At the start of a workshop session and sometimes during break-time the presenter of the research lessons reflected on their lesson. The first reflection was very 'reserved' and the presenter wanted me to do the reflection. Eventually the reflections became more spontaneous and honest. Later on in the report back session the presenters were very realistic and critical about themselves, in my view sometimes too much so. A serious concern from the presenters' side was the time factor. However, since it was a first experience, they realized that with practice this challenge might be overcome. In the end the participants honestly believed that this 'project', as they referred to LS, improved their own classroom instruction. One of the main reasons they mentioned for the improvements were the type of collegiality and collaboration they experienced. The participants seriously tried to implement RME strategies and I could observe definite improvement in the teaching strategies of the participants. One participant said:

> *I like to see my learners arguing, reasoning and enjoying the lessons.*

I could also observe a change in the attitude of the learners. When they saw me coming with the presenter of the research lesson they screamed with expectation:

> *Yeah, today we will enjoy the lesson*.

However, this comment made by the learners, made me realize that currently not all lessons could immediately be adapted to RME principles. Participants confirmed this, because as they remarked:

> *We are not ready yet – we still need you*.

The report back session was very important because presenters gave information about issues they had not considered during their planning. Suitable language plays an important role in RME-rich lessons and these research lessons proved it. Even the participants sometimes had difficulties to find the correct terminology to explain or to guide learners.

<u>Summary of findings emerging from participants' experiences reflecting on research lessons</u>

To summarize the reflection sessions, I can state that overall the research lessons were regarded as being very successful because the cycles of LS responded to the needs of the participants. The participants all changed in the way they presented the lessons after attending the planning sessions. Consequently it gave the participants a sense of 'I can, I am able to be successful' and the feeling that their learners performance might improve in future.

PSMTs' participation in the workshops increased tremendously after they experienced the positive influence of collaborative planning lessons and the individual presentation thereof. They were enthusiastic about the opportunities they noticed and experienced how RME ideas connect with ways learners think and ways how to challenge learners with respect to the content. Participants tried their utmost to attend all PD activities not to be left behind. I would like to focus the attention to some of the participants' experiences by quoting some comments to indicate the influence this tool had on their views and beliefs regarding their mathematics teaching.

The following comments further illustrate the participants' experiences in the implementation of research lessons and reflecting about it:

> *I thought that I am an experienced and capable teacher. I only realize now how much I have learned. The reflection session, where I had to report to my colleagues about my own practices in class made me aware that I still have to learn.*
>
> *I have to change my ways of teaching. I experienced now that I think about a lesson's context before I present it. One particular session has opened my eyes to the importance of number concepts. I have to focus more on mental computation. I realize that my own mental capabilities leave much to desire!*
>
> *It has made me realize that I have to look through the eyes of the learners. Attending the workshop session, being a learner myself, and experiencing how many different responses came up when we had to develop a research lesson made me realize how important collaboration is. My colleagues' reflections (*on their research lessons) *were so honest and open that I realize how important it is to deliver lessons that have meaning for learners.*
>
> *I think about context while doing preparation for the next day.*

The above quotations clearly indicate that the participants were becoming reflective about their own teaching. They were thinking about context and about how the lessons have meaning for learners. Above all, they experienced the sharing of knowledge and experiences, positive and not so positive, encountered in their classroom with their colleagues. They became confident possessors and sharers of subject content knowledge. By planning lessons collaboratively participants shared their experiences they encountered in previous lesson. An important finding was that participants started to question their 'own beliefs held'; for example participants started to explore learners' understanding in a systematic way. Comments like 'I think about context' or 'the importance of number concepts' or 'I still have to learn' demonstrate that participants started thinking of RME principles like the intertwinement, activity and reality principles. Participants started to set the scene by posing a realistic problem which was established in context and which invoked prior knowledge and experience. A disadvantage was that the research lessons could not be planned sequentially because of time constraints.

Another important finding is that participants also realized that their own mental strategies needed development as one of the above quotations correctly states. It was a first experience for participants that their teaching strategies and the application thereof were seriously challenged. Participants generally accepted that they need to pay more attention to their own as well as their learners' mental skills.

The teaching aids prepared for the research lessons will be taken up in Appendices P_3 (p. 468); R_3 (p. 475) and R_{12} (pp. 484-487).

The LS process enabled the participants to come into contact with each other. It was a first experience for Lower and Upper Primary phase participants to share their knowledge, experience, anxieties and joy as colleagues in the same environment. During this study it became evident that these participants became engaged in an active learning community.

- **Participants experiences with respect to RME principles**

Participants' experiences with respect to RME principles by partaking in PD activities which focused on mathematization and RME might have challenged the views and beliefs of participants. Mathematization and RME principles were new concepts for participants.

I present the main findings with respect to the PSMTs experiences during and after the 13 workshops facilitated by me as researcher for this study. These findings are supplemented by quotations to demonstrate the knowledge and skills participants possibly obtained in applying RME principles not only in research lessons but also in their daily practice. Participants had never been exposed to any PD of that magnitude.

The workshop sessions served two purposes for the participants, firstly to acquire knowledge and skills to apply the RME approach and secondly to plan research lessons collaboratively.

I regarded the on-going workshops both as follow-up sessions and as sessions in which a new approach was experienced and practiced. In the following sub-section the findings are presented of how the activities and responses of RME ideas in PD were experienced by participants.

- **Findings emerging from participants experiences in PD activities**

Tangram activity (Appendix F_1 (p. 424))

The first two workshops were more aimed at providing information regarding the research as well as to get all participants informed about what to expect of the PD sessions. After the first session participants were given a copy of a tangram on an A4 sheet (Appendix F_1 (p.424)).

Without being questioned the participants spontaneously reported what they see:

> *There are triangles, a square and a parallelogram.*

Participants were not familiar with the concept ‘tangram’ (a Chinese puzzle consisting of seven flat shapes which can be put together to form different shapes). A lively discussion about the properties of the 2-D shapes arose. All participants know the properties of the 2-D shapes very well. When asked to cut all 2-D shapes out and ‘form’ or ‘build’ any realistic figure, using all shapes they had serious difficulties with this task. Some participants just sat de-motivated and did not know what to do. Working in groups improved the situation. It was quite a challenge for them to come up with a realistic figure. To guide them I put a ‘cat’ on the chalkboard (Appendix F_2 (p. 425)). After half an hour participants had acceptable figures and were very proud of their achievement (Appendix N (p.458)). When I asked them ‘what have you learned’ one excited participant screamed out:

> *Mathematics can be fun. I did not know you can use geometric shapes to create something. What an experience!*

After the excitement I asked them to re-build the square we started with. Again some participants were lost. They were extremely afraid of being evaluated, of being seen as a failure. Interestingly, it was the Lower Primary phase participants who succeeded after some time. Participants went home very excited each with a copy of the tangram to 'test' their learners the next day.

Before the start of the second workshop participants reported back about their experiences with their learners doing the exercise with the tangram. They were quite surprised with the abilities of their own learners. They made remarks such as:

> *Learners are more capable than me. They had no problems to build figures, and also to re-build the square at the end.*
>
> *I think we underestimate the creativity of our learners*.
>
> *We have to do more of these types of activities. We have to think out of the box.*

I observed two of these lessons (using the tangram example of the workshop) and learners really enjoyed it very much. The participants could not believe to what extent learners were actively involved in the lessons in a purposeful way. These responses proved to me that participants would like to participate in activities in which they would be able to update their knowledge and skills in specific areas.

<u>Knowledge Quartet and Problem Solving (Appendices G (p.426); H (p. 428); M, (p. 456) and S (p. 488))</u>

The activity where participants were requested to answer questions and list issues regarding their teaching (Chapter 4, p. 206) was quite disappointing for me as the researcher (Appendix S (p.488)). It seems as if they never really had considered 'what is my purpose as a teacher'. After the discussions participants realized how valuable discussions, in this case about their beliefs about their role and purpose as a teacher, with colleagues can be and to make clear decisions on where to they should be moving as committed and motivated teachers. For the majority of participants it was a 'first time' experience. Participants confirmed that they do not 'talk' about mathematical issues during break time or at meetings. My impression was that participants are able to defend themselves only on issues they feel very passionate about. For many of them it was a valuable experience to learn that to disagree, does not mean 'you do not like me' as one participant put it after the session. It was also a first experience for participants to distinguish between pedagogical and content knowledge. Some participants were quite adamant that they had 'never' distinguished between these two concepts at tertiary level.

When participants were asked to elaborate on how they plan a lesson, it was quite obvious that they only use the textbook to guide them what to do. The Knowledge Quartet (KQ) (Appendices G (p. 426) & M (p. 456)) was an 'eye opener' to them. I did a presentation in the form of a lecture on the concept of KQ. All of a sudden an interesting discussion developed on why a lot of thought has to be put into how to connect problems to real life, even those 'neutral' problems in the textbook. An interesting point a participant made was that she has never thought of a contingency plan because in fact she never considered it to be important. This links to the classroom observation finding in which participants repeat a problem to stepwise 're-explain' the solution rather than to think of another valid contextual problem to be solved.

The solution to the problem at the end of the second workshop was something they did not expect (Appendix H (p. 428)). No one answered the question correctly while the majority of participants did not even arrive at an answer at all. We had a lot of fun because they realized by doing the sum 'mechanically' it happens that there are 3 heads without a body and legs. Participants argued that this type of question could not be asked to Grade 3 learners. They said:

> *If we struggle, how will learners be able to solve this problem?*
>
> *I will not know how to teach them this problem*.

It was amazing what one participant answered to the above question:

> *Maybe we should not teach but let the learners discover for themselves an answer? I will give this problem to my Grade 3 learners tomorrow and report back whether they were able to find a solution.*

The above demonstrates that participants might have very little confidence in their learners' abilities to solve problems. On the other hand some participants wanted to experience whether learners could 're-invent' mathematics – find their own solutions to a problem. The comment of 'discover for themselves' indicated that participants became critical about their teaching and were possibly thinking of allowing more freedom for learners to 'unpack' the mathematics. The Upper Primary phase participants promised to ask their learners to solve this problem.

Before the start of the third workshop the Grade 3 participants and the Upper Primary phase participants reported back on how learners successfully solved the problem. This experience created a mind shift within and among the participants. It was as if they realized that their learners were capable of doing mathematics in a form that they were not used to. A first experience of mathematization was successfully experienced by participants.

The topic 'Counting' in terms of RME (Appendices R_{1-12} (pp. 473 - 487))

In the third workshop participants discovered that teaching-learning processes are not isolated within a single school subject or even within part of a subject. For example participants for the first time realized what role 'counting' has in the development of number concepts. That 'counting' becomes 'formal calculation' they never had thought about. Participants pointed out that it was actually the 'fault' of the textbook that they did not do it the correct way. It was quite obvious that 'context-bound counting' and 'object-bound counting' which leads to 'pure counting' did not function in the lower Grades. Participants indicated that reason for this is that:

> *It might be that we do it the correct way and we just do not know the different terminology as you use it.*

An important finding is that participants came into discourse with RME and the way they were used to teach. Discourse means that participants argued, discussed and reasoned about the pros and cons of the use of RME as an approach to teach primary school mathematics in future.

The participants experienced in the workshops that mathematics is not a tool but a human activity. The textbook is a useful resource, but it is the pedagogical knowledge of the participant and the classroom management that influences the learning process. Therefore, participants were challenged by implementing RME principles in their lessons because it might be 'easier' to follow the prescribed textbook and not to think about a realistic context problem situation for every lesson.

<u>The use of a model in terms of RME</u>

Participants were introduced for the first time to the 'five', 'ten' and 'twenty number frame' (Appendix R_2 (p. 474)) , the importance to know 'number bonds' (for example friends of five/ten (Appendix R_{12} (p. 484); Figure 10)), 'buttons' to use for subitizing (Appendices R_4 (p. 476) & R_5 (p. 477)). Participants were totally overwhelmed. After the participants experienced activities in which calculations were done by 'counting' (for example counting on), structuring (for example 5 + 8 = 5 + 5 +3 or 5 + 8 = 8 + 5) and by formal calculation they understood why certain 'steps', as they called it, are important for learners' conceptual understanding. The available teaching aids I provided for the session were much appreciated. A question arose about why I focused so much 'on the same colour' of counters. One participant answered by saying:

> *You can add only alike items.*
> *I have not thought about it before. But I realize now that two blue counters and three yellow counters do not give you 5 counters. It stays two blue and three yellow. Maybe we should not say two BLUE but only two counters?*

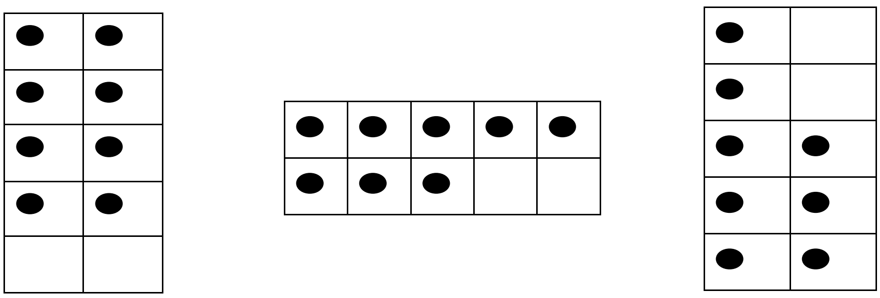
A heated debate followed and it was for the participants the first real engagement of critically looking at an 'easy topic'. Participants mentioned that it was a first experience in which they were exposed to and realized why the topic 'counting' is so important to spend time on. Participants experienced that in RME it is important to ensure that learners are given opportunities in which they are challenged to solve counting-and-calculating situations as they themselves have experienced with the examples demonstrated above.

Addition and subtraction skills were discussed and participants realized that by using for example the ‘ten frame’ it can easily be extended to a ‘twenty frame’ because learners can ‘double’ by that time. Putting counters down leads to ‘add’ and taking counters away leads to ‘subtract’ without doing it mechanically step by step because they have experienced themselves that not all take the same ‘place’ counter away. Some participants wanted to correct their colleagues by telling them when using the ten frame:

> *You have to take from the right side away* or
> *You have your frame up-side-down*

The following is an example of how the participants’ frames looked like:

A B C



To solve for example ‘8 – 3’ participants immediately realized that learners might find the answer much faster if learners ‘pack’ their frame like participant B or participant C.

For the first time participants also realized the importance of language, for example ‘fill up a column’ (C) or ‘fill up a row/s’ (A & B). If concepts like ‘column’ and ‘row’ are not familiar to learners, learners will need guidance at the start of an activity. Participants became aware of the fact that a lot of thought has to be put into planning.

Participants experienced the discussions that arose during the activities as very stimulating. These discussions made participants think about how learners can be guided towards ‘making sense’ of mathematical content. The activities placed them in a situation where they themselves experienced situations as learners and how different each individual thinks. The issue about *‘one size fits all’* (sic) as one participant mentioned all of a sudden became questionable. The 'unpacking' of mathematics was experienced by doing the activities themselves and this helped participants to find ways to use mathematization in their daily teaching. An example from the frames above a Lower Primary phase participant mentioned

Wow, I can use the ten frame now also for solving the following:

8 + ☐ = 10 or 5 + ☐ = 8 or ☐ - 3 = 5

Another participant said:

I will use the example of colleague A to demonstrate 'doubles'

Participants became aware of 'why a teaching aid can be useful in fostering number concepts'. I realized that it is important that before a participant can implement a 'new' approach with new skills these skills have to be practiced. The quotations above clearly indicate when feeling 'free' to ask questions or commenting on each other's teaching practice, the participants in the process learned or refreshed subject content knowledge they would have neglected in the past. The Upper Primary phase participants realized for the first time the difficult task their colleagues in the Lower Primary phase face. By working together, discussing mathematical concepts and designing learning activities for both phases, participants gained a lot of self-esteem by feeling part of the process. Participants for the first time had an experience that their contribution was regarded as being valuable. The Lower Primary phase participants contributed with their innovativeness and useful ideas to adapt provided teaching aids for the workshop sessions. The Upper Primary phase participants contributed with their subject knowledge to put ideas into practice. This increased the motivation to participate in these planned workshops.

Assessment and RME (Appendix O_{1-3} (pp. 459 - 465))

The workshop on assessment (Chapter 4, p. 214) was for many of the participants an event they would have preferred to be attended by all primary school participants. When participants set question papers it is not expected of them to indicate the difficulty levels (Bloom's taxonomy) of the questions. During this PD session participants had severe disagreement about the exercise they had to complete. Some participants were challenged by indicating the level of a question when the same question is asked for two different Grades (Appendix O_3 (p. 464)). This exercise demonstrated the need of participants to set question papers on an appropriate level. The SATs results also indicated that learners perform well on level 1 (knowledge) questions, but very poorly on level 3 (application) questions.

When asked during our discussions whether a ‘good average’ means the work is done on a good standard participants without hesitation answered ‘yes’. Only during our last sessions participants wanted to come back to the issue of tests and examinations for primary school. Tests and examinations are not in the scope of this research but during this discussion participants demonstrated that they have thought of what we have done during the year and how their views and beliefs have changed by attending the PD for ten months. Comments like:

> *I think we focus our teaching too much on tests/examination questions. My teaching focus was on memorization of rules – this is where learners' struggle begins.*

> *I am now interested in how learners solve the problems on their own. It is amazing what they (*the learners*) achieve.*

> *I am still concerned that we use with the ‘new’ approach (RME) too much time – we will not finish in time.*

> *Learners are able to demonstrate their reasoning*.

These comments of the participants illustrate that their experiences with these PD activities made them think differently and more critically about their teaching. However, the concern about time was echoed by the majority of participants.

Participants experienced that issues, for example, knowing the multiplication tables by heart or even ‘drilling’ basic facts, are still important in the RME approach. Even more, participants realized that in primary mathematics it is important that learners must acquire mental skills to become numerate.

Summary of findings emerging from participants' experiences participating in RME-based PD

To summarize participants' experiences in PD activities I found that participants benefitted tremendously from the discussions that took place during and after every activity. The Lower Primary phase participants initially were very quiet and subdued and the Upper Primary participants took the lead in the discussions. This changed later on when the Lower Primary phase participants were as actively involved as their colleagues. The mathematical talk that arose during and after an activity might have resulted in a mindset shift. Participants had not been exposed to situations before in which they were requested to view their opinion about the way they teach or apply a certain strategy. This PD exposed participants to a theory that is consistent with the belief that mathematics is a human activity. However, I was very careful not to ignore the fact that the participants' belief or mind shift changes might have come from different experiences in this RME-based PD.

As the workshops continued the attendance of participants changed remarkably: they became more enthusiastic about the RME-based PD. Enthusiastic in the sense that they started to involve learners in their teaching and experienced that learners were challenged by activities they planned for them. The majority of participants came at least half an hour before the start and either reported back on their experiences or asked questions on how to improve on lessons they experienced difficulties with. I contend that this is an indication that participants appreciated and valued the opportunities for attending the RME-based PD activities.

At the beginning of the PD, i.e. the first five workshop sessions and first two planning of the research lessons, it was usually I who gave advice or answered questions but gradually it became the participants themselves who gave advice or assisted each other with ideas and feedback of what had worked effectively in their classrooms. The majority of participants engaged fully in the discussions and activities in the last five workshops in which the multiplication tables, counting in 2's, 3's, odd and even numbers, and how to phrase questions were discussed. As the participants took part in the workshops on addition strategies, counting in 2's, odd and even numbers they realized the value of practice for mathematics learners. One participant observed:

> *Practice is in other words knowledge, skills, insight and creativity of my side. Wow, I never came to that conclusion before. Mental strategies have to be attended to. I realize now the value of 'drilling'* (basic number facts, and 'knowing by heart')

This quotation demonstrates how one participant's views and beliefs had changed since the first PD activity. I did a survey (page 297) where participants' views and beliefs were measured against statements.

Findings of the interview sessions might elaborate more on the experiences of participants had in this RME-based PD. Therefore the following sub-section will focus on the findings of participants' views and beliefs regarding primary school mathematics teaching. The emphasis will be on the participants' willingness to adapt, their innovativeness, skillfulness and ability to integrate RME principles in their teaching as seen from their viewpoints.

5.2.3 Vignette 3: PSMTs' views and beliefs regarding mathematics teaching

The illustration below serves as an overview to the findings in this sub-section.

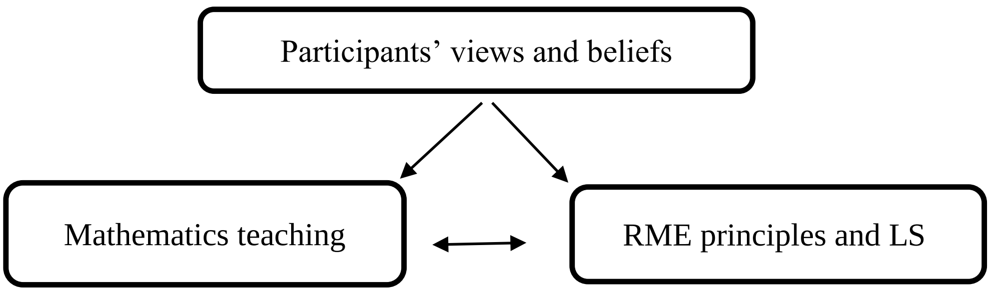


Figure 5.4: Overview of Participants' Views and Beliefs

Participants brought their views and beliefs along to the RME-based PD. However, the PD based on RME principles and LS might have influenced their views and beliefs.

Although I had some definite questions to ask the participants I mainly made use of open- ended interviews. The nature of the process was such that I had to be flexible and could often use answers or remarks by participants to ask further questions. A set of fixed questions would also possibly not provide enough information of their true views on what they have experienced.

I argued that the findings of this sub-section would mainly have to answer one of the sub-question of this study, i.e.:

> *'What are the primary school mathematics participants' views and beliefs about mathematics teaching?'*

My experience was that the interviews went through different stages. During a first encounter a participant appeared eager and cooperative. During a next session (all questions could not be handled at once) this participant appeared uncomfortable, anxious and even defensive. Another participant, after several meetings conducted in a harmonious fashion, became suspicious and bored.

The very first individual interviews were not easy to conduct. When I asked a participant if we could talk I at first did not even use the word 'interview'. I felt apprehensive and sensed that the participants usually had similar feelings. Some of the participants expressed anxiety and suspicion. One participant directly asked me:

> *Are you here to inform the principal?*

On the one hand I regarded this comment as being about gaining trust and access to the participants' classrooms. On the other hand I once again explained the purpose of my study and pointed out the ethical issues we discussed during our very first meeting. I then asked questions but received only blunt and vague replies. I became increasingly uncomfortable and made further attempts to put my participants at ease. I made it clear once again that all information would be treated confidentially and that statements or quotations would be recorded and used anonymously. Still some participants, especially those who had to teach mathematics and felt very uncomfortable about it, mentioned several times:

I don't know whether I will answer your questions correctly.

Many participants were afraid of 'wrong' or 'correct answers' as if they had to pass a 'test', another example of the dominating role of examinations. However, this situation gradually improved. The longer the participants were involved in the study the more they 'opened up' towards me and I succeeded in getting them responding which was one of my aims with the conducting of interviews. From my side it required that I had to listen patiently, show interest and respond in a neutral and non-judgmental fashion.

The tension that might have existed before changed to a feeling of relaxation and exploration during the study. I tried to ask questions very informally and hoped for their full cooperation. I had to make it clear several times that I would like to understand their point of view and I would not judge or evaluate at all.

Some time passed before I was satisfied that the participants cooperated fully. I argue that the majority of participants cooperated fully, especially after workshop three, because they regarded me as a 'participant in a project to help them to develop professionally' as one participant mentioned casually. Eventually, the participants started one by one to participate in individual as well as focus group interviews. After some weeks and working closely together many, if not all, participants enjoyed my presence and liked to share their experiences with me.

This was an extremely valuable type of gathering data. Participants became spontaneous. They did not care to call a 'spade a spade'. During the individual and focus-group interviews I sensed a feeling of 'satisfaction' among them to share their information with me as well as with each other. In addition they asked many questions as well which lead to full participation in an interview session.

There were specific questions in which I was interested during the research period. These questions I posed to individual participants at first but I soon realized that the focus group interviews would serve the purpose equally well. A reason to rather use the focus group interviews was that limited time for the participants and me was an obstacle. Each interview session normally took two hours.

- **Findings emerging from focus-group as well as individual interview sessions**

The first interview question to participants was posed to focus groups (the management, Lower Primary phase and Upper Primary phase group). The reason for this was that the findings will influence the development of all PD activities. The findings of the questions follow. At this stage I will often only quote the direct remarks of the participants, since a comprehensive discussion of the findings will follow in Chapter 6.

What are your expectations of attending the planned professional development?

This question was asked before our first meeting at the start of the school year in January 2014. The answers to this question were important since they influenced the planning of all workshop activities.

The management focus group clearly indicated that their main aim was that participants should acquire additional skills to improve the SATs results at the end of the year. This group also mentioned that they regard the PD of the lower PSMTs as an issue that was neglected in the past. In their view the content knowledge for the upper PSMTs in fact seems to be adequate, but they emphasized that the upper PSMTs could nevertheless benefit from mastering new teaching approaches. There was consensus that upper PSMTs need to have more than one strategy to rely on when learners have difficulty to understand. I was reminded several times of the fact that all PD activities have to focus on the current Namibian syllabi.

The Lower Primary phase participants indicated that they would like to improve their mathematical content knowledge. They emphasized that the PD should focus on their particular needs. An interesting comment made was that according to them the Upper Primary phase participants could learn from them how to have enough teaching aids available in class.

The Upper Primary phase participants made it very clear that they do not want to waste their valuable time. According to them they possess enough content knowledge to teach effectively. The body language of some Upper Primary phase participants indicated their self-esteem that they were not in dire need for PD. They could use their time more effectively. However, after some time, they were very quick to add that maybe they needed an update of content knowledge. Some also indicated that they were in definite need to learn more about different teaching approaches. An argument arose whereby they accused each other of not applying the learner-centred approach.

However, all three groups indicated that it was a first opportunity for management, Lower and Upper Primary phase participants to partake in the same PD. The expectation of closer cooperation between the different groups was mentioned several times during the study.

After this interview session I changed over to individual interview questions. It was important for me to enable participants to elaborate on their views and beliefs individually. To determine whether the findings during classroom observation correlate with how the participants view themselves (professional image) I posed the following question:

Explain what you enjoy about teaching primary school mathematics.

With this question I wanted to determine how enthusiastic the participants were about mathematics teaching. Another purpose of this question was also to determine what their views and beliefs were regarding mathematics teaching.

The discussion of the answers to this question will be handled first for Lower Primary (LP) phase participants and then for Upper Primary (UP) phase participants. The reason is that Lower Primary phase participants, Grade 1 – 4 participants, are regarded as class teachers, i.e. they are responsible to teach all subjects in this phase. During their tertiary studies mathematics as a subject was compulsory. This might have influenced their views and beliefs.

<u>Lower Primary (LP) phase participants</u>

The majority of the participants were not at ease to answer this question. Very short and abrupt answers were given. A variety of answers were given, like

A *You know we HAVE* (increasing tone of voice) *to teach mathematics. I do not enjoy teaching mathematics at all. I am not sure about myself in the subject.*

C *I never had mathematics as a school subject in Grade 10 or 12. I cannot really say I enjoy teaching mathematics. I do not feel safe teaching it.*

E *I am never sure whether I am on the right track. I do not feel comfortable, but I try my best.*

F *We are supposed to teach mathematics every day for at least two periods, but sometimes I skip a day because I do not like mathematics. I cannot say I enjoy anything about mathematics.*

J *I do not like word problems. The other topics are ok. I enjoy that it does not entail a lot of marking.*

From the above it is evident that the overall response to this question was not very positive in the sense that the individual LP participant clearly indicated that he or she teaches mathematics because he or she has to. The responses indicate that the participants wanted to make it very clear to me that they were in a situation which might not be the most suitable one for the learners. The overall impression that these comments demonstrated was that the Lower Primary phase participants possibly lack confidence to teach mathematics. They also demonstrated with these answers that they lacked confidence in their own ability to do mathematics. After I received comments like the above I tried to get them to talk about at least something they enjoy about teaching mathematics.

The following are comments before the workshop sessions started. We normally talked during break time, before classes started or while learners were busy copying from the chalkboard.

M *I like it that a sum (she* meant the answer to a problem) *is either right* (she meant 'correct') *or wrong. Learners do not argue. Learners pay attention, because they know it is an important subject.*

N *I can teach a rule – like step 1 –add on. Step 2 – count all. That is also why I sometimes like to teach – learners can memorize. They also enjoy* *it if they can follow rules. I have strict discipline in my class, but if it comes to mathematics they pay attention without any need to discipline them. That is good. I like that.*

G *I do a lot of drilling. Then learners perform very well in the tests. Then I feel good about myself and about my teaching.*

E *I enjoy that learners pay attention without reprimanding them. Learners know that it is a very important subject to pass if they want to succeed in life.*

What they enjoyed most about teaching mathematics was that they felt learners did not argue about correct/wrong answers. Learners paid attention in class because they knew it was an important subject they had to take. A participant mentioned that what she enjoyed most in teaching mathematics was that there are rules that have to be followed. If learners learn these rules by heart their performance is excellent. She showed me the assessment list and indeed the learners performed above average.

It is very interesting to what extent the responses changed during the research period. These are some quotations which arose during the PD when I asked this question again to individual participants:

A *I enjoy noticing how my learners participate in mathematics now. This is such an enjoyment seeing learners who were passive do activities correctly. It is an indication that I have achieved my objectives. I give learners time to think and not to just shout out an answer.*

C *I feel mathematics is a subject that links to other subjects and is 'everyday' life. That makes it easier to teach. If my learners enjoy the class I am happy too. I can link the content to their world and that makes it a more relaxed atmosphere in class. I get the feeling that learners think now before they answer.*

E *A parent came to me and thanked me for being such a good mathematics teacher because the learner reports back at home that mathematics is fun. The reason why the learner reported it at home might be because I am doing every day now activities with them. This* *gives me satisfaction if I am praised and all of a sudden I like to teach mathematics.*

F *For the first time I enjoy teaching mathematics because I feel 'safe' with the content I have to teach so far because we handled it in the workshops.*

Q *I like to be not so strict anymore. I feel safer to teach mathematics now. Learners can discover methods for themselves – lessons are not so rigid anymore. Learners enjoy it to share their answers in detail.*

These comments indicate that LP participants start to feel 'safe' to teach mathematics. The learners are more actively involved in lessons, because teachers think of real life context problems.

<u>Summary of findings emerging from LP participants' experiences regarding teaching primary school mathematics</u>

The participants explained that in giving learners time to 'think' and 'find their own ways' made them enjoy mathematics lessons and this in return gave them the satisfaction of 'I can teach mathematics'. The change of mind is obvious.

An interesting comment was made by participant E regarding the parents. Learners report positive experiences at home. The comment of the parent served as a motivational factor to further implement the RME approach.

<u>The UP phase participants</u> had to answer the same question, being

Explain what you enjoy about teaching primary school mathematics.

The reason for handling the participants of the Upper Primary phase separately is because they indicated several times that they did not lack subject content knowledge and that mathematics was a major option during their tertiary studies. The findings might point out that these participants had 'fixed' views about mathematics teaching.

The participants did not hesitate to answer this question. The following are some quotations they made before the workshop sessions started.

B *I teach rules; this makes it a very easy subject to teach. I do not need to do a lot of marking as my language colleagues for example. This is what I enjoy most.*

D *We have good textbooks. I do not need to do copy work for learners. I do not need to struggle to find materials for the learners. It saves a lot of time, time I can spend on organizing all extra-curricular activities. We do not have to do a lot of marking. Marking mathematics tests is very fast.*

K *I stick to rules. Learners have to know the rules by heart. That makes it an easy subject to teach. If learners stick to these in the tests they do well. I always have good test results. It is also nice to mark mathematics.*

The above reports that UP phase participants like to teach in a 'stepwise' (mechanical) manner. Participants argued that the learners have to 'learn' rules which makes teaching enjoyable. By teaching rules, learners benefit from it because test results of learners prove it.

- **Findings emerging from UP phase participants' experiences what they enjoy about teaching mathematics**

The above quotations clearly indicate their views and beliefs of mathematics teaching. In their view mathematics is about following a fixed set of rules. It is easy to teach because learners are guided to apply these rules. This they enjoy. If learners adhere to the rules they have been taught the test/examination results are good. This gives all of them satisfaction. Furthermore, they mentioned that each learner has a textbook and this makes it easier to teach. Preparing worksheets is not necessary and saves them a lot of time. Marking tests/examinations in mathematics is 'fast' and does not take a lot of their time. Answers are either correct or wrong, being another major factor why they enjoy teaching mathematics.

Other very interesting answers why they enjoy teaching mathematics were that

P *A mathematics teacher is regarded as very intelligent. That I like – to think that I am respected.*

D *Mathematics teachers are promoted much faster than other subject participants.*

The participants demonstrated with these answers that their self-esteem is at a 'higher' level than those of the Lower Primary phase participants. This satisfaction to be seen as 'somebody important' as one participant answered, made them enjoy teaching mathematics.

However, this question was re-asked several times during this research. Very interestingly it seemed that their views were already influenced by the RME activities done during the workshop sessions. The following are some quotations during the workshop sessions:

K *Mathematics is real life. I can link the content to the learners' reality. If I have a lot of time I think of interesting problem solving activities for my learners. I enjoy it to see their happy faces if they can solve the problems. I am not depending on the textbook so much anymore.*

P *I can guide learners to be good problem solvers in daily life. I focus on solving context problems and since recently I am not interested in the process so much anymore, but in the deriving at a solution that makes sense.*

However, the possibility that participants' responses during the workshop sessions were made only to satisfy me is there.

I argued that the next question might further elaborate how participants portrayed their personal image and if it was in line with what the findings pointed out in the classroom observation.

Elaborate on what the reasons were for you to become a primary school mathematics teacher.

This question's finding will further inform on the participants' views and beliefs of a mathematics teacher.

N *This was the only option I could opt for. My Grade 10 results were not that good. I enjoy being with my own children at school. The mathematics seemed to be manageable and as you see – here I am. I do not think I can call myself a mathematics teacher; I am a qualified*

Lower Primary teacher. I like it that learners of that age are easy to discipline. My colleagues in Grade 6 and 7 struggle to discipline their learners.

G *I always wanted to be a teacher. It was my life dream. Mathematics was not my choice. To specialize in this phase I had to take all subjects. I did not qualify for any other phase due to my Grade 12 results that were not so good. I love to be a teacher.*

I *I come from a rural village. There is a shortage of qualified teachers. I do not call myself a mathematics teacher, but a lower primary teacher. I will always have work – not like some of my friends who studied four years at university and struggle to find permanent employment. To be a teacher means also that you have job security and a good medical aid.*

D *My Grade 12 results were not good. I had a very good mathematics teacher and passed mathematics Grade 12 with an E-symbol in IGCSE level. I taught mathematics as relief-teacher in our village. When the Ministry of Education made the announcement that all BETD students will receive a loan I immediately applied at the College. The content for Upper Primary mathematics is easy. I was also sure that I will have a job after my studies.*

K *My Grades were not good enough for any other option. I like to be the holidays at home with my children. It is a very secure job to have. We have a lot of fringe benefits, like housing and a medical aid. I can handle also learners of that age.*

B *I want to be a principal of a primary school within ten years. Being a mathematics teacher will help me to achieve this goal. I will have more privileges then.*

- **Findings emerging from above quotes regarding what the reasons were to become a PSMT**

The above quotations give a clear indication that the majority of participants did not opt for being a primary school teacher as their first choice. Neither were all their reasons because of strong motivation (None except one participant chose this career because of a strong motivation for it). Mostly Grade 12 results were such that any other career option was not possible.

Many participants further elaborated that having opted to become a primary school teacher ensured them of a ‘life time’ job. Being an employee of Government, especially in teaching, is traditionally regarded as ‘job security’.

Only one participant mentioned that it was her life dream to become a teacher. She enjoys every day of teaching. She did not have qualified teachers for all subjects during her school years which were a reason she could not opt for becoming a secondary mathematics teacher. The entry requirement into this option is much higher. She does not have any regrets because laying the ’foundation of mathematics’ gives her a lot of satisfaction.

The majority of female participants mentioned that ‘going with’ your own children to school and being with them at home during holidays was also a reason to become a teacher. The male participants acknowledged that they actually did not have any other options available mainly due to financial constraints and entry requirement at tertiary level.

Additional to the above one reason was for some participants to rather work with children of a younger age and become a primary school teacher. The participants hold the view that the primary school learners are less complex and have fewer challenges to face than secondary school learners. Discipline is also not a problem at primary school level according to the male participants. Their female colleagues were of a different opinion especially if it comes to learners in the age groups of 11 – 13 years.

Many participants often mentioned strict discipline and performance during our informal talks. The following question might provide some information on why all learners do not perform well, according to them.

In case of your own teaching are there particular reasons why learners struggle with certain topics?

The intention of this question was to determine the way forward after this study. Participants’ teaching experience, some of them had more than 15 years of practices, should provide answers which could serve as recommendations in Chapter 7.

However, I came to the conclusion that PSMTs have not seriously considered this question before because participants had to think for a long time before they answered.

J *I have no idea.*

D *LP teachers do not do their job properly. Maybe learners have to learn too many rules. Many learners are not ready to move over to the next topic. But I cannot wait. I have a syllabus to finish. Some learners cannot learn rules. They mess up with the rules.*

K *There is no foundation. Learners struggle a lot with fractions. I feel the syllabus is overloaded. I cannot wait until all learners understand. I have to finish the syllabus. Management is very strict that we stick to due dates.*

B *In Grade 7 learners cannot do measurement problems. I do not know why. I have not thought about it.*

Q *Maybe we are not doing a proper job. The syllabus is very full. We do not have enough time to do a good job. Some of the learners, maybe even the majority, struggle with all topics.*

One participant quite frankly answered:

I have never thought about it.

Especially the Upper Primary phase participants seemed to agree with the following answer:

The Lower Primary teachers do not explain topics correctly.

However, as time went by and my involvement became more intense, participants realized that some content (topics) poses more challenges than others and started to reflect on reasons why this was the case. The topics that seem to pose challenges to learners that were mentioned by the majority of participants are ‘fractions’ and ‘word problems’. Participants mentioned that they themselves regard ‘fraction’ as a difficult topic to teach. Learners find it difficult to apply the four basic operations in the topic ‘fraction’. Participants mentioned that only by attending the workshop that focused on ‘fractions’ helped them to approach the topic now differently. In ‘word problems’ they mentioned that language plays an important role that learners cannot find solutions to the problems because they do not understand the 'information provided in a word problem' (sic).

- **Findings emerging from participants' experiences regarding what are particular reasons why learners struggle with certain topics**

The Lower Primary phase participants raised the view that it might be that the foundation for mathematics was not laid properly by them. I had to make sure that I understand correctly and asked for an explanation of what was meant by 'foundation'. Very interestingly the Grade 2 participants mentioned that the Grade 1 teacher might not have enough time to spend on 'fractions' and that learners in Grade 1 are not yet ready to do 'word problems' since they cannot 'read' and 'write' properly during their first year of schooling. The Grade 3 participants had the impression that Grade 2 teachers and Grade 4 participants felt Grade 3 teachers are not doing a 'proper' job. What the participants in Grade 2 – 4 answered was that a teacher has very limited time to spend on a topic; therefore, it can happen that the foundation of the learners is not properly laid in the previous phase. Then the next teacher has to 're-teach' the previous years' work trying to catch up. In the process valuable time is lost.

The Upper Primary phase participants raised the issue of 'learners have to learn too many rules' and that it could be very confusing. They mentioned as example the issue of how to convert a common fraction to a decimal fraction. For solving word problems there are also certain steps/rules learners have to adhere to according to them and learners did not apply them correctly. Most of the time learners only write down an answer. This was unacceptable to many of them. If the answer was wrong learners would lose sometimes as many as five marks and if the answer was correct they would achieve only one out of a possible five marks. The majority of participants were adamant that if the learners would follow the steps/rules they taught them during class time learners should be able to solve these problems without difficulty. These participants also mentioned the fact that the learners' foundation in the previous Grades was not properly laid. The issue of re-teaching was mentioned again.

Towards the end of the data collection process I put this question to every participant again. The reactions changed in that sense that participants were much more at ease and eager to respond to the question.

K *You know today I did not experience any challenges and it was a very difficult topic I had to capture today* (it was 'word problems'). *My learners took actively part.*

D *You know I realize there is something about RME – that realistic thing; learners get used to solving real life problems – it makes sense to them – they do not use 'my' method but their explanations to their answers seemed to be correct – do you agree? I think the learner who explained his solution to the class today, for the first time took actively part this year.*

I *Can you imagine I learned from my Grade 4 learners how to solve a sum* (meaning problem) *much easier today. It is great. Previously I would have told the learner to do the sum* (problem) *my way.*

Participants started to realize that solving real life problems learners might be in a better position to solve these because these problems relate to their (learners') experiences.

- **Summary of findings emerging from participants' experiences regarding what are particular reasons why learners struggle with certain topics**

For the information, Participant I reported on how learners solved the problem of the men and sheep in the kraal *('There are 10 heads in a kraal. There are men and sheep in the kraal. Altogether I counted 26 legs. How many men and sheep are in the kraal?'*). I elaborate on this experience of the learners because it shows how learners logically solved a 'word problem' without the teacher instructing them what to do. Learners were implementing RME principles (activity and level principle) and the participant implemented the guidance principle.

One learner calculated his sum by arguing that for every sheep (4 legs) there are 2 men (2 legs). It means if there are 2 sheep (8 legs) there have to be 4 men (8 legs) and he went on saying 3 sheep (12 legs) will result in 6 men (12 legs) which results in 9 heads, therefore another man has to be added. Seeing that the teacher had its doubts the learner showed his drawing of the following table:

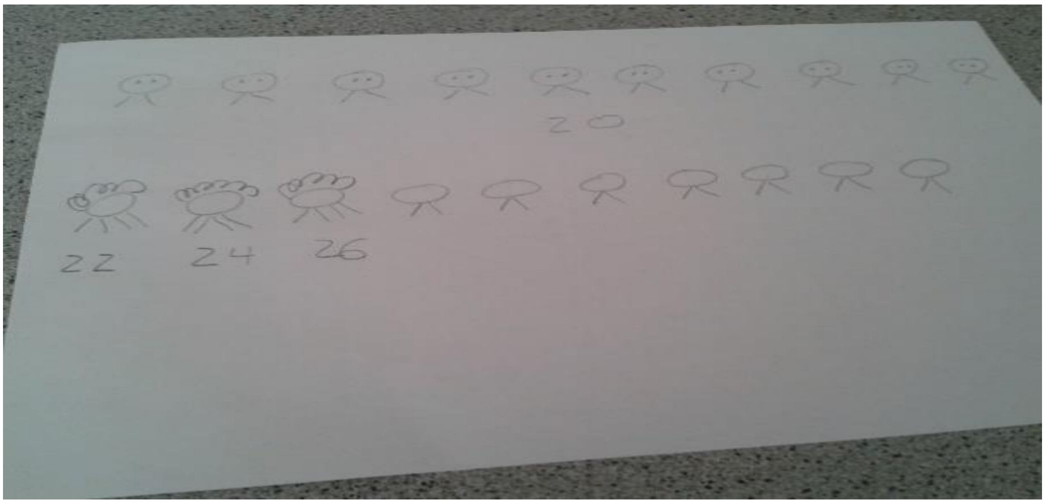
S XXXX	S XXXX	S XXXX	M XX	M XX
M XX	M XX	M XX	M XX	M XX

The participant checked the answer, re-checked and concluded that the learner's reasoning was correct. The participant realized that the learner used the 'ten frame' and 'filled' in the legs, as the learner explained it. The learner started with the sheep indicating XXXX i.e. 4 legs in the first column first row, and then 'filling in' two men indicating the legs in the last row, last two columns, to have the same number of legs, e.g.

S XXXX				
			M XX	M XX

The learner realized that all columns have to be filled, because there are ten heads. This is the reason he started with 'filling in' the 'men' in the last row. When he reached the first row, third column, 'filling in' a sheep, the learner realized there cannot be another sheep, because he was counting on aloud (**4**; 6; 8; **12**; 14; 16; **20** ;22 ;24; 26) while demonstrating his solution to the class.

Immediately another participant reported on the work of a learner in his class:



Example of Learners' Solution

This learner first drew ten heads, and then he assigned two legs to each head. Then he added two legs counting on (aloud) '22', next he added two legs, counting on '24', next he added two legs, counting on '26'. The learner said:

> '*There are only* (emphasis on only) *three sheep and seven men*'.

The participant was astonished how logically, according to him, the very quiet and withdrawn learner solved the problem and with the confidence he presented the solution to the class.

The participants mentioned that these examples of the solution of the learners convinced them that there is 'something' about RME. Learners are very enthusiastic solving realistic context problems they recalled.

The longer my stay the easier the participants became involved in a discussion of their own teaching. The reflection on the research lessons also helped participants to develop a deeper understanding of how learners learn specific subject matter and why some topics are more challenging than others.

The next question's finding will focus on the participants' views and beliefs about primary school mathematics.

Elaborate on your views about what primary school mathematics entail.

With this question my aim was to determine how I could create a link between their views and the RME principles in the workshops. The findings will provide information regarding the way forward with this study.

The majority of responses I received were that mathematics was the 'gate way' to all careers and it was an important subject for all learners. It was very difficult to get participants to 'motivate' their answer.

The question was repeated during different stages of the process because I argued that it was important for participants to also think about their role in primary school mathematics teaching.

The following quotations give an indication of participants' views about primary school mathematics before the start of the intervention.

B *I have never thought about it. Everybody says it is an important subject.*

A *Learning to count, add, subtract, multiply and divide. Learning rules.*

P *It gives the foundation for secondary school mathematics. Therefore, learners must be well equipped with rules how to solve problems. Mathematics is a 'systematic' subject.*

I did not understand what was meant by 'systematic' and the explanation for it came as

Step 1 is…. Step 2 is…. And so on. All problems have rules how to solve it.

K *It serves as a foundation for future careers. They need to know the correct steps how to solve problems.*

J *It is all about numbers and rules.*

As time went by I kept on asking this question. The following are some answers to the question after the workshop sessions had started.

L It *gives learners skills to cope in life. Learners must be able to do the four basic operations.*

B *During the workshops I realized that mathematics can be regarded as a human activity. Previously learners did the sums step-by-step. My learners are engaged in activities in most of the lessons now and enjoy mathematics much more. My research lesson proved it.*

The answers to this question overlapped with the previous question in the sense that the majority of participants still viewed mathematics teaching as 'knowing all rules how to solve problems'.

While finalising the data collection I asked this question again. I received responses like

J *I remember you asked me already this question and I think I answered it the first time wrongly (sic). Mathematics means real life.*

Q *Learners should discover steps/rules how to solve a problem by themselves. Mathematics is for me to find the correct answer.*

K *With guidance from my side learners should be able to find solutions to any problem. Mathematics is about numbers and answers. How to derive at the answers can be different by different learners.*

P *Good and thorough preparation is needed, because I need to be aware where to guide learners if their reasoning is not correct. I need to think of possible solutions and not of only ONE (*emphasizing). *A problem can have sometimes different ways to reach an answer. I wanted to stick to one way only in the past. But overall it is expected of learners to be able to do the four basic operations.*

The comments from the participants indicate that they were implementing RME principles in some of their lessons. Comments like '*guidance from my side*' gives the impression that the participant thought while planning the lesson what to expect from learners. The reality (*Mathematics means real life*) and level principle served in lessons as demonstrated by comments like '*should discover steps/rules*'.

- **Findings emerging from participants' experiences regarding what primary school mathematics entail**

The above illustrates the view that the conception of what mathematics education is, that it is to count, add and so forth. It is how it should be presented. The mechanical (stepwise) way of addressing the teaching of mathematics is what they might still remember from their own school days and this is the way they prefer to continue.

However, participants did not really fully portray their views when asked this specific question. Participants were nervous when asked 'direct' questions as they themselves said. I got the impression that they found it difficult to express their thoughts, views and understanding in words. However, during 'informal' conversations participants more readily elaborated on what their views about mathematics education was. From what I noted down I derive that in their view mathematics is a set of rules and facts.

The intervention challenged their traditional beliefs. The above illustrates that participants started to think differently about mathematics teaching. The PD activities enabled the participants to reflect on their teaching and this might influence their views and beliefs regarding trying out new strategies in order to meet the diverse needs of their learners. The participants realized the important role they as mathematics teachers have in the lives of their learners.

I argued that the following question might provide answers to what participants need to upgrade their mathematics subject knowledge.

What are you reading for your own learning to ensure constant professional development?

The reason why I included this question was that I was interested in whether participants read any mathematical literature, for example searching the Internet for interesting games or ideas for interesting worksheets. The expectance of this question was to determine what additional information participants possess to make lessons interesting. An ability to provide additional information would indicate that participants were informing themselves either by literature or on the Internet.

Participants were quite surprised to get such a question.

J *Daily newspapers.*

B *Huisgenoot.*

Again I pointed out to the question's part stipulating 'ensure professional development'. Many paused for a very long time before they answered.

J *Nothing.*

B *In Huisgenoot are sometimes topics I can use for my learners.*

N *Not really anything for mathematics*

K *Nothing mathematical. Sometimes I search in the net for interesting 'stuff'.*

I made sure about the fact what they mean by 'nothing'. They explained that their day is stuffed with so many activities that they have no leisure time left for reading for professional development.

- **Findings emerging from participants' experiences regarding PD**

From the above it is clear that participants did not understand what I meant by professional development neither what my aim with this question was. For them professional development is 'attending workshops'. However, during my stay at the school I came to the conclusion that there is no doubt that participants want to improve their teaching and are concerned about their learners. It is more a case of a lack of opportunities that come their way. In the past there were no opportunities for them to upgrade their mathematics knowledge and teaching. There is a lack of formalised PD for PSMTs in Namibia (Chapter 2, pp. 63 -68).

However, in the end two participants indicated that they use 'Google' with the help of friends or family to get additional information for topics they teach. One participant pointed out that her husband helped her to retrieve some practical activities from the Internet that she still plans to implement in a lesson.

Later the issue about reading educational material was brought up by some individual participants. Some participants reported that for the first time they dealt with literature dealing with current approaches to teaching mathematics. One Upper Primary phase participant noted

Reading books on mathematics education has widened my horizons.

It became a mind shift for all participants. They enjoyed to retrieve information from the Internet and even took out 'extra' textbooks (from UNAM library) which assisted them in planning their daily lessons.

By having to answer this question the participants realized how much 'outside' help was available to assist them in their daily teaching. However, some of the quotations pointed out that the participants, when challenged by the RME-based PD, were quite willing to do something on their own to develop by making use of the opportunities to use the library of UNAM where they could make use of internet facilities as well.
Participants' efficacy beliefs are seen as how capable they are in organizing and executing their teaching to successfully accomplish their task. The findings of the next question might establish it.

In case of your own teaching what do you regard as "being successful"? Give examples.

This question's answer will determine the participants' efficacy beliefs.
The majority of participants regarded 'good results' as being successful. Having an above average result received during the SATs results was also highlighted as being successful.

Two participants indicated the 'excitement' they see in the learners' faces if they could solve problems correctly. Another participant mentioned that she felt very good if the majority of learners have failed a test and she revised the content and if the majority of learners then passed the re-test. This she regarded as being successful. She indicated in her assessment list only those tests that portray an 'improved' picture.

These interviews took very long and the majority of answers were only retrieved during 'informal' sessions. Apprehensiveness and the sense of uneasiness disappeared as time went by. The individual interviews changed to focus-group interviews including the management and the Lower and Upper Primary phase participants. The participants enjoyed to partake in focus group interviews. These interview questions were asked not all at once due to a time constraint. I experienced it as an advantage to ask these questions later in the study because the participants were used to share experiences by reflecting on their research lessons. The atmosphere of collegiality and trust was sensed and many, if not all, participants felt at ease.

The following question could have been asked at the beginning but being asked later in the research served its purpose. A negative experience of previous PD could have influenced participants' enthusiasm in partaking in this study.

Elaborate on forms of professional development you have attended, if any before this one.

Out of the 15 participants, only one, a Lower Primary phase participant, indicated that she had attended a professional development activity. This was the Annual Mathematics Congress that was offered for all mathematics participants (primary, secondary and tertiary) in Swakopmund, Namibia (Chapter 1, p. 5). She attended this Congress some five years ago. Her school where she was employed at that time, a private school, paid all her expenses to attend the Congress. She made it very clear that if had not been for this she would not have attended the Congress.

Therefore, other participants with up to 31 years of experience had not attended any relevant PD. The only PD activities offered to these PSMT was when the syllabi were revised. In a one-day-session these changes had been discussed with them.

The possibility that some of the participants never had changed their teaching practice, never have tried out new ideas or instructional strategies became reality.

For this study it was important to determine whether participants can benefit from an RME-based PD. The findings of this question will determine the way forward for future PD.

What do you think is the main purpose of teaching primary school mathematics?

The aim with this question was to determine whether participants have thought for example that primary school mathematics should provide a sound broad foundation for future studies in mathematics and other disciplines. Another purpose I hoped participants would raise was that learners can experience mathematics as relevant and worthwhile. I argued that the potential influence of the views and beliefs of these participants on their learners and the classroom practice will indicate the extent to which they are able to exercise personal control over learners' behaviour, thinking and emotions.

Participants gave very similar answers to their 'views of primary mathematics teaching' which they answered individually. The following brief answers were given:

> *Learners need mathematical skills to survive in life,*
> *To have a better future* and
> *It is daily life*

Not one participant considered the rationale given in any school mathematics syllabus. When shown the rationale of the syllabus some participants were so honest to say they have seen it before but not really 'read' it – it was just important that all topics are handled they argued.

When the PD activities came to an end participants were again asked this question. It was very interesting to notice how their answers differed from their first responses. Participants amongst others responded after attending the PD that teaching mathematics means:

> *To develop knowledge and understanding of mathematical skills and concepts in learners.*

They continued to mention that being 'themselves' and being enthusiastic and confident about mathematics makes mathematics enjoyable to learners. The Upper Primary phase participants responded that they realized that by using concrete materials 'gaps' in the knowledge of learners are addressed and mathematics becomes meaningful and sensible to learners. One participant mentioned that learners stopped asking the question why they have to do certain topics. Aspects like

> *A firm foundation*
> *Proper understanding of the four basic operations in mathematics*

were mentioned as important reasons to do mathematics after the RME-based PD. This was interesting because it may have been that they just had said it to impress me. However, at the end of the data collection period, Lower Primary phase participants came to me and reported:

> *I have learned so much, especially how the four basic operations can be taught that it makes sense to learners. It is also culture* (she referred to counting like six as five-one, seven as five-two)
>
> *My learners have a firm foundation now – the test results prove it. The capacity to use a variety of tools as we have used them in our workshops, for example the mental mathematics activities, will give learners skills so necessary in daily life.*
>
> *Learners will not be cheated in the shops with change anymore because they are equipped with skills to quickly do calculations.*

The above indicates the need to have PSMTs in formal or informal communities where they do not feel threatened about discussing their mathematics teaching.

Upper Primary phase participants surprised me with

> *The main reason to include mathematics in the curriculum is that mathematics is everywhere – it is part of daily life. Doing the activities in the workshops we realize that mathematics is also a communication tool – said in the workshop where we handled the different types of questions, for example transparent and hidden questions.*
>
> *Mathematical activities are actually all human activities. This is a new concept to us and this emphasizes the importance of mathematics in the curriculum.*

These remarks demonstrate that participants got used to think about ‘why is mathematics important’. Previously they had declared it ‘because it is important’ without any further motivation. The increasing reflectiveness of participants became evident.

To summarize, I can state that participants at the end of the study came to the conclusion that teaching primary school mathematics is part of culture and that learners need mathematics and the skills to apply mathematical operations in order to solve many everyday tasks.

The following question was asked to determine whether the findings of the classroom observations and my interpretation of what participants could benefit from in the workshops correlate.

Which topics in mathematics do you find difficult to teach? What do you think are the reasons for that?

The participants' answers were important to guide me to which subject content for the workshop sessions had to be included. The answers guided me in designing the workshops in such a way that the particular needs of the participants were addressed. This might have ensured participants to feel part of the PD.

The management group indicated the following topics for:

Lower Primary:

Number concepts, problem solving, fractions, time, money, geometry, long division.

Upper Primary:

Rounding off, comparing and ordering (relationship signs), common and decimal fractions (especially the four basic operations), long multiplication/division for 2 to 3 digits, word problems.

These topics indicate almost all the topics for the mathematics syllabus. The Lower and Upper Primary phase participants indicated number concepts, problem solving and fractions.

Participants mentioned that a source of concern was that the foundations of learners apparently were not laid in deep ways where in previous Grades the development of and connections with and between mathematical concepts were made visible or noticeable. The fact that learners often did not even try to solve problems because they feel 'lost' was proof for the above statement. However, when asked whether they could think of a solution to this challenge they said: *We will think about it.*

I argued that the last question was important because no reform could take place if participants were not involved and were feeling part of the reform process.

What is your experience (if any) regarding the prescribed syllabus? Is there a recommendation you could make regarding improving the syllabus? Explain.
The answers to this question are important to indicate the way forward.

All three groups indicated that the syllabus was overloaded and that there were too many topics in the syllabus. Participants did not have enough time to focus in detail on the learning objectives and basic competencies. This is significant since participants are not supposed to continue with new skills before the previous ones have been mastered. They are constantly rushed for time throughout the year. Time was mentioned as a very crucial hamper to success throughout the research period.

The Lower Primary phase participants made an interesting point that they ‘jump around’ too much. After some time I understood that in a week certain days are set aside for certain topics, e.g. Mondays are for ‘number concepts’, Tuesdays are for ‘computations’ Wednesdays are ‘for ‘measurement’, Thursdays are for ‘problem solving’ and Fridays are set aside for tests. They recommended that this issue about a more sensible sequencing of topics should be looked into with the new reform. According to them all schools apply this schedule and it should be changed.

The Upper Primary phase participants did not raise serious concerns regarding the syllabus, except that the topics should be reduced. They raised the concern of teaching through the medium of English. Many learners do experience challenges to speak and especially to write the official language. This has a serious effect on the learners’ performance when it comes to ‘word-problems/problem-solving’. They recommend that participants should be granted the opportunity to ‘code switch’ if the participant’s mother tongue is that of the learner who experiences difficulties.

From the above it is evident that participants’ answers were short and abrupt. The reason for this was that maybe for the first time somebody was interested in their views. They never had had the opportunity to really discuss these issues. The contact sessions provided a platform to engage in mathematical talk and exchange views and beliefs about mathematics education. One participant mentioned that for the first time he thought about his future as a primary school mathematics teacher.

The following is a summary of a survey of statements made during the research period. I indicate the answers of 10 participants (given in percentage) in the following table:

	Early in research Period			**Towards end of research period**	
Statement	**Agree: %**	**Disagree: %**		**Agree: %**	**Disagree: %**
1. Learners struggle to do mathematics	80	10		30	70
2. Mathematics is about finding the correct answer (the emphasis on correct)	100			60	40
3. There is only one correct answer to a mathematical problem	100			50	50
4. The best way for learners to learn mathematics is to see an example of the correct method to find the solution on the blackboard and then do many similar exercises	100			30	70
5. Learners have to indicate all steps in presenting an answer, otherwise they will not be awarded full marks in tests/examinations	70	30 Not sure what to answer		40	60

6. Too much time is wasted if learners have to do investigations on their own	80	20		50	50
7. Teachers have a distinct influence on the mathematics performance of a learner.	40	60		60	40
8. Learners are able to express their reasoning.	10	90		40	60

Table 5.1: Answers (in %) to Statements made before and almost at End of Study

The above demonstrate that the participants' views and beliefs were influenced by the RME-based PD. However, care has to be taken that the answers in the last two columns indicate views and beliefs while participants still experienced the excitement and motivation of their achievements during the research lessons and with the study still in progress.

This research provides findings about RME-based PD and LS. However, the following limitations during this study were experienced.

5.3 LIMITATIONS

I argued to use an ethnographic case study, because ethnography tries to capture the complexity of 'something', in this case PD for PSMTs in Namibia, and to report about the situation in a sensible way. Further, according to Genzuk (2003), ethnography needs to investigate from inside the context, i.e. in the natural setting. For this reason I argued that I as the researcher would directly immerse in the setting and could act as observer, data collector and also be a participant in the setting.

In this study an intervention was undertaken in the sense to encourage PSMTs to develop professionally by participating in an RME-based PD. Ethnography can be conducted at a single site or multiple sites. However, throughout this study I was aware of the fact that an ethnographic case study has limitations too. The main research question, prompted me to involve only one primary school in Windhoek, Namibia. Therefore, the findings might have presented a more valid and representative sample if the group of participants would have been bigger. More participants would have contributed more data and a greater variety of viewpoints. If more primary schools would had been included more PSMTs might have benefitted from the RME-based PD. Due to a constraint of funding and time it was impossible for me to include more than one primary school in this study.

The levels of knowledge and teaching skills among mathematics teachers vary significantly. It is therefore impossible to select participants who are representative of all mathematics teachers in Namibia particularly if they are from only one school. Therefore, the findings might be more relevant to certain groups than to others.

Initially some participants were unwilling to become involved. One reason for this could be that participants were unsure whether their own knowledge and skills would have been sufficient for the activities expected of them. Another reason may have been that participants felt secure with what they knew best. Therefore, participants preferred to stick to their well-known methods with which they were sure they could cope and which had given them some degree of success over the past number of years.

It was a big challenge to find a suitable time for the PD activities in the afternoon. Participants would have loved to have more contact sessions but due to afternoon extra-mural activities in which all participants were involved it was not possible and was therefore, a big limitation.

Through the contact sessions participants learned to co-operate and collaborate. The contact sessions enabled participants to feel free to invite me into their classrooms; I experienced that as having achieved more than co-operation. Contact sessions will improve not only collegiality but also a sense of belonging to a learning community. Participants could not observe each other's research lessons and it placed a limitation on the process of LS.

A limitation of this study was that the PD activities came to an end after ten intensive months. To develop participants' knowledge and skills in on-going way PD is essential. If the RME-based PD could continue participants could continue to implement research lessons in which RME principles feature in their year plan.

LS serves a very important purpose, i.e. that participants should be able to observe each other's lesson and to re-teach a lesson if corrections are needed (Chapter 3, p. 92). This was not fully possible in this study and was a limitation. Participants could not leave their classes unattended. No funding was available to find substitutes to enable participants to attend each other's presentation. Since participants were bound to their schemes of work and normal progress in the school it was difficult to repeat lessons for the Lower Primary phase. Upper Primary phase participants could also not repeat a lesson for the same group since they were also bound by a scheme of work.

A serious limitation was that I was the only researcher in this study. It was a major task to get participants involved in PD activities they have never before experienced. The RME principles and lesson study were both new experiences for the participants. If more researchers (or research-assistants) would have been involved the focus on either RME principles or lesson study would have made this task much lighter.

Since it was a first experience for participants a challenge was to bring diverse participants together to work skillfully and effectively in an RME-based PD that might lift them up and have them moving towards the same aim. The models and use of context is so important in the RME approach that it had to be adapted to suit the Namibian context and different Grade levels. My leadership in this regard was limited by the circumstances. More participating teacher educators (i.e. lecturers of the Faculty of Education of UNAM) are needed to have a broader and diverse input on the structuring of PD. I was the only principle researcher. To conduct a research of this magnitude more resources, intellectual (participating educators) as well as physical (teaching aids, venues), are essential.

The influence of RME on learners' performance in this study has not been established without a doubt. In the Namibian context the performance of learners is measured against SATs results. Time was a limiting factor to focus on this issue comprehensively.

However, I reason that these limitations did not have such an impact on this study that it cannot be verified. In the next section the verification of this study is presented.

5.4 VERIFICATION

At the start of this study I posed two questions regarding PD to myself since very little information regarding PD in Namibia is documented. In ensuring validity I asked myself the question ‘what do I know about the relationship between PD and teacher learning?’ The question continues ‘what evidence validates that relationship and how trustworthy is that evidence?’ These questions guided me in the analysis of this research as follows:

- I have observed at the research site for a period of one school year. Regular and repeated observations of similar phenomena and settings occurred on-site. I observed participants’ teaching before as well as during the intervention. Participants’ experiences with respect to LS and RME were reported on in detail.
- In other words I triangulated data. Bazeley (2013) informed me that triangulation as a strategy for validation usually involves obtaining one or more alternative sources of data independently and checking whether the inferences drawn from the data are comparable with those obtained in the first instance. Data was collected through multiple sources which included classroom observations, lesson study, workshop sessions and individual as well as focus-group interviews. The findings emerging from the different vignettes report that participants’ teaching had changed after participating in the PD activities. The views and beliefs of participants have been challenged by the PD activities in the sense that active learner involvement in the teaching process was visible at the end of the study.
- I regularly confirmed with participants throughout the analysis process. An on-going dialogue regarding my interpretations of the participants’ reality and meanings ensured the true value of the data.

Participants reported that having experienced RME and attending PD activities has led them to re-evaluate their classroom practices and their beliefs about what constitutes mathematical development for learners. One participant commented after the last session that she was not always able to express her feelings and emotions due to a lack of English communication skills. She said:

> "*Ek het baie geleer – nie net vir die saak van my leerlinge nie, maar vir my eie kinders se wiskunde ontwikkeling ook. Ek kan myself nou ook beter help. Ek het besef ek kan my kollegas ook vra sonder dat hulle dink ek is stupid.*" (I have learned a lot – not only for the sake of the learners but also for the development of mathematics of my own children. I can help myself now. I realize that I can ask my colleagues for help without them thinking that I am stupid.)

The following question *'how was the theory of RME implemented?'* is verified as follows.

The research lessons participants designed included the following:

- Participants thought of meaningful context (a problem situation in reality). This demanded of learners to apply mathematical organization, being horizontal and vertical mathematization. (Reality Principle)
- This context served as source and intertwined with other strands. For example, when we did fractions, equivalence, measurement and proportion was included (Intertwinement principle).
- At first learners received activities which actively involved them (Activity principle). Later on learners had to develop tools in the form of using teaching aids that were provided or they developed their own (Level Principle).
- Learners had to discuss, negotiate and collaborate. This demonstrated that mathematics learning is a social activity. Participants were well aware of the fact that the whole class should be kept together but that problems could be solved at different levels of understanding (Interaction Principle)
- Participants developed a different learning environment compared to before. They deviated from their previous routine as described in the section 'different

stages in participants' teaching'. In creating this environment the participants ensured room for guided re-invention. They tried to plan for anticipated challenges learners might experience (Guidance principle).

Chapter 4 describes that the distinctive characteristic of an ethnographic analysis is to document and understand the meaning of the social interactions that occurred in a natural setting. In this study I verified the theoretical relationships between what was observed and what participants reflected on.

5.5 CONCLUSION

By providing a detailed description of the observations and the interpretation of answers to questions I intentionally focused attention on the complexity of the process of PD.

The three adaptations to the theory of RME to suit the Namibian context as described in Chapter 3 on page 74 were adhered to and achieved. Firstly, this study reports that the participants acted as learners during the workshop sessions to learn how to support their mathematical learning by including RME principles in classroom activities. Secondly, participants were exposed to instructional resources as means of supporting their own and their learners' learning. Lastly, participants' orientation changed to one that acknowledges the mediating role in the classroom.

The report indicates that participants utilize a lot of time teaching steps (procedures/ methods) in primary school mathematics. I claim that there is nothing wrong with this but the procedures or methods need to be explicitly connected to underlying concepts which in the past PSMTs did not have access to or had limited opportunities to engage in PD. However, the results clearly indicate the fact that during the RME-based PD the majority of participants were able to effectively implement the provided teaching aids. Later during the research period noticeable changes in the participants' teaching practice were clearly evident. The findings of the participants' teaching before and after the intervention indicate significant differences with the participants' usual teaching practice.

The views and beliefs of these participants were challenged by their experiences in the PD and the research lessons. Participants realized that not all learners find solutions to problems in the same way. Through guidance and actively involving learners in the teaching, learners experience mathematics as making ‘sense’.

This on-going relationship between workshops and the planning of research lessons provided participants with a powerful medium for professional development. It was clearly apparent that the participants could critically reflect on their primary school mathematics teaching. This, however, only happened towards the end of this study. An important stimulation on their ability to reflect on their experiences was the presence of a researcher in their classroom. The presence of their colleagues in the workshop sessions with whom they could discuss their reflections, also positively contributed to reflect on primary school mathematics.

In the current findings the PD efforts that might have brought improvements in participant learning focused principally on ideas gained through the involvement of a researcher. The participants had limited opportunities to engage in professional activities before. Obviously the participants in this study need additional time to further deepen their understanding of the RME principles, analyzing their learners’ work and to further apply the new approach.

In this study the availability of sufficient time was crucial to success. Although very time-consuming it has nevertheless shown positive effects on the participants’ learning. This study proves that in order to achieve the needs of PSMTs regarding primary school mathematics teaching it requires considerable time. The time available needs to be effectively organized and the content carefully structured in line with the needs of the participants.

The findings that if the PD is purposefully directed and focused on content and pedagogical knowledge it is evident that it results in positive experiences of the participants attending such on-going PD activities. In this study the activities were designed to help participants understand better both what they teach and how learners acquire specific content knowledge and skills.

In the next chapter I will present a discussion on the findings on the experiences of the participants in attending an RME-based PD. The focus will be on mathematization and professional development in RME and LS. This is essential in order to determine the recommendations for the way forward.

CHAPTER 6

DISCUSSION ON FINDINGS

6.1 INTRODUCTION

One of the main challenges affecting primary school learners' performance in mathematics education is the perception that the Namibian Primary School Mathematics Teachers (PSMTs) are unable to equip these learners with the relevant content knowledge and skills (*The Namibian*, 16/01/15).

Namibia has made significant strides in training teachers since independence. However, it is suspected that many of the PSMTs, especially those responsible for teaching Grades 1 – 4, lack sufficient content knowledge while those responsible for teaching Grades 5 – 7 lack the necessary teaching skills. I realized the need to improve the mathematical content knowledge and skills for all PSMTs by engaging them in Realistic Mathematics Education (RME)-based Professional Development (PD).

To attempt to achieve that I did the following:
Chapter 3 was an in-depth study of the literature on the theory of RME and on-going PD. I tried to link both these concepts to Lesson Study (LS). My intention was to provide an alternative approach for PSMTs to enhance both their mathematics content knowledge and teaching skills.

In Chapter 4 the methodology and research ethics of this study are discussed. It includes classroom observation, lesson study, workshops and interviews.

The findings as presented in Chapter 5 have focused the attention of the reader on the fact that in this research participants were active and independent learners of the RME theory themselves. Throughout this research participants' subject content knowledge and skills received attention. They actively took part in solving the challenges they experience in practice rather than only being passive recipients of information. The findings of LS indicate that participants experienced the opportunity to spontaneously reflect critically on their own practice. By doing that participants generated knowledge for their own practice and used this to improve their teaching practice.

Throughout this research the need of listening to each other, participant to participant, participant to me and vice versa and collaborating to understand the current practices has been noted in the previous chapter. This is exactly what Chapter 1 points out namely that one of the values of PD is that teachers have to show commitment to the idea of collaboration, cooperation and collegiality.

The findings indicate that in Namibia there is no clear definition of quality education. 'Good results' are mostly an indication of quality. Therefore the concept of quality is relative and needs to be discussed, defined and re-defined. However, the issue of a definition for quality is actually beyond the scope of this research.

In this chapter the findings in answering the sub-questions will be discussed first. By doing that I will repeat the sub-questions again. The first is:

> *'How can Realistic Mathematics Education (RME) principles and Lesson Study (LS) contribute to the professional development (PD) of the primary school mathematics teacher (PSMT)?'*

The second sub-question is:

> *'What are primary school mathematics teachers' views and beliefs about mathematics teaching?'*

The discussion of the second sub-question will also address whether the existing views and beliefs of the participants have been challenged by the RME-based PD.

After the findings of the sub-questions have been discussed, a summary of the discussions will follow to supply the answer to the main research question:

> '*What are the experiences of primary school mathematics teachers who participated in RME-based professional development?'*

This chapter will then conclude all findings.

The discussions of the findings are presented as follows:

PROFESSIONAL DEVELOPMENT

Experiences of PSMTs

↕

The role of mathematization

Similarities and differences in teaching before and during intervention

↕

RME principles and planning of research lessons

The influence of collaboration, collegiality and reflection on own teaching

↕

Views and beliefs before, during and after the intervention

Figure 6.1: Outline of the Presentation of the Discussion on the Findings of this Study

The two-way arrows indicate the inter-relatedness the different components in this study had on each other.

6.2 THE CONTRIBUTION OF RME PRINCIPLES AND LS TO THE PD OF PSMTs

At the start of this study I argued that to enhance mathematics learning in primary schools the teachers need extensive opportunities to further develop mathematics knowledge and skills in both content and teaching. This study supplied the participants with the opportunity to participate in both RME-based PD and LS. In this study PD is defined as an intensive, on-going (continuous) and systematic process that aims to enhance not only participants' teaching but also their learning.

RME-based PD and LS were totally new concepts and thus also new experiences to the participants. In the beginning, participants were quite skeptical about the sensibility of the RME approach as well as LS. Throughout the research I was guided by the work of Van den Heuvel-Panhuizen (2008, 2010 & 2013). Since the primary school mathematics textbooks in Namibia are not written to cater for the RME approach I used and adapted in my workshops ideas from the book '*Children learn Mathematics*', of which Van den Heuvel-Panhuizen (2008) is the editor. I will discuss the findings on the different components of RME in relation to the participants' experiences.

Mathematization plays an important role in applying RME principles and this study would be incomplete if the discussion did not pay attention to the role it played in the experiences of the participants.

Before the discussion on the contribution of the RME principles is done a brief recapitulation of how mathematization in this research served is explained.

- ***Mathematization* (Chapter 3, p. 108)**

For the first time PSMTs were in a situation where they came across the concept of 'mathematization'. Participants became aware of the importance of 'doing mathematics' but had never realized that mathematization is the core goal of mathematics education. Therefore, during every activity we did in the workshop sessions or planning research lessons participants were made aware of the fact that learners had to organize 'un-mathematical' matter to reality. In the end the participants were able to apply horizontal and vertical mathematization (Chapter 3, p. 108). It was a process that took quite some time because the participants' existing views and beliefs were challenged.

It took the majority of participants at least three weeks to accept that learners pass through different levels of understanding according to which mathematizing takes place. The reason is that they themselves experienced how to devise informal context-bound solutions to find a way of drawing pictures (for example the problem regarding '*There are 10 heads in a kraal. There are men and sheep in the kraal. Altogether I counted 26 legs. How many men and sheep are in the kraal?*') to finally gain insight into the general principle behind the problem. This enabled them to see the 'whole' picture which leads a learner from one level of inquiry to a higher one (Chapter 3, p. 117). Participants themselves experienced the importance of linking relevant context-bound problems to the life experience of learners (Chapter 4, p. 208). Being able to do this the participant needs to know the culture and environment of his/her learners as it is required for example in all types of counting in an RME approach. Previously the participants used the textbook as only resource and I maintain that the use of a textbook in contrast displays a more uniform environment. Therefore, participants are challenged by implementing RME principles in their lessons because it might be 'easier' to follow the prescribed textbook and not to think about a realistic context problem situation for every lesson. However, I also became aware of how time-consuming it is for teachers to plan lessons. A possible reason for teachers to use the textbook as only resource might be that it is less time-consuming because the textbook is readily available. Participants became aware of how thoughtful lesson planning takes time and I argue that they need support from school management to make 'thoughtful lesson planning' possible. This could be possibly achieved by a structural or a time table issue and the support from the Ministry of Education.

Later during the study period it was obvious to note that the majority of participants in this research always tried their utmost best to find realistic context to link to the lesson objectives of the day. It was normal practice that participants during workshops or the daily break-time shared ideas about realistic content for topics prescribed in the national syllabus. While planning research lessons (part of LS), participants made sure that the same context could be used for more than one prescribed topic. This was a first experience for the participants to find every-day realistic examples for topics to stimulate their learners' interests and to motivate them to find solutions on their own. In the end many participants were so conscious of the fact that the principles of the RME theory cannot be achieved without mathematizing.

The RME theory includes basically six principles which are important in the applying of the approach. How mathematization in the various RME principles was experienced by the participants will be discussed next.

Some of the RME principles originate more from the point of view of teaching and are therefore more connected to teaching, meaning they require more input from the teacher in terms of using realistic contextual (everyday life) examples ensuring that learners learn, and applying guided re-invention. These principles are called the teaching principles. They are the reality principle, the intertwinement principle and the guidance principle. The other three principles are considered as learning principles. They put more emphasis on the effective involvement of the learners in the teaching process. These principles are the activity principle, the level principle and the interactive principle (Chapter 3, p. 114).

The schematic presentation below provides an overview of the discussion how the different RME principles served in this study.

RME Principles

Mathematization in

- Implemented in research lessons: <u>**Teaching principles**</u>
  - Reality Principle (the use of context)
  - Intertwinement Principle (various learning strands- learners learning)
  - Guidance Principle (guided re-invention)
- Implemented in research lessons: <u>**Learning principles**</u>
  - Activity Principle (how learners can use their own productions and constructions
  - Level Principle (the use of models)
  - Interaction Principle (interactivity in teaching process)

Figure 6.2: Mathematization in RME principles

The teaching principles in the RME theory, being the reality principle, the intertwinement principle and the guidance principle, will be discussed first, and in that sequence.

- ***The reality principle (use of context)*** **(Chapter 3, page 116)**

Literature (Chapter 3, p. 116) informed me that I can regard this principle as a teaching principle because it emphasizes the aim to make learners capable of applying mathematics. It requires from the participant to find relevant context problems that requires mathematical organization, thereby implying mathematization.

In the beginning many participants were challenged to find suitable problems which would lead learners to a higher level of thinking. Here it was noticeable that the Upper Primary phase participants put very little thought to relate everyday-problems to the topic of the day. They were used to solve with learners only 'plain' problems as Chapter 5 (page 234) points out. The prescribed textbook was applied in a very rigid way.

In the end the majority of participants were extremely anxious to come up with 'more suitable' realistic context problems than their colleagues. Without instructing participants to note down all suggestions of their colleagues, in the end they did have a whole file full of realistic (relating to learners' experiences) examples which served while doing revision for the end of year examination session. The majority of participants were aware of the fact that to start with rich context that demands mathematical organization (for example transparent and hidden types of questioning) would enable learners to use and apply their mathematical understanding and tools to solve experientially real problems (Appendix K_{1-4} (pp. 435 - 453)). It is the context that affords horizontal and vertical mathematizing. An example of a context problem in which it was required from participants to mathematize follows below:

<u>Discussion of a context problem</u>

It was interesting to note how the Upper Primary phase participants struggled with the problem when participants had to solve the following in a workshop session:

> *How many cups can be filled out of 16 cans, if one cup can be filled by 5/8 of a can?*

The Upper Primary phase participants wanted to save time and solved the problem mechanically (they claimed at the start of this study that they do not lack content knowledge). Mechanically meaning they used the 'method' of 'how to divide by a fraction', i.e. multiply by the reciprocal (that is how participants expressed themselves). After they have struggled for quite some time they arrived at an answer of 204,8 cups. One participant explained it on the chalkboard as follows

> *You have to convert 16 cans to a fraction. Therefore 16 x 8 = 128. Now divide 128 by 5/8. If you have to divide you multiply by the reciprocal. The answer is 204,8 cups.*

Immediately the majority of participants shook their heads in disagreement. Asking whether they agreed with the answer one of the Lower Primary phase participants said

> *The answer does not look realistic. Imagine 205 cups from 16 cans– no way!*

Immediately all nodded in agreement, even the Upper Primary phase participants. Asking one of the Lower Primary phase participants to come and explain how she solved the problem she mentioned that they had not arrived at an answer yet but they had approached it as follows:

> *We made use of a table like this:*

Cans	*Cups*	*Remainder*
First can	*1*	*3/8*
Second can (having now 11/8 available)	*2*	*1/8*
Third can (having now 9/8 available)	*1*	*4/8*
Fourth can (having now 12/8 available)	*2*	*2/8*
Fifth can (having now 10/8 available)	*2*	*0*

Table 6.1: Lower Primary Phase participants' Explanation on Context Problem

Immediately one Upper Primary phase participant screamed out excitedly:

> *Yes, they are approaching the problem correctly. There can be 8 cups be filled with 5 cans, therefore the answer is 3 x 8 + 1 = 25 cups and a remainder of 3/8 of a can.*

It was a beehive of activity to explain how this participant then arrived at the answer so quickly after the fifth can. Most, if not all, participants mentioned that for the first time they experienced to think in terms of having a realistic picture in your head. One participant came to the chalkboard and demonstrated the solution to the problem this way:

> *5 cans fill up 8 cups*
> *10 cans fill up 16 cups*
> { *15 cans fill up 24 cups*
> { *1 can fills up 1 cup and leaves a remainder of 3/8 of a can.*

Many participants immediately realized that they should have tried to establish a pattern as displayed above. I argue that participants became aware of 'proportionality' or 'equivalence' that underpins the reasoning in this example. The above example made use of 'proportion' and how participants' applied 'equivalence' will be explained below.

Participants wanted to know what went wrong with the 'mechanical' (multiplying by the reciprocal) method, claiming:

> *The mechanical way MUST (emphasis on must) work. Is it possible that there is another way of solving the problem?*

It took quite some time because I wanted them to find the answer by themselves. They discovered by converting the 'cans' to 'fractions' as they called it,

> *You have to divide only by 5 and not by 5/8, because the cans display now 128/8 and the eights 'cancel each other'.*

Asking how they arrived at the comma 6, they replied:

> *Don't worry, the solution is now correct. We used a pocket calculator!*

This was an extremely valuable exercise because the majority of participants realized the value of solving problems in a way that makes sense to learners. Not only have participants related to sense making but by drawing the table as a representation and tool for reasoning about the proportionality or linearity, they have 'organized' the mathematical information in a table, i.e. mathematization. Some Upper Primary phase participants realized the importance of 'equivalence' in working with fractions. Immediately a participant did the following on the chalkboard:

X: $$128/\mathbf{8} \div 5/\mathbf{8} = \frac{128 \div 5}{8 \div 8} = \frac{128 \div 5}{1} = 128 \div 5 = 25{,}6 \text{ cups}$$

Still some Upper Primary phase participants had problems with the answer because according to them 0,6 which is equal to 3/5 are left and not 3/8. Interestingly a Lower Primary phase participant (A) demonstrated the answer then as follows:

A: *128/8 ÷ 5/8 = 125/8 ÷ 5/8 + 3/8 = 125 ÷5 + 3/8 = 25 +3/8*
We have done the 4 basic operations and know that 125 is divisible by 5, this is a basic fact. Therefore the answer is 25 cups and 3/8 of a can is left.

This was a problem which kept the participants busy quite some time because the issue about cups and the remainder of a can was not solved. After a lengthy discussion an Upper Primary participant came with the following answer.

Y: *I like the explanation of Maria (pseudonym) because she explains it logically that 3/8 of a CAN (emphasis on can) is left. For the first time I realize how complicated a very easy sum can be. You see, 0,6 displays CUPS (emphasize on cups) and 3/8 displays CANS (emphasis on cans). This means that 0,6 which is equal to 3/5 of a CUP equals 3/8 of a CAN in this problem. To show you I can add: 3/8 ÷ 5/8 = 3/8 x 8/5 = 3/5 = 0,6. Very complicated!*

All participants were astonished by this answer and this was a major 'breakthrough' for participants that they themselves could find an explanation to a 'difficult' question. Several participants mentioned that for the first time they made sense out of the 'rule' to multiply by the reciprocal if you divide with a fraction. One participant argued that

> *My colleagues complicated the issue – take 16 and multiply by 8/5 and you will also get 25,6. But I agree, it does make more sense if you give learners the opportunity to discover themselves the rule.*

After this explanation which I had to comment on whether the reasoning is correct or not (I confirmed the answer) everybody was satisfied. However, the participant's (X) explanation above, applying equivalence, was favoured by the majority of participants. It was a matter of *'we know this method'* and I state that it was a good exercise for participants to demonstrate their knowledge in applying different strategies.

<u>Discussion of participants' experiences regarding the context problem (Cups and cans)</u>

At the next workshop session some participants reported back that they gave the same problem to their learners in Grades 4 – 7. Even learners in Grade 4 were able to come up with a correct solution after drawing pictures of how they fill up the cups. This convinced the participants to regularly apply the RME approach applying for example in this case the reality principle (use of context) in their classes since very young learners are already able to mathematize. However, the time factor again played a very important role. They used a double-period (two periods) to solve the problem with their learners. One participant remarked that it is worth the time since learners understand the concept of a fraction so much better. This is an experience for learners to mathematize everyday challenges. The context is important; it is that what makes the activity effective.

<u>Summary of discussion on reality principle</u>

Many participants experienced that the learners who approached problems 'mechanically' by using a method did not all derive at the correct answer (e.g. the cups and cans problem). This incident made many participants realize the importance of having realistic examples available for which learners can reason logically whether an answer could be correct or not. Based on my interactions and support I maintain that the majority of participants had become more critically about reflecting on an answer during this RME-based PD.

It also became evident that most participants were able to estimate whether an answer was realistic or not. This finding in this study correlates with what Van den Heuvel-Panhuizen (2010, 2013) and Ndlovu (2014) mention about the importance of using context and models (in the context of the Netherlands and South Africa respectively). The majority of participants experienced that it is much easier to estimate whether an answer is correct or not if the problem is based on realistic context. The problem regarding the 'cans and cups' convinced many participants that by doing problems mechanically the logic behind solving problems is sometimes lacking.

It appears that most participants realized that to find realistic context, as instantiated in the cup and can (measurement) problem in the above, they could use other topics within the syllabus or even subject areas content to link to the mathematics topics. In the next session it will be discussed how the intertwinement principle contributed to the PD activity.

- ***The intertwinement principle (intertwinement of various learning strands)* (Chapter 3, page 119)**

The RME theory advocates that topics in the mathematics syllabus should be integrated (Chapter 3, p. 119) and not be presented in isolation. By integrating various topics learners will experience mathematics as 'real life'. Other school subjects, especially in the Lower Primary phase, could also provide suitable context for mathematics.

Participants have the responsibility to do extra-mural activities in the afternoons. From January to end of April learners were involved in athletics activities. Estimation and conversion served as topics while we were practicing this principle in our weekly workshop sessions. It posed no problem at all for participants to come up with reality-based examples of questions like:

- ✓ *Demonstrate with this board ruler* (metre ruler) *how far is a jump of 1m 45 cm?*

- ✓ *Will a jump of double the jump fit in the classroom?*
- ✓ *How many times will my ruler of 30cm fit into the jump of 1m 45 cm?*
- ✓ *Joseph bought three tickets for the athletics meeting at N$16, 00 each. He paid with 3 N$ 20.00 notes. How much change did he receive?*

The above is an indication how participants became able to implement daily life experiences which relate to various topics in the syllabus for example measurement and money in their teaching.

Summary of discussion on the intertwinement principle

It appears that most participants realized that mathematics can not to be seen as a subject totally on its own. This corresponds to what Van den Heuvel-Panhuizen (2010) mentions about the issue to make situations real for learners. The major strength of this principle, as many participants mentioned, is that for the first time they realized the coherence of a mathematics primary school curriculum (Chapter 3, p. 119). The participants for the first time realized that they were able to do different topics simultaneously, in this case measurement, fractions, equivalence and money, as demonstrated by the examples they provided.

The findings of the experiences of the participants regarding the guidance principle will be discussed next. The guidance principle is important in the sense that it expects of the teacher in the teaching process to not only provide opportunities for real life context but also opportunities for learners to 're-invent' mathematics.

- ***The guidance principle (guided re-invention)* (Chapter 3, page 120)**

According to this principle a route to learning, in which the learner will be able to find the intended mathematics by him/herself, has to be mapped out by the teacher (Gravemeijer & Terwel, 2000). In Chapter 3 on page 120, it is mentioned that the teacher should provide learners with opportunities to develop their own mathematical knowledge. This principle is inspired by the informal solution procedure (Gravemeijer & Terwel, 2000).

I will describe and do an analysis on 'guided re-invention' in this section. In particular I will consider the 'word problem' in Grade 5 which dealt with biscuits which had to be put into packets.

This was a very challenging principle for participants to implement. It challenged their existing beliefs that mathematics can be presented as a 'ready–made system', the 'step-by-step method' (stepwise, mechanically) they were so convinced of and willing to apply.

It was the most difficult part for the participants not to be the 'instructor' of mathematics education but to have materials available that guided learners to work in small groups and to enhance learners' own thinking and learning. To reach the shift in learners' understanding was an eye-opener for the participants. Van den Heuvel-Panhuizen (2013) points out that teachers should have a pro-active role in learners' learning. In the following paragraphs a description of how a context problem was handled and how this problem with guidance from the teacher would have had made a difference to learners' learning.

<u>Discussion of a context problem</u>

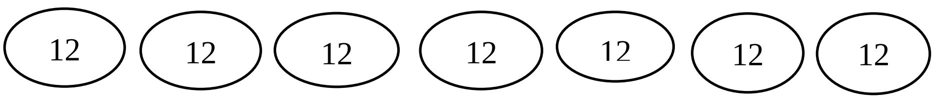
During the research I came back to the 'word problem' the Grade 5 participant gave her learners ('*Mother baked 84 biscuits. She wants to put them into packets to sell. If she puts 12 biscuits into each packet, how many packets can she fill?').* With the permission of the participant, I copied the answers of the learners on the chalkboard.

Learner A: *12, 24, 36, 48, 60, 84 = 6 packets.*

Learner B: *84 ÷ 12 = 7 (took very long to answer)*

Learner C: 84 – 12 = 72; 72 – 12 = 60; 60 – 12 = 48; 48 – 12= 36; 36 – 12 =24;
24 – 12 = 12 and 12 – 12 = 0

Leaner D:



$$12 + 12 + 12 + 12 + 12 + 12 + 12 = 84$$

I asked the participants which answer or answers were correct. By asking 'or answers' immediately some reacted '*so, there MUST be more than one answer correct'.*
After some time, participants started to react as follows:

> *Learner B is definitely correct.*
>
> *Learner A made a mistake; he forgot to add 72 after 60. With guidance, it could have been easily corrected. I like the way the learner approached the problem.*
> *I like the way learner D approached the problem – he just forgot to count the number of bags – with guidance the learner would have realized to note down the answer. The learner just forgot to write down the answer. The solution is very logically displayed – yes I like it.*

Nobody commented on learner C's answer. Waiting for a long time for participants to reply on my question 'what about learner C?' one participant commented:

> *I do not like the method he is doing (sic) the problem. Yes, we know that division is repeated subtraction but it is difficult for learners to understand. I see now that his answer is actually also correct – he just forgot to note down how many times he subtracted 12 from 84. He subtracted 12 seven times from 84; yes, you can regard the answer as correct.*

The participant in whose class this problem served answered the comment above as follows:

> *I demonstrated to my learners a division problem as repeated subtraction – why not? Multiplication is repeated addition and division is repeated subtraction.*

This was an extremely valuable exercise to explain the guidance principle and the role of 'mathematization'. The above discussion made most of the participants aware that if proper guidance is provided learners can 're-invent' the mathematics – they 'unpack' un-mathematical matter to find a solution to a mathematical problem situation. With guidance from the participants' side learners could have been assisted to build on their own ideas to expand and adjust their thinking (for example to count 'how many bags' or 'times subtracted'). With this example participants realized the importance of their role in guiding learners in their understanding and learning. Participants also experienced how valuable a discussion about their own teaching strategies could be – this discussion created an atmosphere of interest to learn more about different colleagues' teaching strategies. Sharing of information and experiences in the classroom created a learning community amongst the participants.

Summary of discussion on the guidance principle

The majority of participants experienced that the guiding principle for RME aims at helping learners build upon their own ideas and help them to expand their thinking. Using concrete materials or teaching aids can be a powerful means of support in such a process. Many of the Upper Primary phase participants experienced that it is critical that scaffolding tools are tailored towards mathematical relations that learners are to build on. The issue of solving 517 + 129 was demonstrated as 'seeing that 7 + 9 = 16; therefore the tens will be increased by one' and learners were able to solve this problem mentally. One participant used my arithmetic rack and one learner moved on the top rod 9 beads and on the bottom rod 7 beads. Learners immediately mentioned 'add 1 bead to the 9 beads on the top rod and move one bead away from the 7 beads on the bottom rod'. Many, if not all, of the participants quickly sorted out when to use which aid to guide learners.

However, this principle can be applied as both a teaching and a learning principle. The participants planned learning experiences which were implemented in their teaching to help learners acquire skills (e.g. mental addition and multiplication skills), i.e. learning.

This planning of learning experiences could not have been done if participants had not applied the activity principle. The idea of mathematization refers to the concept of mathematics as a human activity. The activity principle's emphasis is on the active involvement of learners in an activity and should thus be regarded as a learning principle. The findings on the activity principle followed by the level principle and the interaction principle as learning principles will be discussed next.

- ***The activity principle (use of learners' own productions and constructions)*** **(Chapter 3, page 115)**

This principle's emphasis is on the fact that learners must have sufficient opportunities to produce more concrete solutions by themselves. The RME theory advocates that if a learner is involved in an activity, he or she will be able to develop his/her own informal problem solving strategy (Chapter 3, p. 115).

In this section I will describe and do an analysis on the 'activity principle'. I will consider in particular the 'tangram activity' in which it was expected of participants to use their logic and spatial reasoning skills to build any realistic figure by using the shapes of triangles, a parallelogram and a square contained in the tangram.

<u>Discussion of tangram activity</u>

The very first experience (at the end of the first workshop session) the activity of the tangram convinced most of the participants that it is possible to relate mathematics to real life for primary mathematics learners (Appendix F_1 (p. 424)). A tangram, a Chinese puzzle, is a dissection puzzle consisting of seven flat shapes, called 'tans' which are put together to form shapes. In this exercise the tangram was drawn in a square configuration. The objective of this puzzle exercise was to form any specific shape (given only an outline or silhouette) using all seven pieces which may not overlap.

The aim of starting with an activity like the tangram was to let participants experience an activity that they might be able to use for different topics later on. The issue here was that participants had to experience themselves to use their logic and spatial reasoning skills to assemble the shapes of triangles, a parallelogram and a square. Mathematization could also be demonstrated by this activity making unfamiliar mathematics familiar or 'unpacking' mathematics. I argued that doing an activity the participants might not yet have experienced might serve as motivation at the beginning of the planned study.

Participants realized that 'ready-made' lessons in which learners are passive listeners could be changed to lessons in which learners were actively involved. Doing an activity sometimes 'out of line', as this type of activity is sometimes called, can serve an important aim. In this case it gets learners' creativity stimulated or enables another activity to determine the properties of two dimensional geometric shapes. Participants experienced themselves what it means to see mathematics as a human activity and that learners' mathematical skills should never be underestimated (Freudenthal, 1973 & 1991).

Many of the participants were astonished by the levels of creativity of the learners. For example learners were able to construct different figures using the shapes of the tangram in a much shorter time than many of the participants had been able to. The same activity was used for Grades 4 – 7 when the properties of the triangles (obtuse, acute, isosceles and right-angled), square, rectangle, parallelogram and trapezium were discussed. Participants were eager to use the same activity in order to demonstrate that the shapes learners used can be utilized for the representation of many different problem situations. The participants adapted the original activity by giving more specific instructions, for example:

> *Build any realistic shape by using only the triangles in the tangram.*
> *Build any realistic shape by using only the right-angled triangles.*
> *Use any four shapes to build a trapezium.*
> *We have different triangles in the tangram – put them out separately*
> *Can you find some properties for the different shapes? Write them down.*

Summary of discussion on the activity principle

This activity has demonstrated that participants are able to organize some activities in informal ways which can lead to learners' own productions. With guidance from the participants' side these productions lead to reflections and more formal mathematics, namely to note down the properties of the different shapes. Without realizing the majority of participants moved with their learners beyond the visual level (lowest van Hiele-level) to the descriptive/analytical level.

Many, if not all, participants became aware of the fact that learners must be confronted with a realistic problem situation in order to develop mathematical tools and insights. This is also what Cheung and Huang (2010) advocates. Simply presenting plain ready-made lessons do not encourage the active involvement of the learners in the lessons. Participants realized this because they themselves had been learners in this RME-based PD to improve their instructional practices. Leu & Ginsburg (2011) emphasize that if it is expected that teachers should apply a 'new' strategy they should experience these themselves first.

The majority of participants for example realized that by involving learners in discovering the properties themselves, i.e. horizontal to vertical mathematizing learners were able to recall all the properties of the different two dimensional geometric shapes without having to revise these with them even after two weeks had passed. This activity of the tangram which was an activity participants experienced themselves in a workshop session (Chapter 4, p. 205) emphasizes once again the necessity of a professional developer of PD activities. Participants would not have experienced this principle themselves if they at one stage would not have been learners themselves in this process.

Although initially constantly complaining about the time factor many participants later realized that spending time sensibly in having learners actively involved at the beginning would save time in the end by not requiring too much time for revision. Participants realized that learning mathematics can be constructive and activity-based with adequate guidance from the teacher which at the beginning of the PD was quite contradicting to the idea of learning as absorbing knowledge which is presented. The apparent lack of time for constructive activities was a factor participants raised as being not in favour of applying learners' own productions and constructions. This might be a reason why participants liked to focus on a mechanical approach (Chapter 5, pp. 233 & 241) which is indeed more time effective if your main aim is to get through a syllabus.

Participants had to be guided how to apply the level principle and the discussion of this to the contribution to their professional development is described next. The focus of this principle is on mastering different levels of understanding and bridging the gap between context-related and more formal mathematics.

- ***The level principle (use of models)*** **(Chapter 3, page 117)**

This principle's aim is to guide learners through different levels of understanding (Chapter 3, page 117). It was therefore necessary that participants experienced context-related situations which could be presented by models which could serve as a device for bridging the gap between the informal context-related mathematics and more formal mathematics. I consider this principle as important to expose participants to because it guides growth in mathematical understanding.

While the concept of mathematization served through all topics handled in the workshops, participants experienced challenges in understanding the need to pay attention to the use of models in the beginning. The break-through came when many participants were busy with the topic 'counting'. Participants had the experience of horizontal as well as vertical mathematization by doing activities they had to apply the following days in their lessons.

Many participants mentioned the obstacles of language and of counting in general. The majority of learners are not English mother tongue speakers; therefore counting in English up to 'ten' as well as passing 'ten' creates a language problem for learners especially in Grades 1 – 3. Speakers of one particular mother tongue group count in their mother tongue as follows: one, two, three, four, five, five–one (6), five-two (7), five-three (8), five-four(9), two five (10). In the past participants used only class reciting (all learners chorusing) and sometimes a rhyme to practice counting.

<u>Discussion of participants' experiences being exposed to models</u>

Participants, having received the five, ten and twenty frames, beads and strings, immediately saw a solution how to overcome this problem. We used a five, a ten and a twenty bead frame which we extended up to a hundred bead string to be used by the Grade 3's and 4's. The bead strings were based on the five bead frame, a ten string was made up of 5 white and five red beads. This was very useful when we moved over from context-bound to object-bound to pure counting activities. Participants immediately realized the usefulness of theses strings and frames. They now had a variety of activities and teaching aids available that they had used never before. For 'counting on' activities some of the teachers put a washing peg after 'two fives and then another two beads– learners immediately 'saw twelve' and counting on could simply continue (Appendix R_2 (p. 474) & R_{12} (pp. 484 - 487)). Previously learners counted silently up to twelve and then chorusing the numbers onwards. Participants could not believe how 'fast' learners coped with this teaching aid. However, a problem was that learners became too dependent on the teaching aid. It was a first time experience for learners to be exposed to such models. With more time and more practice participants should be able to guide learners to move to the symbolic level.

The majority of participants were quite surprised how 'easy' learners' mental calculation skills improved after the five and ten frames and bead strings were implemented. Learners immediately related '4 fives' to twenty without any difficulties. A participant was so impressed that the majority of learners were able to relate doubling to the frames – two 2's are 4, two 3's are 6 (will 'move over five' in learners' terminology) and so on. Learners knew the number bonds without chorusing them every day. By using the 'friends of five and ten' (Appendix R_{12} (p. 484), Figure 10) learners knew by heart that the sum of a 3 and a 7 will always result in ten. When learners had to count a number of beans (e.g. counting 68 beans) some immediately made groups of five, while others made groups of ten. This enabled them to count either in 5's or in 10's.

To illustrate the above statement it is important to explain the following. Previously many participants most of the time involved learners only in rote counting, i.e. counting by heart; learners might know the sequence of the numbers but not necessarily noticing structure. The workshop sessions were aimed at implementing RME principles in activities. Teaching aids for counting were provided to practice the implementation thereof. The teaching aids appear in Appendix R_{1-12} (pp. 473 – 487). Participants experienced in the workshop sessions that reciting the counting sequence (i.e. rote counting) is an activity that develops separately from the counting of quantities (i.e. rational counting; counting one-by-one).

Several participants mentioned that the majority of learners can count up to ten if they enter Grade 1 and therefore they do not spend too much time on the topic. This implies that the mathematization, i.e. the unpacking and studying of numbers and numerals in their written and oral forms, does not receive the necessary attention in the first primary school Grade. I experienced that learners do not really have a clear idea of what counting is about. Apart from being able to show with their fingers how old they are, many of the classroom activities also relate to 'imaginary' quantities. It is precisely in this kind of situation that learners feel the need to present quantities symbolically.

Without focusing with participants too much on the terminology involved with the types of mathematization they realized that they had done every counting activity in the past in a mechanistic way. In Chapter 3 (page 110) it is mentioned that Cheung and Huang (2010) refer to mathematization as various ways of organizing activities for the learners to bring reality to the classroom. Participants became aware of how 'pure counting' can lead to 'calculation by counting'

7 + 6 = 8; 9; 10; 11; 12; 13

'to calculation by structuring'

7 + 6 = 7 + 3 + 3 = 10 + 3 = 13 and eventually to

'formal calculation'.

17 + 16 = 20 + 13 = 33

The textbook is a useful resource but it is the pedagogical knowledge of the participant and the classroom management that influence the learning process. I realized that the participants had to depend on textbooks and their own resources for the development of their subject knowledge. This might have given them a weak foundation which as a consequence left the society with no confidence in them teaching primary school mathematics. They lacked a profound and updated knowledge base. The participants became aware of how the materials provided, e.g. 'five' and 'ten' frames and bead strings helped them in devising their own ways of working through a mathematical concept, for example in the topic '*Counting*'. In the collaborative learning environment of this study the continuous emphasis on reasoning and whole-group discussion resulted in the emergence of key concepts like for example rote and rational counting which in the past was only addressed as displayed in the textbook.

The textbook plays an important role in participants' teaching because currently it is the only resource they can relate to and have readily available. I reason that participants should not be discouraged to use the textbook but to be made aware of the availability of the variety of other resources also available. The shift to using other resources in their teaching became evident in their research lessons presentations.

The use of models served very prominently in the workshop sessions because this was a request from the participants that they would like to be introduced to different teaching aids in this study also called 'models'. A summary of the different models will follow below.

<u>The contribution of 'Models' to the PD of PSMTs in this study</u>

During our workshop sessions the participants were introduced to different types of models which can be used in order to structure numbers. The line-model (the bead strings were put on top of the number line), the group-model (numbers were re-arranged in 'fives' for example 8 = 5 + 3) and a combination-model (where the line and group model were combined) by using the arithmetic rack (Appendix R_{12} (pp. 484 – 487), Figure 8 & 9). The participants were not at all in favour of the last model. I had a twenty rack for demonstration purposes available and mentioned that they could use the abacus. However, I could not convince them in making use of this model. Participants all had an abacus available in their classrooms but they very seldom made use of it. Soon they realized that the abacus is actually the combination of the models we used in our afternoon sessions. Using washing pegs on the abacus they agreed that they would use it more often in future. The currently prescribed textbooks use the number-line as example in almost all calculation activities and this was the reason the participants were initially in favour of the first two models.

When learners were given the 'plain' ('naked') problem of 317 + 214 to solve, they could solve it much more easily than year groups before, because these learners had 'models' at hand. Participants reported that in the past they would immediately have corrected a learner who solved the problem as follows:

317 + 214 = 500 + 30 + 1 = 531.

Previously they would have 'insisted' that learners write it as 500 + 20 + 11 but doing number bonds learners immediately see, as the participants would call it, that the tens are increased by a ten (7 + 4 exceeds ten).

The above problem was solved by a Grade 4 learner by writing down the answer as follows:

> *317 + 214 = 520 + 11=531 (He was talking aloud 'five –two –eleven ok it is five –three- one - ok it is five hundred thirty one').*

The participant reported back that she could not believe how effective the lesson regarding having a 'model' at hand was. After the participant had reported this incident to the group another participant remarked (referring to the solution above):

> *This learner understands 'place value'.*

I maintain that participants, by means of sharing their experiences, became reflective practitioners about how important it is to take learners from one level to the other level of understanding by applying models which could serve as a device for bridging the gap between the informal context-related mathematics and more formal mathematics.

For example, PSMTs experienced mental strategies in this study which they have used and will in future use in their classroom teaching for learners to become numerate. Learners need to experience the value of having different mental strategies at hand to solve problems much faster and in 'easier' ways. This might ensure that learners will get actively involved in finding solutions to problem situations themselves. The use of the five, ten and twenty frame helped learners with their mental skills. By knowing for example that the 'friend' of 7 is 3 learners immediately had a better understanding of the place value system, e.g. 97 + 4 will exceed hundred by one.

It took quite some time for participants to use and apply teaching aids in ways where the imbedded mathematical meanings in the design of the teaching aids were explored for purposes of mathematizing. Using teaching aids complemented by using the correct language (mathematical terminology) meant that a lot of practice from all the participants was required. How to provide guidance to be able to use the teaching aids correctly was another skill participants had to practice.

One strength of this level principle was that participants realized the value of at first using models in an informal way, to later using them in a more formal way (when counting became calculation). Participants did all the activities we did for counting and calculation up to 20 for all Grades because they argued that it could provide learners with a proper foundation. Upper Primary phase participants found that the challenges learners had experienced with the four basic operations before were much easier to include after the introduction of the different calculation models.

However, the bottom-up process as explained in the literature review (Chapter 3, p. 117), which implies that the models should be invented by the learners themselves, was a bit unrealistic and did not happen in this study. In this study the participants experienced for the first time how to use the models provided and they were afraid that they might not yet have the required skills to guide learners correctly when they would use their own different models. The majority of participants lacked experience but with time they should become more confident to allow more ‘freedom’ in class.

Many participants were extremely conscious about ‘gaps’ in their own knowledge in order to guide learners in the direction they would like to address content later on more formally. The learners’ own productions must occur in a natural manner and they will need time to become capable to develop these skills. In this research the participants provided a learning-rich environment for the learners by providing activities that were related to reality. Realizing it was a ‘first’ experience we could not proceed to the level of learners’ own productions. However, participants regarded the initial drawings learners came up with as ‘own productions’ in their own right. I did not argue about it because it might have demoralized the participants.

The use of models as described above attributed the role of bridging the gap between the informal understandings connected to the ‘reality’ of the learners on the one side and the understanding of the formal system on the other side. This is similar to what Van den Heuvel-Panhuizen (2010) advocates about the use of the RME theory. The participants themselves experienced for the first time how to be guided (instead of instructed) towards growth in mathematical understanding.

With time the majority of participants were able to scaffold their instruction in such a way that 'new' learning builds on previous learning. The means for scaffolding was important because it meant that the participants were able to implement models/ teaching aids to help learners to build upon their own ideas and help them expand their own thinking. The example of the activity with the tangram for example did not end with the concrete model but it was extended to discovering the properties of a square, rectangle, parallelogram, trapezium and other different types of triangles. The progression from the everyday experience of 'models of' (horizontal mathematization) to 'models for' (vertical mathematization) led to higher levels of mathematical reasoning and proof. The participants experienced this progression as a tremendous growth in their ability to teach primary school mathematics.

Participants experienced that the learning of a mathematical concept or skill is a process which is mostly spread out over a longer period of time. Several participants mentioned that they were too conscientious to 'finish in time' that in their teaching in the past the movement from various levels of abstractions had possibly been neglected and this they experienced as a weakness in their present teaching. At the end of the PD activities many, if not all, participants had 'tools and models' available to move from context-bound mathematics to formal mathematics, thus they were able to bridge the gap between the concrete and the abstract.

<u>Summary of discussion on the level principle (use of models)</u>

The use of teaching aids, in this research used as models, has an important role to play in allowing teachers to model representations of mathematical ideas (an important condition in applying RME principles) and in supporting learners to develop mathematical thinking and understanding. However, I maintain that the effective use of any resource also depends on the participants' mastery of the subject matter. The representation (use of a model/ teaching aid) had helped the participants to imagine what would help to develop the mental imaginary of the learner (making it 'realistic' to the learner). Participants were able to utilize the models provided to assist with learners' understanding of a particular mathematical concept.

Another strength of this principle in this research was that the participants found it extremely helpful to have, as it is called, the 'correct teaching aids' available to guide learners to better understanding. However, in order to be able to use these aids effectively the PD which took place in the form of workshops also aimed at improving the teachers' subject and pedagogical content knowledge. Many participants mentioned it several times that without the continuous RME-based PD, the teaching aids, if provided without training, would not have been used at all. This study was viewed by the participants as continuous PD because they experienced the value of attending a number of workshops and planning collaboratively research lessons as continuous development which would not have been possible in a 'once off' PD activity.

It is evident from the findings that when the Knowledge Quartet (Rowland, Turner, Thwaites & Huckstep, 2009) was discussed, the participants were eager to learn more regarding subject and pedagogical content knowledge and that it could not be achieved within a single PD activity (Appendix G (p. 426) & M (p. 456)). The KQ also emphasized the use of illustrations, demonstrations, explanations and examples to help learners in their understanding and learning of mathematical concepts. This helped participants to find the link to the RME theory in this case being the level principle.

After the PD had come to an end the classrooms of the majority of participants looked very colourful with all the teaching aids (models) displayed against the walls and on 'washing lines', as the participants called them, in front of their classroom. The classroom of the participants looked like, as they called it, 'now we have real mathematics classrooms'. The participants' skills in finding suitable and realistic teaching aids improved tremendously. In the end they were able to apply a model not only for a single lesson but for a series of lessons.

The sharing of ideas and strategies is an enriching experience which can be achieved by arranging PD sessions that has the focus on 'numeracy'. In this study it was not possible to arrange more sessions focusing on 'numeracy' but it is a point that should be recommended for any future PD for PSMTs.

In applying models (as well as 'mental' strategies) participants had to plan in their lessons how to most effectively implement models and for that the interaction principle was applied. A discussion of how the interactive character of the teaching process was experienced by the participants will be done next.

- ***The interaction principle (interactive character of the teaching process)* (Chapter 3, page 120)**

This principle offers learners opportunities to share their experiences, strategies and interventions with each other and the teacher (Chapter 3, p. 120).

I will describe and do an analysis on the 'interaction principle' in this section. In particular, I will consider some of the problems that served in the workshop sessions. The findings of participants' teaching pointed out that before the intervention this principle did not serve. Firstly, an analysis of participants' teaching will be given and then how they were able to include learners in their lessons follows.

Many participants were challenged to actively involve learners in their teaching. It was a new experience for the majority of participants to provide opportunities for learners to actively engage in their teaching. Many participants allowed learners in lessons to share their solutions to context problems with each other and also to reflect on their answers even if answers were not correct. I argue, with the information supplied in Chapter 3 on page 120, that the majority of participants evidently demonstrated their capability to involve learners in their teaching.

<u>Discussion of participants' experiences implementing the interaction principle</u>

Later on during the study the participants in their planning of lessons made room for learners to be encouraged to share their own ideas with each other. For the first time the majority of participants experienced that collaborative work can solve problems experienced in overcrowded classrooms. At first they were very skeptical of allowing 'too much freedom' as they called it to learners. However, the example of *'There are 10 heads in a kraal. There are men and sheep in the kraal. Altogether I counted 26 legs. How many men and sheep are in the kraal?'* convinced many participants that learners can indeed learn from each other. Participants realized that to make a drawing and assigning first 2 and then another 2 legs to the heads makes it very easy to find the solution. Making a 'model' is very helpful and it puts the problem into perspective and in the end a lot of 'teaching time' is gained by not repeating the content. The fact that teachers can also benefit from learners' reasoning skills should not be underestimated, for example the ten frame of the learner which he used to 'fill up' with the legs of sheep and men (presented in Chapter 5, p. 285).

I contend that progress was made in the sense that many participants slowly started to question their own teaching. A first step towards applying mathematization in their teaching was done. The majority of participants started to realize that learners can achieve higher levels of understanding if they are challenged with context-bound problems linked to the real-life experience of the learners.

Many, if not all, participants realized that they were used to teach in a traditional way (i.e. teacher-centred) and very seldom left time for learners to discover mathematics for themselves. This challenged their beliefs about mathematics teaching because being always pressured by time to finish the syllabus learners were not allowed to discover strategies to solve problems on their own. They preferred to provide a 'method' to learners to solve the problem mentioned above but in this case they did not have a 'method' at hand to demonstrate to learners. Here the RME approach proved that learners are able to find solutions without having 'fixed' methods at hand.

Indeed, before the intervention started I experienced strict discipline overall during class time. Participants were well prepared as far as the correctness of the subject matter was concerned and the lessons did not have any contextual errors. However, participants were very rigid and mechanical in their approach as they expected of the learners to memorize and learn rules or tricks. Learners were not involved in the process of 'finding a solution to a problem situation' neither to engage in the teaching process.

The Upper Primary phase participants only used the chalkboard most of the time as teaching aid to explain the content of the day. Learners in the Upper Primary group were sometimes called to the front to solve problems on the chalkboard. While learners were busy participants very seldom explained or gave guidance. If a learner did not know how to continue another learner was simply called to the front to take over. Lessons often did not reflect learners' needs, interests or capabilities because the lessons were based on the textbook content. The interactive relationship between the participant and the learners were lacking. By calling learners to the chalkboard to solve mathematical problems, in many cases not even being able to find a solution, is not the means to be interactive in their teaching.

Most of the time the textbook was strictly followed especially for the Upper Primary phase. Interesting topics such as decimal fractions for example were not linked to real life examples. Learners had to solve problems mechanically, i.e. applying 'rules' or 'steps' as demonstrated by the participants. This is what the literature review states as the mechanistic approach where it is expected of learners to do problems based on drill practice. Mathematization which is an essential factor in RME was not observed. Learners had limited opportunities to 'unpack' the mathematics and to get involved in the teaching and learning process. This can be demonstrated with the occasion when I asked one participant why he used an example like 4/7 to convert to a decimal and not another 'easier' example like for example 3/8 and the answer was

It is the example used in the textbook.

Several learners experienced major problems in converting common fractions to decimals. When I asked the participants whether there was no other way to solve this problem regarding the conversion of 4/7 to a decimal fraction the answer was 'no'. I maintain that learners know that ½ = 0,5, ¼ = 0,25, in other words the decimals that are 'easy' in terms of the participant's terminology. Learners are aware of these facts. The mathematization is about 'equivalence' in particular, equivalent fractions for which there are an infinite number of ways to write ½ or ¼ for example. I argue that it is a case where the participants do not investigate or bring to the fore the underlying mathematics as it is the case in mathematization. When I asked the participant whether learners could estimate 4/7 as a decimal, the answer was '*I will ask the next group this question*'.

The participant was very astonished when one learner gave the answer as

4/7 is more than half, therefore the answer will be 0,5 something (sic).

The participant was very impressed with his learner. Estimation is a topic that is included later in the syllabus, and the participant admitted that he never thought of asking his learners to estimate a possible answer before it serves as a problem.

Summary of discussion on interaction principle

Many participants became aware of the need to implement this 'interaction principle' in their teaching. By involving learners in their teaching mathematical content that might pose a challenge to learners can become more approachable. Learners might experience the satisfaction of having their ideas discussed and analyzed. Not only do learners benefit from this but the participants learned also from their learners how they reasoned out problems logically, e.g. the conversion of 1/8 to a decimal.

The topic 'Fractions' was mentioned by many participants which needs attention. The concept of a fraction, the conversions of common fractions to decimals and the four basic operations of fractions were mentioned as problematic. Therefore, I tried to put a lot of focus on it by asking participants a lot of questions and guiding them in being reflective about their own understanding of the topic. Coming back to the above example, except that it was in my view not an appropriate example to do in class, the participant was aware of the fact that 4/7 is a rational number that can be expressed as a decimal number. However, it was a good incident that happened because the participants talked about this issue during break time. Most of the participants know that the answer to 4/7 as a decimal is about 0,5 because 4 is more than 3,5 which is half of 7. This incident served as an 'awareness' to ensure that examples done on the chalkboard should be 'realistic' and should serve as the link to mathematization and above all should involve learners in finding a solution to a posed problem.

For the first time many, if not all, participants experienced the satisfaction of involving learners in their teaching. They never before had given learners a chance to discuss mathematical issues, whether there might be an easier way to derive at a solution in this case, for example the learner who was sure that 4/7 must be equal to '0,5 something'. The experience that learners can contribute to the teaching and learning in class was something they never before had 'thought of' neither had tried out.

The above is an important issue that syllabus developers should take note of. The above is about syllabus sequencing where an underlying unifying big idea such for example as 'equivalence' is not exploited and also not accessible to PSMTs. I maintain that mathematization in the primary school Grade levels has to be about 'equivalence'. Fractions and equivalence can be applied through mathematization in other topics like measurement for example.

Summary of mathematization in RME-based PD in this study

To summarize the mathematization in RME principles I reason that the findings pointed out that it was evident that participants were rigid and mechanical (step-by-step, stepwise, applying methods or rules) in their teaching approach before the intervention started. The emphasis was on the performance of the participant (teacher-centred) rather than the effective understanding and learning of the learners (learner-centred). Opportunities for learners to actively engage in the teaching-learning process were very limited. The following is an example. Word problems were seldom linked to the learners' real world experiences or situations; this implied that the interactive character of the teaching process got lost. The topic of the week often did not correlate with the word problems being done during that week. The textbook was the only resource participants used. In some cases problems in the textbook could easily have been adapted to make problems more concrete and real to life for the learners.

The opportunities that were created for the participants in the workshop sessions allowed them to share their strategies and interventions with each other. This is what Leu and Ginsburg (2011) advocate that participants should be allowed to experience a situation before they implement it. In the end participants were able to fictionally create opportunities for learners they could implement in their research lessons. Examples of teaching aids are attached as Appendix R_{1-12} (pp. 473 – 487). The participants' own reflections on their knowledge and teaching practices reached higher levels of thinking and broadened their views of their own situation. Van den Heuvel-Panhuizen (2000 & 2013) mentions that reflection is necessary to reach higher levels of thinking. This was a major contribution to teacher learning.

The six teaching and learning principles of RME were a first experience for participants and they applied these in the research lessons. The contribution of LS, in which the planning and presentation of research lessons were focused on, will be discussed next.

- ***Lesson Study (LS)*** **(Chapter 3, page 91)**

In this study LS was an important component of RME-based PD. The connection was that LS served as a tool to practice the implementation of the RME principles in the research lessons. In this study the process of LS is regarded as being planning a lesson, presenting the lesson, reflecting and drawing conclusions about instructional strategies and learners' learning (Chapter 3, p. 91). A research lesson is regarded as a lesson that was planned collaboratively and presented by individual participants.

I will describe and do an analysis on the research lessons presented by the participants in this section. In particular I will consider the experiences of participants planning research lessons collaboratively and the reflections done after these lessons.

In an ethnographic design there are different roles a researcher can take of which a participant observer is one (Hesse-Biber & Leavy, 2011). Another possible role, like that of complete observer, where the observer keeps a distance (the 'fly on the wall' principle) was not suitable in this study because the aim was indeed to also get the direct viewpoints of the participants after a research lesson was presented. Therefore, in this study the role of participant observer enabled me as researcher to engage in the setting. In the beginning I had to participate in the LS process (being planning a lesson, presenting the lesson, reflecting and drawing conclusions about instructional strategies and learner learning very actively (as set out in Chapter 3, p. 91). My role with respect to observing LS in this study could be regarded as that of a 'participant observer' according Hesse-Biber and Leavy (2011).

To include LS in this research was in my view a good decision. It helped to meet my aims for this study, namely that all participants would be entitled to a rich, broad and challenging mathematics experience. These aims are spelled out in Chapter 1, page 17. One of my main intentions of including the process of LS in this study was to put the focus on participants' teaching. This implied that the planning of research lessons and the reflections afterwards played an important role in this study.

Discussion of participants' experiences regarding planning and implementing Research Lessons

In literature (Buhari, 2011) a 'research lesson' is explained as the actual classroom lesson that provides opportunities for participants to practically apply their ideas, views and beliefs, subject content knowledge and teaching strategies. Hurd and Licciardo-Musso (2005) state that one participant should present the lesson and the others should act as observers. In the situation of this study this was not possible because during school time classrooms could not be left without a supervisor. The main aim of the research lessons was to improve the subject content and the quality of the participants' teaching and to determine whether they are able to integrate RME principles in their daily teaching.

A main aim of this study was not only to involve participants in PD to update their knowledge about primary school mathematics but also to provide pedagogical content knowledge which might influence their mathematics teaching. In providing pedagogical content knowledge I argued that the Knowledge Quartet (Rowland *et al.*, 2009) would link to the RME theory in that sense that the four dimensions, i.e. foundation (subject matter knowledge), transformation (In RME: reality, intertwinement and guidance principle), connection (In RME: reality and interaction principle) and contingency (In RME: guidance principle) have to be considered while planning lessons.

As researcher I played a proactive role in teacher-learning in the workshop sessions; the participants could use me as a role model while playing the same role in their research lessons. In this study the participants created opportunities in the research lessons for learners to find their own mathematical strategies.

The problem-based learning approach (using everyday life context) in which well-planned instructional materials guided the participants to work together was implemented in the research lessons. I refer to this approach because it links with the reality principle in the sense that relevant context problems require mathematical organization. In the end every participant was accountable for their own lessons. Participants assisted each other and as a last resort I could be consulted for assistance. The participants were present and available all the time during the research lessons to anticipate difficulties and to help learner groups in meaning negotiation and collective self-reflection on their problem-solving strategies. Participants managed this role very well in the end.

By planning research lessons, attention was paid to the three levels construction principle as described in data generation (Chapter 4, p. 187). Cheung & Huang (2010) describe a similar scenario in their study done in China. I contend that the classroom level was adhered to according to the design of lessons described above. The course level was reached by the majority of participants using the designed/constructed material (teaching aids, for example fraction strips) according to its mathematical and didactical essence in order to promote learner understanding. By reflecting on and discussing and deliberating changes after the presentation of the research lessons, the participants constructed for themselves a form of local theory for a specific area of learning and therefore applied the theoretical level that Streefland (1991) advocates. I argue that participants planned, taught and experienced the research lessons and their experiences, views and beliefs are reflected in the discussions after the research lessons, as well as the classroom observation and many discussions during this study.

The literature review on teachers' views and beliefs and PD (Tella, 2008; Webb & Webb, 2004) made me realize that working with RME represents a significant shift from how participants view the learning and teaching of mathematics from the start of this study. I recognized that many participants experienced discomfort and skepticism in the beginning as their previously held beliefs were challenged. As Chauvot and Turner (1995) point out it was quite difficult to motivate some participants to try out 'new' ideas in this study but when the participants reported about their successful experiences in their classroom I got the impression that a mind shift had taken place.

Therefore, the focus in the research lessons was for the participants on the learners' learning and the connection to the lessons and their own teaching. In the research lessons my focus was on what happened 'differently' between the participant and the learners during the intervention. All research lessons were planned collaboratively but presented individually. This was a first experience for all participants. In general I can report that it is not expected of participants to write out the lesson plans in detail.

Therefore, the experience of writing out a lesson plan as a group was also a first experience for the participants.

Although the majority of participants initially did not really want to get involved it should not be seen as unwillingness to become part of the process. It can rather be attributed to uncertainty namely the fact that they might have felt threatened by their colleagues and that there really exist differences about mathematical issues amongst them. The Lower Primary phase participants initially did not take part actively, possibly because they felt inferior. However, in the end it became evident that they were much more innovative and practical and often made more useful contributions in the planning process. Although the Upper Primary group is obviously academically more knowledgeable in mathematics they apparently lack the practical ideas and initiative and are more rigid and routine-like in their approach to mathematics.

Before the intervention most of the participants put in their teaching much emphasis on ‘methods’ and not always attention was paid to understanding, i.e. the reasoning behind these methods or why these methods work. Mathematization and gradual refinement of informal procedures did not take place. The mechanistic procedures used by the participants as described previously indicate that mathematization did not play a role. Realistic context examples were not used for example by using various learning strands. This made me aware of the fact that participants did not have access to unifying notions within and across the topics they had to teach.

Before the workshops started I got the impression that many participants used strict discipline to cope with the big class groups. Participants put more emphasis on classroom management than on the actual conveying of knowledge which created the impression on teacher-centredness. Many, if not all, participants focused more on their role as a conveyer of knowledge than on the role of learning on the learners’ side. Learners were not granted enough opportunities to ask questions neither to demonstrate how they derived at an answer during a lesson presentation. However, if the participants realized that not all learners understood the content they repeated the lesson. The participants might have argued that repetition might be the ‘more effective’ or ‘best’ strategy in terms of the time available. Another reason might be that the participants regarded this as a lesson consolidation or conclusion.

During the first research lessons learners demonstrated a very dependent attitude. They lacked innovativeness and self-confidence in attempting to solve context problems (Chapter 5, p. 240). This was very similar to the attitude the participants demonstrated at the first few workshop sessions. Having been exposed to RME-based PD participants gained confidence in their own abilities to find solutions other than those displayed in the textbook and this in turn, I contend, motivated them to apply RME principles in their daily lessons.

Initially a serious challenge was that learners were not very active as they did not respond to guidance and did not know how to start during the first research lesson presentations. A reason might have been that up till then they had been used to a more passive role during presentations. Later on a challenge was to apply orderly classroom management. Participants argued that the learners lacked discipline during the research lessons because they became very argumentative and even interrupted or 'overruled' their peers in a group. However, participants acknowledged that it was the first time learners were really involved in mathematical discussions. At this stage it was problematic for participants to give proper guidance during the lessons.

The new form of classroom management was initially somewhat problematic for the majority of participants. Learners often shouted out for help and guidance. However, in the end the participants themselves reported that this type of behaviour had changed. The intervention of the participant was minimized and the groups quickly organized themselves in such a way as to find a correct answer as soon as possible. However, many learners were interested in the answer only and did not pay attention to the process of solving a problem. This could be a result of a misconception that 'a correct answer demonstrates understanding' or that 'you are clever'. Previously learners were not given the opportunity to explain how they derived at an answer, so they were initially not used to that idea.

Many participants became aware of the fact that learners could come with different strategies to solve a problem. Learners could reason out a problem in a way that would unfold a situation differently from how a participant would have done it. The issue of mathematization gradually became a reality to participants. However, by involving learners actively in their teaching, their classroom management as they reflected seemed to be ‘unruly’. It did not take long and learners started to act very differently; they became very enthusiastic in finding solutions and ‘behaved’ in a more disciplined manner. This was seen as a major achievement by the participants.

In the end many participants were overwhelmed by the creativity of the learners when exposed to stimulating context problems (e.g. the tangram-activity). In this case the RME-based PD also had a major impact on learners’ development of creativity and ability to discuss their solutions even if their answers were not correct all the time (e.g. completing the 3 x 3 square). The majority of participants, however, were able to guide learners in their reasoning to derive at the correct solutions.

By being involved in the process of LS gave participants a degree of ownership of the PD by their involvement in decision-making and by being regarded as true partners in the whole process. Many participants were able to change their traditional/normal way (step-by-step; stepwise, mechanically) of teaching to one that involved the active participation of learners. Learners were given the opportunity to find their own solutions to context problems and this enabled them to reason and to better understand the mathematical content.

Summary of discussions of participants’ experiences regarding LS

The process of LS, i.e. planning a lesson, presenting the lesson, reflecting and drawing conclusions about instructional strategies and learner learning, proved to me that change is a gradual, difficult and also a painful process as the findings have pointed out. However, ‘practicing’ LS affords opportunities for on-going support from critical colleagues and management. In this study the findings have validated that there was an improvement in the quality of the teaching and learning processes in the classroom. Quality in the sense that the research lessons’ content was always presented in context and that special attention was given to what could be expected of learners to learn and to understand. Participants ensured that the needs of the learners were addressed. The majority of participants were able to use teaching aids that served as models (e.g. the arithmetic rack, the frames) which effectively supported learners in a transition towards more sophisticated mathematics. It took time for many participants to experience that the teaching aids did not represent the more advanced knowledge of the teacher but the learners’ own knowledge. Gravemeijer (1994a) argues that this is a core element of the level principle in the RME approach. This was an experience the Upper Primary phase participants were exposed to for the first time.

Many of the participants experienced what it means to keep a fine balance between teaching and learning. While planning research lessons participants also experienced what is required to map out a learning route for learners to acquire mathematical knowledge and skills.

I maintain that it is evident from the findings that participants proved that collaboratively well-designed lessons would contribute to professional and innovative PSMTs. In this study LS was a tool that helped many participants to use their combined talents and experiences to increase learner achievement by applying the knowledge they had gained through the PD activities in their research lessons. I argue that these participants were empowered by the process of LS because their ability to improve their practice and the learning of their learners was demonstrated in the research lessons and their critical reflections on these lessons.

The PSMTs' collaborative planning and the critical reflections of individual participants at the end of a research lesson was a first and very valuable experience for the participants. A valuable discussion, agreement and disagreement, of what should be done in the lessons preceded the writing out of the lesson plan. Therefore, the lesson plan did in fact really not portray all the participants' valuable contribution in these planning sessions. I did not put too much pressure on the participants to write out the plans in more detail because this might have had a negative influence on their eagerness and motivation to implement research lessons.

Most participants' concerns were addressed in workshops in which they participated actively. The workshop experiences lead to the development of research lessons in which they developed relevant activities suitable for a specific Grade. Opportunities for planning, reflection and refinement of lessons were provided and resulted in the professional growth of the participants. The cases where participants gave learners the activities (e.g. tangram, 'cup and cans' 'ten heads, 26 legs, men and sheep') they had done in the workshops created opportunities in which most participants realized that learners are able to solve problems using informal strategies. The changes in their existing beliefs about teaching and learning derived largely from the classroom practice and the report back on successes and failures. This in turn led to the acceptance of a new approach to teaching.

By attending the PD activities, which were carefully planned and based on RME principles and LS, participants were granted opportunities to reflect on their own teaching on a continual basis. This had never happened before and could not take place in a single PD that was not well-planned. However, the future success of LS will depend on the continuing spirit of working together amongst the participants to learn together and to share ideas without having a researcher facilitating them.

In the research lessons presented, most participants demonstrated that they are able to plan lessons that have the aim of how learners develop a deeper understanding of specific subject matter. Towards the end, many of the participants were very capable to refine presented lessons without any help. The Lower Primary phase participants took issues into consideration for next lessons (e.g. when learners had difficulties in solving for example ½ + 1/3, in a follow-up lesson they did exercises of comparing of fractions by specifically paying attention to equivalence) and the Upper Primary phase participants normally took care of changes in their teaching for a next group of the same Grade the lesson was presented to (e.g. conversions of common fractions to decimals, whereby they first converted 'easier' fractions (e.g. ¼) to decimals, before paying attention to for example converting 5/8 to a decimal). Reflections after lessons became a normal procedure even if it had not been a research lesson.

The longer my stay lasted the easier the participants became involved in a discussion of their own teaching. This, I maintain, is a strong point about the need for PSMTs to be involved in on-going PD within their own school environment and teacher educators or subject advice from ministerial side. The reflection on the research lessons helped participants to develop a deeper understanding of how learners learn specific subject matter and why some topics are more challenging than others.

Some participants portrayed through their reflections that they had the ability to increase the effectiveness of learners' involvement and learning. An example is where learners had to convert 1/8 to a decimal number. A participant reported back, that after

I had asked him whether his learners would be able to estimate 4/7 as a decimal number (a learner impressed him with the answer), he asked learners to convert 1/8 to a decimal number without any guidance at first. A learner reasoned that 1/8 is half of a quarter, because a quarter is equal to 2/8. Learners know by heart that ¼ is equal to 0,25. Therefore 1/8 must be equal to something like 0,12 (half of 0,25). This reasoning of the learner impressed the participant and made him feel very proud of himself and of his learner. The experience of 'having achieved something' gave participants satisfaction and motivated them to be even more involved in PD activities.

At the end of the study most of the participants answered learners' questions with confidence because, while planning the research lesson, they anticipated a situation whereby learners could derive at answers quite differently. At the end of the study the participants and learners enjoyed the lessons very much realizing that they could generate own solutions to problems. Participants engaged learners in conversations using it with the target that learners attempt to scaffold their understandings. The use of this scaffolding conversation emerged as an important moment for learners both cognitively and affectively.

The expectation of closer cooperation between the different groups, i.e. Lower and Upper Phase participants, was mentioned several times during the research period. Talking about syllabus issues, planning lessons collaboratively and reflecting about experiences created a learning community amongst participants which they had experienced never before. Many participants mentioned that this close cooperation between Lower and Upper Primary phase colleagues was something that should be done for all subjects. This finding needs to be conveyed to the subject advisor for primary school mathematics in Namibia because close cooperation between the different groups (especially Lower and Upper Primary phase) will definitely benefit the implementation of subject syllabi. The different groups will be better informed of what is expected of learners in each phase if opportunities were created where PSMTs can meet and discuss issues of concern.

- ***How can RME principles and LS contribute to the PD of the PSMT?***

This is the first sub-question in this study that needs to be answered. Therefore, the discussions on the RME principles and LS will be summarized in this sub-section to derive at an answer. Firstly, the summary will focus on what happened before the intervention started and then the focus will be on the participants' experiences and on their teaching during the intervention.

I argue that it is safe to say that the regular contact sessions of the workshops allowed the participants to collaborate and to communicate in ways they had never experienced before. The contact sessions and my presence during most of the school hours also allowed me to become part of their learning environment. The majority of participants started to invite me to their lessons something that is not a 'normal' procedure in Namibian schools.

At the start of the RME-based PD participants were aware of the fact that the Namibian Education System expects of them that they should teach in a learner-centred way. Though, as the findings of the majority of participants' teaching indicate, they mainly taught mathematics as a system of rules, or as they called it 'step-by-step', in other words in a mechanistic (mechanical) way in which mathematizing was not visible. Most of the participants thought that by asking a learner a question means the learner is involved and that is learner-centredness. However, I maintain that learner-centredness is to be seen that the focus is on the learner's learning, whereby teacher-centredness means that the focus is on the teacher and his or her teaching.

At the start of this study mathematization, where learners have to organize 'un-mathematical' matter to reality, did not feature. Many of the participants did for example not ensure that when learners had to sing a song or recite a rhyme that it related to the day's lesson and also that it made sense to the learners. They sang a song of 'ten bears' whereas they have never considered that there are no bears in Namibia and how the particular song could possibly lead to 'unpack' the mathematics. For example many participants used the song or the rhyme as an introduction to the lesson but a plan how to use this song or rhyme in the further development of the lesson was lacking. Flexibility and the ability to gain experience from previous lessons were lacking. Mathematizing means that learners should have had the opportunity, for example, the song 'one little bear, two little bears (counting)' to bridge learning from 'informal' to a context toward more formal 'counting' for example counting in two's or three's or even to explore relationships in addition strategies.

It was quite a challenge to expose participants in the workshops to experience the benefits of mathematization, for example, the development of number concepts in which participants had to interpret a given situation using a model (number frames, bead strings, bead racks and ‘open ‘number line). Participants were exposed to RME situations in the workshops in which it was expected from them to formalise, to illustrate, to represent and to schematize mathematical problem situations. The exposure to mathematization and the focus on ‘guided re-invention’ and the learner (participants were learners of the RME theory in the workshops) was a first experience for participants.

In the literature review (Brousseau & Gibel, 2005; Gravemeijer, 1994a, Sembiring *et al., 2010*; Van den Heuvel-Panhuizen, 2010) the strategy applied by the participants at the start of this study is described as being ‘mechanistic’. However, as the workshop sessions progressed some participants gave learners the opportunity to do some investigation (one of the applying strategies for the four basic operations) but learners were not yet allowed to produce their own models. This could be regarded as an example of the empiric approach as described by Dickinson & Hough (2012). The Grade 5 – 7 participants used especially in geometry the structural approach as described by Wubbels *et al.* (1997) whereby they tried to do some ‘proofs’ with learners regarding the properties of the different 2-dimensional shapes. Most of the participants demonstrated in the end that they were able to apply the RME approach (number concepts; 4 basic operations, mental strategies) in their research lessons (Appendix K_{1-4} (pp. 435 - 453)) based on their interpretation of the RME approach. It has to be taken into consideration that the participants implemented an ‘adapted’ RME approach to suit the Namibian context and not an ‘adopted’ approach. In future the participants’ classroom circumstances would constantly dictate the extent to which they would have to adapt an RME principle or idea to make it appropriate.

However, I reason that an achievement in this RME-based PD was that most of the participants’ teaching became guidance-centred, meaning that participants provided learners with learning opportunities (e.g. involving learners in solving of real life context problems) to develop their own mathematical knowledge. A possible reason is that participants attended 13 workshops and planned collaboratively four research lessons. The majority of participants made effective use of the opportunity to increase their content knowledge and to improve their teaching, by taking part as active, independent learners and problem-solvers rather than as passive recipients of information of the RME theory. Knowledge about their own teaching (and its shortcomings) was constructed when they were given the opportunity to reflect regularly on their own research lessons. The participants were exposed to a process of RME-based PD and LS in a way to generate theory from practice and practice from theory.

Models (participants preferred the concept ‘teaching aids’) served an important role in this study. Streefland (1985 & 1991) detected the shift in models as a crucial mechanism in the growth of understanding in learners. Most participants became aware that a model (teaching aid) was necessary for learners to bridge the gap between informal and more formal mathematics (e.g. using at first the frames and bead strings to solve 7 + 9 (‘model of’) and being able to solve 127 + 39 (‘model for’) later). This became evident in the findings that it was crucial in participants’ own learning. Most of the participants themselves experienced during the workshops the impact of the shift of ‘model of’ to ‘model for’ as a significant element within RME thinking and in learners’ understanding (they have been themselves learners in the PD activities) of mathematics. This finding relates to what Sembiring *et al.* (2008) also stated.

The PD, i.e. the series of workshops on RME principles, LS, collaboration and contact with participants not only developed the participants’ knowledge about their own teaching but also developed their ability to find appropriate context for subject matter. After attending the workshops most participants extensively used the context and the intertwinement and guidance principles in their teaching in order to plan their daily lessons. To ensure that effective learners’ learning was taking place, the activity, level and interaction principle were also integrated in the planning. The majority of participants reached a balance between insight (their own understanding) and skills (their own teaching) during the PD. They realized that normal drill-and-practice methods are not totally rejected but new ideas have been developed about basic abilities and how learners can build upon these abilities which have been experienced by most of the participants in the RME-based PD and were later on applied by them in their research lessons.

Later in the study many of the participants were able to distinguish between productive practices (practice on drill) and reproductive practices (RME). Most participants had not before regard these two concepts as important in RME. The difference is that in productive practice the form and content of the practice is determined and pre-structured by the participant. In the Namibian system it is mostly done by the prescribed textbook with tasks and questions that are fixed. Reproductive practice is more indirect and problem-linked and requires from the learner to show initiative. It was an important part of every workshop in which research lessons were planned to emphasize this fact. Participants realized that ‘drilling’ (to use the participants’ words) is still very important and that RME is not actually that much ‘different’. When participants experienced and practiced the activities done in the workshop sessions themselves their attitude towards the RME approach changed from ‘being reserved’ to ‘being positive’.

Many aspects of the RME-based PD influenced the teaching practice of the majority of participants. However, one of the most significant aspects has been the increase in many participants’ use of real-life context for teaching mathematics. A contribution of this research to the professional development of participants was that they now have a range of strategies available not only for mental calculations but for the four basic operations in general. In the findings it became evident that many participants are able to teach mathematics coherently, meaning to find a link between topics that are separately indicated in the national syllabus. Before the intervention started the majority of participants taught the place value system in isolation. They taught for example the concepts of tens and ones without relating them to addition and subtraction. During the PD activities they experienced and then implemented in their research lessons how the incrementing and decrementing by tens and ones develops an understanding of the place value system.

The RME-based PD represented a very different way of working in the classroom and posed a significant challenge to most of the participants. The literature review (Chapter 3, p. 87) cautioned that a lack of sufficient time for PSMTs to engage in PD can be a barrier for success. Therefore, I was aware of the fact that the majority of participants would need time to deepen their understanding of subject matter and to develop new approaches to and skills of instruction. However, by simply providing more time for PD would yield no benefit if the time was not used wisely and effectively (Guskey & Yoon, 2009). Therefore, in the next section a summary of the discussion of participants' experiences regarding the RME-based PD will follow.

- ***Participants' experiences regarding the RME-based PD***

Initially most of the participants were not comfortable at all to try out the new approach. A change in their practice became visible when planning for the research lessons started and the materials supplied, developed and applied during the workshop sessions were 'tried out' during their presentations. In this respect the on-going PD had a significant impact on the professional practice of the participants. The majority of participants reported back that they had experienced the sessions as stimulating and enriching and would have liked to continue with these sessions since all topics in the syllabus were not covered. They emphasized that it was important that teachers were involved in on-going PD. They need regular 'updates' of the use of recent trends in mathematics education especially after a major reform has taken place. It is not effective to have one- day-workshops to be informed about changes in the curriculum and a new textbook. They argue that

> *To be provided with a syllabus and a textbook and be expected to use it was simply not addressing current challenges we experience regarding learners 'performance'.*

During the study most participants were concerned about time. Time was a crucial issue because several times participants made the comment that by allowing learners to ask questions and to argue time was actually 'wasted'. However, my impression was that many participants are hampered by a lack of confidence including a fear that they may lose control by allowing learners 'too much freedom' (as they called it) in asking questions they might not have an answer for. However, the communication skills of some of the participants might have played an important part here as well. Their limited knowledge of mathematical terminology in English might have made it difficult for them to teach efficiently.

I contend that the participants will still need support in learning, practicing and improving on the different strategies since time was a limiting factor throughout this research. On-going PD for the participants will be essential to enable them to successfully implement LS and RME principles in their daily teaching practice. Askew (1999) state that the more skilled teachers are those who base their teaching activities on the fact that learners need to make connections between different aspects, symbols and methods. This links to the RME approach whereby the learning principles (the activity principle, the level principle and interaction principle) are constructive activities and not a body of knowledge that can just be transmitted by the teacher as Treffers (1993) states it. However, to motivate and involve learners and to design interactive instruction and group work will not be nearly sufficient. Mathematics teaching still has to result in learners achieving the conventional mathematical aims (in the Namibian context often interpreted as 'good results'). The literature review points (Chapter 3, p. 147) out that according to current constructivist views on mathematics education these aims may be achieved by guiding learners to build on their own thinking while constructing more sophisticated mathematics. Many of the participants who participated in this RME-based PD might find it possible to achieve this aim. I would like to see that RME-based PD activities will continuously be organized to upgrade participants' teaching skills.

A positive contribution to the professional development of the participants was the process of LS. By providing the opportunity to support and learn from one another participants planned, discussed and reflected on the research lessons. This was a valuable first experience because different teaching styles appeared to contribute to different types of learning opportunities. The participants complemented each other, some with their vast years of teaching experience and the 'younger' participants with their innovativeness, eagerness and willingness to try out 'new' approaches. The opportunities provided by the processes of this study to talk and discuss RME principles and to implement what was learned in research lessons were valued the participants. Such research based opportunities had seldom been available to participants before.

Participants teaching different Grade levels discussed how a particular lesson could be 'adapted' to suit a next Grade level. For the first time Lower Primary and Upper Primary phase participants talked 'with' one another and not 'to' one another. It was very interesting to see how innovatively Lower Primary phase participants came up with 'real life' problems to be used in Upper Primary phase lessons. For example Upper Primary phase participants were used to present only 'naked' problems to learners, e.g. 345 – 123. Lower Primary phase participants immediately came up with a 'problem situation' like:

> '*During winter a farmer lost 123 sheep from his herd of 345 sheep due to the cold. How many sheep are left?'*

Another Lower Primary participant came up with:

> '*I have 123 beads but I need 345 beads to complete my necklace. How many beads do I still need?'*

Upper Primary phase participants could not think as fast as these 'problem situations' were mentioned.

The presenters of the research lessons whom I have observed as well the others who presented the developed lessons reported back comprehensively before the start of a next PD activity. It was interesting to note that participants 'opened up', they were quite critical about the outcome of the lesson and about themselves. For a first time participants were granted an opportunity to find own solutions to challenges they experienced in their teaching by sharing their concerns with the group. I had the impression they wanted to hear whether their colleagues experienced similar challenges and which solutions they might come up with.

It is evident from the findings that many participants' teaching was indeed influenced by the RME-based PD. Differences in their way of teaching was not only observed by the participants when they reflected on their teaching, but also by myself. The Lower Primary phase participants presented their lessons with much more confidence than before. They demonstrated enthusiasm which was carried over to the learners. The Upper Primary phase participants made use of teaching aids that they had developed in the planning of research lessons or which they had received from me in the workshop. They were also able to adapt some of the teaching aids we developed for the Lower Primary phase to suit their phase.

Participants are aware of the fact that the learner-centred approach is prescribed in the Namibian school curriculum. In the constructive approach it is expected that the teacher plans lessons to solve problems from the known to the unknown. In the RME approach learners are guided to solve problems by investigating practical ways of finding solutions. This is called guided re-invention. Many of the participants experienced the difference in emphasis regarding the constructive and the RME approach. It was obvious to note how most of the participants, while planning research lessons, put emphasis on constructive learning rather than on re-constructive teaching. This is what Gravemeijer (1994b) describes about the development of RME. However, the majority of participants mentioned that having explicit learning objectives and basic competencies as indicated in the Namibian syllabi caused some difficulties to them in applying the RME approach during the research lessons. They felt that learners should focus on solving the problem. By providing the lesson objective, as it is done in the Namibian context at the start of the lesson, would give away the concept which the learners should actually have discovered themselves.

The majority of participants experienced that the PD's effectiveness was related to its relevance (taking the national mathematics syllabi into consideration), delivery style (on-going workshop sessions and doing LS) and opportunities to interact (focus group interviews, planning research lessons) with each other. The age range of participants is quite extensive and still their responses indicated that they experienced the PD as most effective, because it was relevant and useful in their classrooms.

- ***The relevance of RME-based PD in this study***

I argue that any reform process requires continuous PD. In this research many of the participants verified their willingness and their continuous efforts they made to attend all sessions. The participants summarized their own method of teaching in the beginning of the PD as follows:

- Introduction – sometimes they used a story not always relating to learners' real world (for example using bears, snow, strawberries);

- Formalization of the topic of the day – wrote objective on chalkboard – procedures that followed were step-by-step (routine-like) – in no particular context;
- Conclusion – revising main points – learners had to practice similar exercises.

The instance of stepwise control and teacher-centredness was here visible.

At the end of the PD and after several research lessons the participants summarized their teaching as follows:

- Using relevant context as an introduction in which learners were given a 'problem' or to sing songs/recite rhymes (Appendix R_7 (p. 472)) – this context contributed to help learners to make sense and to take decisions;
- Learners were encouraged to develop a strategy by using a model provided (for example the frames, strings, number lines);
- Asking learners to discuss their strategies/findings – this can lead to another context in which the model/strategy is developed in cooperation with learners;
- The models are gradually 'taken away' – models are becoming formal mathematics (model of →model for).

I reason that the relevance of this study can be attributed to the following factors:

- The PD focused on the theory of RME adapted to suit the Namibian context, content and school Grade level participants taught;
- The PD included participants from management and the Lower and Upper Primary school phase;
- The PD was aligned with the prescribed National mathematics syllabi;
- The PD was not simply theory-laden but instead focused on classroom-practice (teaching).

A major achievement of the PD was that the majority of participants themselves became advocates for the RME approach and LS. They were willing to get involved in training and assisting me in any future RME-based PD activities at primary schools in Windhoek. While many of the participants described how their teaching practice was influenced by this study and the positive impact it had on their own learning it became apparent that other teachers in the school were also beginning to become influenced.

However, mathematics teaching will not improve without leadership. Since the principal and HOD's were involved in this study the sharing of ideas how to develop teachers professionally, served at cluster meetings. The positive feedback of these management members on this RME-based PD resulted in many further requests to be also involved in this type of PD. With any PD activities the views and beliefs of the participants regarding the issue play a major role. The discussion of the findings of the participants' views and beliefs before and after the intervention will be discussed next. The participants' views and beliefs are important because they will have to implement any 'new' system.

6.3 THE PSMTs' VIEWS AND BELIEFS ABOUT MATHEMATICS EDUCATION

This is the second sub-question of this study and will be answered by a discussion on the findings in Chapter 5. The discussion will focus on participants' views and beliefs before and during the intervention. A discussion of the findings regarding participants' view and beliefs portrayed in their teaching is followed by a discussion of the findings noted in participants' views and beliefs during the RME-based PD.

Literature (Chapter 3, p. 148) informs me that many participants' views and beliefs about mathematics education usually link with their way of teaching. In the findings of this study it is evident that initially the majority of participants were rigid, mechanical and routine-like in their teaching. The reason for this might be that the participants themselves had been influenced by their previous experiences they had encountered while self at school or during their tertiary study. I argued that many participants' views and beliefs might have been influenced positively if they would have been engaged as active learners in a well-developed and continuous RME-based PD. Participants' views and beliefs might then have resulted in acceptance and continuous reflecting on their own teaching. To conceptualize and apply different approaches can only be achieved through continuous influencing and practice at PD sessions. The participants' views and beliefs of mathematics teaching before and after the intervention will be discussed.

It is difficult to come to a conclusion on what the existing views and beliefs about mathematics teaching of these participants were, because the participants' views and

beliefs prior to the intervention were not empirically derived at. However, I had the impression that in this study the views and beliefs of the majority of participants were dominated by the general educational priorities such as achieving 'good results' and managing the class effectively (in this case orderly). Many of the participants went through tertiary education in which the constructive learning approach served but the reality of the school programme influenced the participants' goal for a particular activity. To finish the syllabus in time and having enough time available for revision might have dominated their views and beliefs of 'innovative' mathematics teaching. Since I base my findings on what was reported in the interview questions
(Explain what you enjoy about teaching primary school mathematics;
Explain what you enjoy about teaching primary school mathematics;
Elaborate on your views about what primary school mathematics entail;
What do you think is the main purpose of teaching primary school mathematics?)
the validity of this finding might leave room for debate.

Discussion of participants' views and beliefs noted in their teaching

During classroom observations I could consistently sense the general belief of several participants. This common belief that I have noted was that mathematics teaching is a set of rules (step-by-step, stepwise, mechanical teaching): operations and procedures should be learned; the teacher must be in control all the time and reinforcement (regular repetition) were regarded as effective strategies for good learner performance in primary school mathematics. There was constantly an emphasis on the performance in the classroom (teacher-centred), rather than on effective learning in the classroom (learner-centred). I would like to emphasize that in this study I did not and could not directly 'measure' or observe participants' views and beliefs. I prefer rather to discuss what they have shared with me during our conversations, interviews and classroom observations in Chapter 5.

The observation of participants' teaching put me in a position to discuss the definitions of terms that participants used during our informal talks afterwards or during the interviews (individual or focus group) with them. I identified particular aspects that the participants were unable or maybe unwilling to discuss with me. Being with the participants on site for quite some time allowed me to become familiar with their way of thinking. The following is a typical example: most of the participants were sure that they were motivating their learners consistently by asking whether they understand. They did not interpret learners' answering together as chorusing. They still saw it as each learner answering for himself or herself. The majority of participants also regarded the word problems used in textbook as linked to the experiences of the learners simply because it came from a prescribed source. After our workshop sessions participants realized that they might have had a different view and understanding of what was meant by a particular concept. The word 'realistic' is an example of such a concept.

The literature review (Drageset, 2010) informed me that PSMTs should have a central role in changing or reforming primary school mathematics education. I argued that the attempts at changing instructional practice in this RME-based PD will only work if participants are convinced of and believe in the positive and practical contribution of this intervention. An expectation in this study was that the majority of participants would like to improve their own mathematics subject knowledge, improve learners' understanding of mathematics and to improve their own teaching skills. I argue that the example above demonstrates that this expectation was met.

Discussion of participants' views and beliefs noted during RME-based PD

The workshop sessions focused all the time on RME theory and the research lessons planning were for some of the participants something they had not come across before. To share knowledge and apply it as a team in a lesson was quite an experience for them. Some participants were not at ease to give learners 'so much freedom' in the lesson. Some participants' views and beliefs were challenged by the idea that learners 'should re-invent' mathematics something they had to be given time to experience the value of 'allowing' time to discover. Most of the participants were used to show or demonstrate learners what to do and how to do it (i.e. teacher-centred). The focus is here on the performance of the teacher and not on the learner. In RME the focus is very much on 'guidance' meaning that the teacher observes and listens to learners as they work and ask questions that are designed to help learners to see connections or even to articulate generalization.

However, I would like to contend that during this study the majority of participants were quite explicit in expressing their experiences about how the RME-based PD influenced their views and beliefs regarding mathematics teaching. Working with the principles of RME represented a significant shift in how most of the participants viewed the teaching and learning of primary school mathematics before and after the PD. I was prepared and accepted at the start of this research that participants would be skeptical because previous long-standing beliefs were challenged by this study. Chapter 3 indicates that teachers' views and beliefs have a significant influence on the way they teach. I interpreted teachers' views and beliefs as the personal conclusions that were directly relating to their performance in their classroom.

Wubbels *et al.* (1997) describe the encouragement of reflection. In this study the research lessons have put a lot of emphasis on the participants' capacity to analyze their own teaching. I maintain that this capacity was an important means to direct most of the participants' own PD, in the sense that they reflected on their teaching after the presentation of the research lesson. By doing this, the participants' existing views and beliefs regarding their teaching were challenged.

I gained the impression that many participants started to be able to implement the RME theory. Participants experienced in different activities that the level principle (use of models) draws the attention of the learner (in this case it were the participants themselves) to particular features without telling what to see or to notice. Many of the participants made an effort to ensure that they would be able to guide learners if they might encounter challenges with the activity planned for the lesson. Another change in their approach was that they themselves thought of different possible solutions to a problem whereby their view and belief of 'only one correct method and answer' was challenged.

By experiencing the change in the attitude of the learners the majority of participants realized the value of relating to real life context problems. Primary school mathematics then becomes a subject where rules and methods are not the main focus but where the learners should experience mathematics as part of real life. *'Practice without context'* as one participant mentioned is senseless. This statement demonstrates the shift in the views and beliefs.

Participating in RME-based PD provided an opportunity for PSMTs to be involved in analyzing their own teaching. I state that it was a first opportunity participants were asked questions about their experience about primary mathematics teaching for some of them having a teaching career of over 20 years. The majority of participants gained self- confidence in being exposed to an approach they experienced themselves in the facilitated workshops. This prepared them to plan lessons in a different way, i.e. always starting the lesson with a realistic problem situation they were used to and this in turn created satisfaction in answering learners' questions which then also resulted in more active participation of the learners. Experiencing the excitement of learners deriving at their 'own' solutions challenged participants' long held beliefs that mathematics cannot be 're-invented' especially not by primary school learners.

Many participants slowly began to report about the significant change in how the RME-based PD and the implementation of LS had a real impact on their views and beliefs about primary school mathematics. As the report back session after research lessons demonstrated that most of the participants' beliefs that mathematics should be taught as a 'step-by-step' model quite naturally changed to that of learners to be challenged by activities in which the significance of affective aspects of learning and inquiry are included. Many of the problems the participants experienced in the PD sessions confronted them with the fact that many problems can have more than one method/strategy to derive at a correct answer, a belief that was challenged during the RME-based PD.

The majority of participants demonstrated through their research lessons that they had made significant shifts in their understanding and beliefs about the teaching and learning of primary school mathematics. At the start of the intervention the participants were of the view that by allowing learners to do a number of exercises on an example (which does not need to relate to a context problem) demonstrated in class would indicate that learners were good problem-solvers.

However, during the PD many participants stated that problem solving was essential to learning mathematics but that all problems should relate to real life. The majority of participants also claimed during the intervention the conception that in allowing learners to use models/teaching aids would encourage better understanding of mathematics. It was evident from the participants' responses during conversation that language ability might still have been a hindering factor in bringing about a change in the mathematics performance of learners.

Most of the participants came to adopt an investigative attitude towards their own teaching which resonates in the RME philosophy and LS. Participants were able to compare solutions and the ways in which learners tackled the set problems. The participants' views changed from explaining to facilitating learning and above all, helping learners to analyze answers to problems.

The sharing of personal beliefs about teaching helped to build strong collegial bonds between the participants. Participants were 'united' and were not working as 'individuals' anymore. However, it took time until participants felt comfortable to share and accept disagreement on their views and beliefs. This study provided the 'safe environment', as they called it, in which they were given the opportunity in which their needs and anxieties were accepted and dealt with sympathy. They had grown more confident and had become closer as participants.

The majority of participants turned from being very skeptical at the start to enthusiastic participants throughout this study. The outcome of the interviews explains that many participants started to believe in the philosophy of RME and that they experienced that learners learn mathematics through this approach in a very natural way. The majority of participants reported that they were convinced that learners definitely benefited from the RME approach because more learners were willing to become engaged in activities after they as teachers had attended the RME-based PD.

Many participants reported that this study had a positive impact on their enthusiasm for teaching mathematics. Many of the participants did not have fond memories about the mathematics education they received during their own schooling. The belief that mathematics is difficult changed to a more realistic view.

> *There is a solution to a problem. We can make a plan, for example draw a table or a model to find a solution.*

Applying RME principles in their daily lessons made them aware of the different possibilities of relating to learners' experiences. Mathematics teaching does not just mean applying a set of rules but as the participants mentioned, it is part of daily life and a human activity. The fact that the teaching principles (the context, intertwinement and guidance principles) within the RME approach complement the learning principles (the activity level and interaction principles) enlightened them to see the creativity in learners' problem-solving strategies and that 'ready-made' lessons would not be as beneficial as RME-based lessons would do to learners' learning. This was another challenge many participants faced at the start of the intervention. The belief that 'enough practice ensures success' will not result in the ultimate aim of learners understanding a mathematical concept.

- ***Self-efficacy beliefs of participants***

The findings which reported on the comments made by most of the participants in Chapter 5 demonstrate that the workshop sessions and research lessons had an influence on the attitude of the participants. The self-efficacy of the majority of participants had changed. After attending the PD activities especially the Lower Primary phase participants reported that they were more positive about mathematics compared to what they had experienced during their official tertiary training. They were more able to relate the prescribed mathematics to the experiences of the learners and were in a better position to lay down a proper foundation. The evidence that many participants were able to use real-life context in their daily mathematics lessons had a positive impact on their confidence. Participants reported that they now felt more confident in exploring learners' different strategies which influenced their longstanding view of equipping learners with the 'correct method'. Being able to use different explanations as part of the facilitating role of the teacher gave especially the Upper Primary phase participants more self-confidence.

- ***Participants' views and beliefs regarding the prescribed syllabus***

However, still at the end of the research period some participants still felt that they might not be in a position to finish the syllabus in time since they had to get used to the 'new' approach themselves. The sessions in the afternoons helped them in a group to cope but if the research comes to an end they would be again 'alone' in their classrooms as they viewed their position.

The view and belief that the syllabus had to be finished in time to have enough time available to revise subject content with learners at the end of a school year is just another example of how 'syllabus-driven' and 'text book driven' Namibian teachers are even in the face of learning some exiting new knowledge and skills. I contend that these are important issues about institutionalization of the content versus opening up the content for purpose of learning. It will take time to convince the Namibian syllabus developers and PSMTs to 'invest' in time rather in 'filling up' the content of the syllabi. Mathematization can only happen if learners can be given time to 'unpack' the un-mathematical matter to find ways to organize activities in order to exhibit characteristics of mathematics such as generality (e.g. classifying and structuring) and exactness (e.g. modeling symbolizing and defining).

- ***Participants' views and beliefs regarding primary school mathematics assessment***

An important issue participants were concerned about was assessment. The view and belief of 'good results' versus 'effective teaching' was challenged. The prescribed assessment structure in Namibian schools poses limits to the freedom to learn in interesting ways because learners need more time in RME lessons to make sense out of mathematics and develop their own strategies. Having a 'test' every Friday hampers the enthusiasm in applying RME in all lessons at this stage.

Drageset (2010) states that long-held beliefs can present barriers against applying a new approach. However, most of the participants realized towards the end of our PD activities that context-rich problems result in less focus on repeated practice because procedural rules are not the norm of the day anymore. Problem-solving activities in this study that involved reasoning and argumentation from the learners lead many participants to situations where they learned more about learners' mathematical thinking, something they had not often thought about before this study.

Most of the participants also expressed their more general views and beliefs on mathematics teaching regarding good assessment procedures during the research period. The question arose whether a 'method' (the learner has to show all the 'steps') has to be indicated or whether full marks can be awarded if only a correct answer was provided. The majority of the participants were still at the end totally against giving full marks for only the correct answer. It is a difficult 'change of mind' as participants called it if

> *Learners indicate answers only. They could have copied their neighbour's answer.*

However, some participants thought about it and came to the conclusion that:

> *If you have proper control learners cannot copy. Having good mental skills learners will be able to write down answers only.*

The fact that learners often did not even try to solve problems because they felt 'lost' demonstrates the need to pay more attention to 'mathematization' in early school Grades. Learners need to be equipped with ways to unpack the mathematics finding ways to make the un-mathematical matter making sense which will lead to find solutions to problems. Many participants argued that the availability of time definitely hampered the teaching of some of the topics and also paying attention to mathematization. Several participants believe that the syllabus is overloaded with topics and, therefore, they have to leave out topics of which they know will not be examined at the end of the year. I did not understand that point clearly and they mentioned that they will ask very few level three questions (Bloom's taxonomy) on fractions for example, because in the previous SATs very few level three questions were asked on 'fractions'. I argue that the participants had a misconception in the sense that their tests and examinations mainly determine memorization and not understanding. In the end through the discussions participants realized the necessity of indicating the level of questions in test or examination question papers so that all participants responsible for a Grade could argue and agree or disagree on the levels indicated. The majority of participants experienced in the workshop on assessment that this was an issue that needed further development.

Summary of discussion on participants' views and beliefs

Participants had never before experienced the impact of the RME principles on teaching and learning. They were used to the belief that new mathematical knowledge arises through theorems, rules, definitions and algorithms. Their views and beliefs were challenged in the PD activities in the sense that they were exposed to activities depending on the nature of the problem. They realized that a teacher has to decide what aspect of the problem must be recognizable for learners from the text on the basis of an analysis of the learners' existing cognitions. This was a major shift in their view of how to teach for understanding.

I reason that the majority of participants' views and beliefs influenced their teaching. The potential influence of this study is reflected by their teaching before and after the intervention. Participants' active participation in the workshop sessions and their contributions in the planning of research lessons demonstrated their willingness to think about how to improve their teaching. Their contributions during the PD sessions demonstrated that they respect each other's views and are willing to consider these. However, an important aspect in these findings was that many participants became more comfortable and accepted my role as a professional developer. The majority of participants became aware of the contribution the RME-based PD had on their teaching. They were willing to 'adapt' their views and beliefs regarding mathematics education because being allowed to express their concerns, needs and own ideas and thoughts made them feel part of the PD activities. This gave them 'ownership' of their own PD and of course this influenced their previously held views and beliefs. In the end the majority of participants realized the difference between mathematics as being taught as a set of rules or algorithms and mathematics as a human activity.

- ***Influence of views and beliefs in becoming a PSMT***

I came to realize that many participants' views and beliefs might have influenced their choice of becoming a PSMT. Currently there might be many PSMTs whose first choice was not to become a mathematics teacher for the primary school phase but it was the only option available to them at that time. For many participants in this study their Grade 12 results were such that any other career option was not possible. These findings are important because during the classroom observation I noted that the majority of participants were very rigid and routine-like (mechanically, stepwise) in their teaching. Perhaps enthusiasm and the necessary empathy for teaching primary school learners mathematics were lacking and a reason for that could have been that these participants did not realize the important need to popularize primary school mathematics as a whole. By partaking in RME-based PD participants realized the need that all learners have to do mathematics because of its cultural significance as a human invention and activity as displayed in the RME theory. A possible lack of enthusiasm to teach mathematics to primary school learners might be found in the admission regulations to tertiary institutions in Namibia.

The majority of participants made it very clear that the entry requirements into the option of becoming a primary school teacher are very ‘easy’ as they put it. The majority of participants did not have mathematics as a subject option up to Grade 12 level. The entry requirements into the BETD were indeed very favourable. The minimum academic level entry requirement into the Lower Primary option was 25 points in the candidate’s best 6 IGCSE/HIGCSE Grade 12 subjects with a D-symbol in English and a minimum of a D-symbol in the mother tongue (MoE (Broad Curriculum of the BETD), 2009). For Upper Primary a student needed a D-symbol in mathematics and a D-symbol in English. Student intake requirements before 2009 were an E-symbol for English and an E-symbol for mother tongue (LP) and an E-symbol for mathematics. Students with ‘relevant’ teaching experience (5 years) were allowed into any of the options with only a Grade 10 certificate. This last requirement indicates that many primary participants might teach mathematics without having had the subject ‘mathematics’ up to Grade 10 level.

Another reason that may have influenced participants to opt for primary education was that all students opting for education were granted a Government loan which covered all costs. The study was thus highly subsidized by government and it was affordable for students since the majority also needed hostel accommodation. All School-Based Studies (SBS) activities, for example transport to and from schools, were paid. Students even received a small amount of money to buy clothing for the SBS activities. This made it very attractive to apply for a teaching career. Therefore, many regard teaching as a ‘job’ for a salary and not as a ‘calling’. I claim that more has to be done to encourage PSMTs to love the subject mathematics. It is evident from all the conversations I had with the participants that they are apprehensive about primary school mathematics because of their own history with school mathematics.

I also came to the conclusion that some participants did not always really fully portrait their views when asked specific questions directly regarding primary mathematics teaching. Several participants were nervous when asked 'direct' questions as they themselves admitted. I got the impression that they found it difficult to express their thoughts, views and understanding in words. However, during 'informal' conversations participants more readily elaborated on what their views about primary school mathematics teaching was. From what I noted down I derive that in their view mathematics is a set of rules and facts. This is confirmed by Ernest (in Webb & Webb, 2004). This view was also demonstrated in the lessons observed. Another view some participants demonstrated was that 'anybody' could teach at primary school level because entry requirements into this option at tertiary level confirmed this view.

- ***Participants' possible change of views and beliefs***

The literature review (Chapter 3, p.147) states that the participants could possess an instrumentalist, Platonist or problem-solving point of view. Several participants, judged on the answers they provided in the interview sessions and during informal conversations, changed from an instrumentalist to a Platonist or problem-solving point of view. The first one views mathematics as a set of rules and facts, the second one views mathematics as a unified body of specific knowledge which can be discovered but not created, and the last one views mathematics as a human creation and therefore a cultural product. This view links to RME in which mathematics is seen as a human activity. During this study participants were gradually able to adapt their teaching to where learners could experience mathematics as a human activity and therefore gradually moved 'over' to a problem-solving point of view. I argue that this was a challenge to their views and beliefs that mathematics was a fixed set of rules and algorithms.

Some participants' indication of 'have never thought about it' to interview questions that were asked can be interpreted that to invest in future PD beyond the formal tertiary qualification should be considered as 'important'. Many of the participants' views reveal the extent to which they were 'left alone' and worked in their classrooms on their own with little to no support from management, subject advisors and teacher educators. Many answers also point out that by being exposed to an approach (RME) to mathematics teaching that was different from the ones the participants had experienced and practised previously upgraded their (participants') subject as well as pedagogical content knowledge. RME-based PD in this study introduced participants to an approach that involves explanation, discussion and negotiation within the classroom. Therefore, the aim to develop insights into learners and their difficulties in learning mathematics proves to be an essential need for PSMTs.

Looking back, reflecting on the research process, some of the interview sessions were not 'flowing' (smooth) because when some participants sensed that they might be on the wrong track they stopped to participate. This was what de Haan (in Sembiring, Hoogland & Dolk, 2010) also found. Some participants are afraid to say something 'wrong'. Being for a 'long' time at the school (ten months) I was often able to interpret the real meanings behind the words of the participants. I came to the conclusion that most of the participants for the first time really thought about basic questions concerning mathematics. They were simply teaching what was prescribed with the main aim to 'finish the syllabus' in time and that in their view implied that they might be regarded as successful in their teaching.

The possible shift in participants' beliefs and practices definitely had an impact on learners. The classroom observations and the reflections of the participants after the research lessons clearly indicated this.

The effectiveness of an ethnographic research for me was that the more time I spent at school the more the participants trusted me and were willing to share their views and beliefs with me without feeling threatened. During the whole research period I noted down answers to questions informally asked. The reason for this was that I wanted to get more information regarding their views and beliefs about mathematics education. At the start of the research period I made the statement that mathematics is about rules to follow. All participants answered in the affirmative and completed my statement by saying

> *and it is the most important school subject.*

The conversations during break-time or while waiting for the start of a class provided additional information about participants' views and beliefs of primary school mathematics teaching. It provided me also with background knowledge of the participants which I gained through our 'informal' conversations. By allowing this I got the impression that many participants spoke about their inner thoughts and meanings, struggling to express what was really inside their heads. They spoke from their individual construction they perceived viable in their own practice. This was also evident in the reflections on their own practice during the classroom observation session and what they answered in the 'formal' interview session. In this ethnographic research analysis the interviews and informal conversations helped me to reflect and interact with the participants constantly in order to understand the meanings and 'truth' of the participants.

My daily reflections helped me to capture experiences and views and beliefs of participants they shared with me during our informal conversations. Being an ethnographic design, these reflections form part of the data and provide valuable insights as Sierhuis (1996) pointed out. Participants reflected:

> *Working together as a group (of participants) has changed my beliefs about teaching. Mathematics is action and not about memory. Problem solving is no longer a problem because the problems link to learners' experiences. I just struggle to find suitable word problems all the time.*
>
> *I feel now comfortable to teach mathematics. The rush to formal mathematics is now a natural process. Learners have models to go back to if they struggle.* (The participant was referring to the 'strings of ten' and 'friends of'*).*
>
> *The use of context builds learners' confidence to participate in class. Learning is a long-term process. The intertwinement principle helped to understand that expecting of learners to learn every period something new is unrealistic.*
>
> *Learners make more sense out of word problems. I link word problems mostly to environmental education. Therefore, I gain periods for doing mathematics.*

> *I realized that very few learners made sense out of what we taught previously. RME convinced me to give it a try. The emphasis on resources changed the atmosphere in my classroom.*

The above demonstrate that several participants' views and beliefs had been challenged by the RME-based PD in the sense that they viewed mathematics teaching not as a set of rules as such but that learners should be involved in real life context problems for which they can find their own informal ways or strategies.

Most of the participants were united in the view that PD should serve as part of any curriculum if successful implementation is expected. The majority of participants reported that they had experienced the RME-based PD as providing them with useful activities and ideas they could readily use. They did not mind in the end to spend time attending these PD activities although time was a crucial factor to consider.

<u>Summary of PSMTs' views and beliefs about mathematics teaching before and after the intervention</u>

The views and beliefs of PSMTs before the intervention were not empirically determined during this study. I could only deduct from their answers during the interview sessions general educational priorities such as 'good marks', teaching 'rules' and 'maintaining discipline' in the classroom.

However, I maintain that the RME-based PD influenced the views and beliefs of most participants in different ways. The majority of participants for example became aware of the role of the learners, learner-thinking and learning, the use of real context in problem-solving activities and their role in guiding learners to 'invent' mathematics (the guided re-invention principle). The improved ability to teach mathematics and possibly the experience gained from the research lessons' implementation offered many participants the freedom and resources for a close consideration of an RME approach. The self-confidence many participants gained during this study can further develop interaction between participants and learners and consequently improve learning results.

The above section discussed the findings and answered the sub-questions of this study,

- *How can RME principles and LS contribute to the PD of the PSMT?*
- *What are PSMTs views and beliefs about mathematics teaching before and after the intervention?*

This study was quite extensive and the findings discussed. To put the main focus in place a summary of this research will follow.

6.4 SUMMARY

In the main research question

> "*What are the experiences of primary school mathematics teachers' who participated in RME-based professional development?"*

the focus is on the 'experiences' most participants had during this study. It was, therefore, important to also put this question to the participants when this study came to an end.

I myself have never taught in the primary school phase and I sensed a feeling of anticipation when participants also recognized and accepted the role to 'teach' me about certain curriculum issues in the primary mathematics syllabus. This gave them satisfaction and also the feeling of being fully involved in this study. Many, if not all, participants accepted my role as researcher to help them to develop professionally. They started to analyze their own teaching after research lessons and helped and assisted each other where necessary. This brought valuable information to this research. I argue that this research did not only focus on the PSMTs but also on my role as a teacher educator to expose pre-service education students to RME principles.

Before the end of year examination for primary schools started in middle November 2014 the participants were given the chance to reflect about their experiences regarding the RME-based PD and LS. On a Thursday afternoon where all participants were present we met for a 'last time'. The majority of participants reflected in a very positive way as they discussed their experiences. The reflection of the participants and the report on the findings can be summarized in three categories:

- Firstly, many, if not all, participants were united in commenting that the RME had significantly influenced their understanding of mathematical learning. The six principles (the activity; level; reality; intertwinement; interaction and guidance principles) initially seemed to them to be very difficult but through planning research lessons the implementation of the principles started to make sense. They experienced mathematics as '*fitting together parts of known issues'* as they put it. Responses like:

  I have been challenged in every workshop I attended. I am just concerned that a challenge will be to find time to create and implement changes in future without having you assisting us.

  The workshops and discussions resulted in new ideas about a theory I would like to implement. I feel enriched. Above all, the sharing of information amongst us is a first time experience for me.

These reflections demonstrate that many participants valued the RME-based PD they had been exposed to. However, a concern that was raised several times was that PD should be on-going. Even this one year of PD should be complemented with regular updates on PD that take the needs of participants into consideration.

This study reported that the majority of participants demonstrated in the research lessons that they were able to implement problem-solving activities which related to learners daily life experiences. They related all activities to context problems which made sense to learners after they had attended some workshop sessions. The answers provided in the interview sessions and informal talks are an indication that participants think while planning their daily lessons how to implement the reality (use of relevant and realistic context); intertwinement (linked different subject content) and the guidance (to guide learners towards guided re-invention) principles in contrast to what they have previously done, i.e. using the textbook as the only resource.

- Secondly, the majority of participants felt part of the PD process since this PD focused on the prescribed national mathematics syllabus and participants decided on topics that served in the series of workshops. Some responses were:

  We practiced the theory and that made it worthwhile attending the workshops.

  I realize how weak my learner's mental skills are – even my own. I will have to pay attention to it. Learners number concept skills were not developed – we did everything in isolation (topics are done in a fixed sequence in syllabus).

  I spent a lot of time attending all workshops. I do not regret it. It was something I needed. I want my learners to perform; therefore, I need to incorporate new ideas into my teaching. The workshop focused on our syllabus.

  The material we received and also developed made it worthwhile. We can use it in our daily teaching. It fits into our syllabus.

Most participants mentioned that the PD activities related to the national mathematics syllabus and that gave them ownership, they felt part of this endeavour. The intervention addressed their needs and concerns. The above quotations are supplemented by the findings of this report. The majority of participants demonstrated that they felt enriched by attending PD activities. Participants also demonstrated that they understood the concept 'realistic' when the research came to an end. In the research lessons it became evident that many participants were able to make use of practical problems in an everyday life context. However, since these types of problems play a significant role in RME, especially in primary mathematics education, the participants understood that the 'real' in 'realistic' has to be understood as 'making sense to learners'. I experienced this as a real mind shift. At the start of this research several participants stated that they adhered to 'realistic' mathematics because the textbook is named *Mathematics in Context* (Patyus *et al.* 2010) and the exercises address everyday life experiences. It never appeared to them that these experiences might not address their learners' real environment. Many participants used the textbook's exercises by adapting these problems to address their learners' cultural or environmental context after attending several workshop sessions. By attending the RME-based PD most participants experienced that their reality of mathematical knowledge encompassed more mathematics then the learners' and that they had to be careful when planning their daily lessons. This was an important realization because participants had to be careful not to overestimate the effectiveness of concrete materials. They experienced that a model should always help or assist a learner in constructing, or in RME terms, inventing more sophisticated mathematics. Too much dependency on the concrete material, or as participants used to call it 'teaching aids', is something participants had to determine whether it might become a factor they would have to reconsider in future.

- Thirdly, some participants mentioned that their beliefs about mathematics teaching were '*shattered'* (sic) when this study came to an end. They mentioned that their own school experiences in mathematics influenced their teaching. The few times that I had observed the participants' teaching, this was changed by way of giving learners the chance to be exposed to text-rich context and at the same time to be involved in mathematical activities. This enabled learners to experience mathematics as 'relevant' (e.g. real life context problems served) but also containing 'abstract' content (e.g. conversions of fractions to decimals) that they would have taught in a normal classroom setting. The existing view of some participants was that if learners answered questions (even if only with 'yes' or 'no') they were involved in the lesson; therefore, the lesson could be regarded as being learner-centred. It was a first time experience for these participants to really involve learners actively in their teaching.

> *By talking to one another I got my colleagues' views and interpretation of issues. I did not agree with all their views, but it made me think. I am still not convinced to give learners too much freedom in class – it wastes time. It worked this year, but you have been in class. I will see what happens next year.*
>
> *I will try to implement the new approach. I do not know whether I can do it alone. I hope we continue as a team together as we did this year. I*

will try to do more activities in class – not only focusing on the 'correct method'. As I teach, I was taught and I thought that it is a good way of teaching.

I learned to reflect. I think differently now about how learners learn. I was a learner myself in the workshops and could not belief in our sessions how different we all are. What is important to me was not important to my colleague.

I have realized that I cannot continue as in the past. I have to concentrate on my learners. I will have to improve on my teaching practices, not as in the past where I thought I did a good job, but my learners just followed 'steps' I hammered on. I thought mathematics can be learned by 'rules' or 'methods' – this is what I emphasized.

In my view, having been exposed to RME-based PD, which provided participants with a different route through which mathematics content can be presented, most participants started to link their daily lessons to interesting topics to create active participation of learners. I am of the opinion that the participants became aware that they should allow flexibility in applying different strategies to solve problems. The 'correct method' was not an issue anymore but to use a correct strategy to derive at a correct solution became an issue. In contextualizing and setting the scene many participants oriented learners towards applying prior knowledge and experience, i.e. mathematizing. Several participants started to provide a rationale by posing a problem that was contextualized not necessarily at the beginning of a lesson but at the beginning of a new topic or idea.

From the above it is evident that many, if not most, participants realized that mathematics is more than just solving problems in the workshops. Teaching aids can easily be duplicated with low cost (photocopying the five, ten and twenty frames; beads can be bought at '*Crazy Store'* for a minimal amount), everyday materials (bottle tops, buckets in which groceries are bought) which can lead learners to higher levels of mathematics. Several participants became very creative in the activities they planned for their learners. The textbook still served as a resource but it was not the only resource they made use of. Much was done to deconstruct dependency on the textbook.

In this RME-based PD some participants realized that people who are uncertain of themselves prefer to work in groups where they can share knowledge, ideas and responsibilities. Once they are certain that they have mastered a new method they get more excited, more daring and willing to change and to work again as individuals. This is a finding that became evident when participants were implementing research lessons through the process of LS.

The process of LS provided the majority of participants with an opportunity to reflect critically on their own teaching practice. Unfortunately the idea of participants observing each other's research lesson could not be fully implemented. However, their reflections created an awareness of 'how can I improve my own teaching' because they had the opportunity to perceive themselves through their learners' eyes. The Upper Primary phase participants who were so confident about their subject knowledge commented that attending all sessions together (i.e. Lower and Upper Primary phase participants) was an enriching experience in the sense that they did not only share subject knowledge but also gained pedagogical knowledge while planning research lessons.

This study promoted the idea of collaboration, cooperation and collegiality. The contact sessions created opportunities for participants to work and assist each other in the same project, i.e. this study. By working together and assisting each other they benefitted from each other by sharing their knowledge, experiences, views and beliefs with each other. This cooperation between the participants resulted in collaboration. This first experience of attending contact sessions as one group, i.e. management, Lower and Upper Primary phase participants together, created a sense of collegiality between them which did not exist as such before.

A modest claim is that this study enabled most participants for the first time to experience a PD which enabled them to design problem-oriented activities for learners that made sense to them. Many, if not most, participants got motivated once they experienced that 'word-sums' if linked to the reality of the learners, can become interesting, worthwhile and relevant. In the past 'word-sums' were done in 'isolation'. During the study every lesson started with a concrete and familiar problem situation learners had to find a solution for. During the PD activities almost all participants used the problem-solving activities in the textbooks but with slight adaptations to make them more relevant, interesting and linked to the cultural experience of the learners. At the start of this study participants did not realize that only slight adaptions to the word-problems in the textbook could make them more realistic and interesting to learners.

During the RME-based PD several participants were taken to the library of the University of Namibia to expose them to primary school mathematics resources, i.e. available literature, teaching aids and using the internet facilities to acquire additional skills in retrieving relevant information regarding their teaching. The possibility of including Integrated Communication Technology (ICT) for PSMTs into any envisaged PD activities should be considered because it was a first experience for most of the participants to be exposed to such an activity. PSMTs need to be abreast of available technology nowadays. Specific sessions could be set aside where participants can be exposed to websites which could help and assist them in their daily planning of lessons. The PD will then also enable participants to use websites that are recommendable and free of charge to be used.

Initially the participants tried to find security in sticking to the syllabus. The reason could possibly be that they argued that they had signed a contract with their employer, the MoE, and that it was expected to 'finish the syllabus' in time. It was difficult for them to see the need for change if they were reasonably 'successful'. They regarded themselves being 'successful' if learners passed their class-tests. Only during the PD activities they realized that many of these tests were in fact invalid since they did not test what they were supposed to test according to the syllabus. A possible reason for that might be that the availability of time is an issue. It is much easier to grab the textbook and copy questions for tests than designing own relevant context problems. It was mentioned several times that the day of these participants was filled with a variety of other duties which is strictly organized into administrative, teaching and extra-mural duties. In addition the Lower Primary phase participants have to teach several subjects. These extra duties required of the participants primarily to make decisions how to survive the day rather than being effective teachers. 'Good marks' do not necessarily reflect that learners have mastered the required skills as described as 'basic competencies' in the prescribed national syllabus, although participants' performance is measured against these criteria of 'achieving good results in the SATs'. It will take time for all parties involved to realize that without proper and sound foundations of learners' mathematical skills the SATs results will never show improvement. Due to time limitations this study could not focus in detail the role of RME in assessment. However, it is still an issue for almost all participants that PD on assessment skills is an urgent need.

At the start of this study most participants understood mathematics as being very mechanical. They would repeatedly apply the 'correct method' to find a solution. Learners had to follow these methods slavishly – doing it 'step-by-step'. Learners had to apply 'fixed methods' and were not allowed to use 'short-cuts' to derive at an answer. Many participants several times expressed their view that mathematics is structured, i.e. 'step-by-step'. However, later in the study many participants demonstrated that their focus in a lesson had changed. Participants tried to reach a balance between insight and skills. This also included a revised view about doing exercises. Instead of simply rejecting the traditional (normal) drill-and-practice methods new ideas had been developed about basic abilities and how learners could build up to these abilities. Participants still applied the drill-and-practice method when for example it came to practicing mental skills because they became aware that their own mental skills needed these practices.

The majority of participants paid attention to the use of concrete materials, context problems and how to involve learners in active class participation. Learners were allowed to discuss their solutions with their peers and the participants were astonished to see the success of their instruction. Their 'fixed' view of mathematics education was challenged. A well-known motivational principle was proven. Many participants became eager to 'try out' a new approach because they were successful in their research lessons. They gained confidence through applying the 'new' approach in the research lessons.

The findings of this study indicated that most, if not all, participants' teaching practice had in fact changed towards the end of this study. These changes were more than merely changes in how to teach mathematics. Several participants' views and beliefs were challenged in this RME-based PD. It became evident when the data collection for this study came to an end that various changes in the classroom had taken place. Most participants gained a deeper understanding of primary school mathematics by attempting to teach more for understanding. The majority of participants experienced what it means to mediate between the learner and mathematical knowledge and between the learner and the classroom. They experienced how to give learners more opportunities to partake actively in classroom activities that encouraged them handling classroom discipline differently. Participants experienced that reasoning was fundamental to any mathematical activity in planning lessons together as a team (e.g. Lower Primary and Upper Primary phase participants). This enabled most participants to create learning opportunities for their learners in which the reasoning skills of learners were developed. Revision, as done in the past, was limited because learners had to memorize less and were allowed to apply their own strategies.

The majority of participants initially portrayed an authoritarian attitude and style in their teaching. They did not make provisions for learners to become engaged in the teaching activities. Many participants portrayed themselves as inflexible and not responsive to the needs of the learners. The Lower Primary phase participants demonstrated that they were more innovative in their teaching than the participants in the Upper Primary phase. A reason for this finding might be that the Lower Primary phase participants were less textbook-bound. Another reason could be that they had more confidence as teachers because they were used to teach in a language they knew well, i.e. the mother tongue. This changed after participants had been involved in PD activities and collaboratively planned research lessons. The cooperation between participants from the different phases in the primary school enabled them to share knowledge and skills which enabled each participant to have a broader picture of mathematics education. Participants were not only focused on their specific Grade and phase level but realized that every topic would have to be planned in such a way that learners would benefit from it in future. The planning of the research lessons was an extremely valuable exercise in this regard. Participants experienced in reality how to plan a lesson in such a way to, with some alteration, address different levels of difficulty so that it could be used for different primary school Grades.

At the end of this study many, if not all, participants were able to give learners challenging tasks, providing opportunities to use concrete materials that allow for different ways and different levels to solve the same problem. The majority of participants were able to portray their views and beliefs and the growth they have shown in terms of reflecting on their own teaching before and after the intervention.

One of the most important findings for me was that this study indicates that most participants' teaching practice has changed from 'transition of knowledge' towards 'learning as the construction of knowledge'. Participants demonstrated that they were able to plan for a problem-centred and interactive classroom culture. They included in their daily lessons activities which were meaningful and relevant to their learners. This is what the literature review (Chapter 3, p. 101) points out what characterizes an RME approach – to use examples that make sense to learners because they link to the reality of the learner. As time goes on one might see the profound impact of this RME-based PD on the teaching in the classroom of the participants though it is evident that these participants would still need on-going PD to further develop and practice their teaching in applying the RME approach.

With this ethnographic case study design I was interested in 'what are the experiences of PSMTs participating in an RME-based PD?' Much emphasis was put on the SATs results by the management of the participating school before the start of this study. Having been with the PSMTs for almost one school year I realized that participants had to be taken through certain subject content which was displayed as being problematic in the complete report on the SAT's 2013 of the Ministry of Education issued in March 2014. These topics represented number concepts (especially strategies for the four basic operations), fractions and measurement which were also indicated by the participants during our first sessions. The topic measurement did not really serve due to time constraints. To include the topic somehow I used 'measurement' in an exercise where participants had to indicate the levels of questions. Especially the last five workshops focused on different types of questions and how to guide learners through mathematization to better performance. I got the impression that participants realized, especially in the topic 'number concepts', that this 'making short-cuts and discovering connections' (as they put it) between concepts, is distinguishing RME from any other approach.

In comparing the outcome of PSMTs teaching in the spirit of RME I clearly discussed how participants gradually changed from ‘attending’ to ‘participating’ in PD activities. The different stages in participants’ teaching analysis link to what participants said when interviewed. My role as participant observer during the research lessons can confirm what presenters reported back after their presentations. Hesse-Biber & Leavy (2011) argue that it is an important learning process in LS to critically reflect on one’s own teaching. LS served an important role in this study especially having SATs in mind, because the fourth cycle in LS, re-teaching a research lesson and ‘refining’ where necessary, happened almost naturally and automatically especially in the Upper Primary phase since these participants are responsible for more than one group. In the Lower Primary phase the participants wanted to improve in the next research lessons and this did happen. A big constraint was that the majority of participants were afraid of the time factor. It was an obstacle we did not quite overcome during a year of on-going PD. The planning of research lessons helped participants to develop a better understanding of the four levels of performance which play an important part in SATs. The four levels being ‘below basic achievement’, ‘basic achievement’, above basic achievement’ and ‘excellent achievement’. ‘Below basic achievement’ implies that a learner demonstrates insufficient knowledge and skills across all themes in the syllabus; ‘basic achievement’ implies that a learner demonstrates sufficient knowledge and skills across all themes in the syllabus, ‘above basic achievement’ implies that a learner demonstrates proficient knowledge and skills across all themes in the syllabus and ‘excellent achievement’ implies that a learner demonstrates excellent knowledge and skills across all themes in the syllabus. The workshop sessions focused on these levels of knowledge and skills of learners (Appendix O_{1-3} (pp. 459 - 465)).

In addressing the different principles of RME that are closely related to mathematization participants themselves experienced the different levels of understanding in the various workshops. Sembiring *et al.* (2010) stress the fact that change can only occur if the participants experience the theory of RME themselves through guided activities in PD. I argue that by having had so many discussions with participants during this study which included their reflections provides a scaffold for participants’ professional development.

The literature review points out that PD is an essential factor in a reform process (Chapter 3, p. 89). Especially participants' views and beliefs about the teaching and learning are considered as critical in determining the pace of curriculum reform in mathematics education.

The findings of this research are influenced by the fact that participants were involved in RME-based PD over a substantial period of time. It was a totally new experience for the participants. In this research they were guided about how to act and what to expect from their learners in terms of their own professional development and the development of their learners. This was a first experience for primary school mathematics teachers in Namibia. Participants were granted an opportunity to learn in workshop sessions what they later had to implement in the research lessons on which they were granted the opportunity to reflect upon. They had a researcher who acted as a role model in the implementation of the RME approach. The experiences of the participants demonstrated the need for on-going PD. Participants commented frequently that this PD was well-organized and well-structured and this made it a worthwhile experience. Gierdien (2008) reports that teachers' discussions and debates with their peers and a researcher should be seen as happening in 'practice' meaning that they are capable of 'learning from practice'. I contend that in this study the majority of participants, through implementing research lessons, they were granted the opportunity to share ideas and to learn from each other, i.e. 'learning from practice'.

This was an intensive RME-based PD in which participants were not only exposed to RME principles but also to LS. Sufficient time, always an essential factor, was needed for participants to acquire the necessary skills and also develop an understanding of RME which enabled them to make their own decisions how to act. Though the time factor was mentioned often participants managed to use the time available for this study effectively. The reflections done by participants were extremely productive as a means of enabling participants to analyze their own practice and share possible effective strategies. The RME approach provided participants a different route through the mathematical content than they had been used to.

I claim that reforming primary mathematics education in Namibia to be in line with RME principles will depend on at least two issues. The first is the ability of PSMTs to create a problem-based classroom culture based on the real-life environment and to engage with learners in interactive mathematics instruction. The second issue is that teachers must be able to design instructional activities that allow for re-invention of mathematics together with the ability and skills to support this re-invention process.

I would like to point out that a possible reason for the dedicated participation of the PSMTs in this study may be a result of that they felt partly ownership of this study and that they learned through modeling. Participants had to get rid of their initial doubt in their own abilities. After that they had the desire to improve their teaching.

The next section will conclude the discussion on the findings of this study.

6.5 CONCLUSION

The evidence from this study is that many, if not most, participants' teaching changed by participating in continuous PD (one school year) which resulted in an increased understanding of the underlying concepts and an improvement in problem-solving skills and greater learner-engagement with mathematics in general. Yet this is not the end of the process. Even the participants in the PD will need sessions in future where they have collaborative discussions but also further hone their teaching skills.

The indications are that adapting the RME approach to teaching and learning mathematics in Namibia in on-going PD for teachers could result in teachers being genuinely functional in their ability to convey mathematical knowledge and skills to learners how to effectively use mathematics in their daily life. The PSMTs need support in the form of PD and LS. The PD needs to be well focused and preferably focused on a few 'big' issues at a time, like in this study RME principles and LS. PD should be convenient in terms of location and schedule like in this study where I as a researcher was involved at one school for almost a year.

The most vulnerable part of any reform in Namibia is the learners' test (SATs) scores. I like to argue that reform does not mean to only opt for different content to achieve improved test results but also to think about teaching approaches which will stimulate mathematical reasoning within learners by providing them with an inspiring learning environment. Further research on RME and assessment in Namibia could indicate the way forward.

The next chapter will address the recommendations derived from the findings on how PD can be organized and conducted in the Namibian context.

CHAPTER 7

CONCLUSION

7.1 INTRODUCTION

In this study the following sequence was followed: The motivation and background for the study and a brief description of the concepts Realistic Mathematics Education (RME) and Lesson Study (LS) are presented in Chapter 1. This chapter also briefly describes the current situation for Professional Development (PD) for Primary School Mathematics Teachers (PSMTs) in Namibia. The statement, goals and a brief outline of the data collection procedures of this study are included.

Chapter 2 puts the Namibian Education System with specific reference to PD for PSMTs into perspective. A historical overview of the Namibian Education System before and after independence is included to supply the necessary background information to understand the current situation. Thereafter the current situation in Namibia is discussed with specific focus on PD in Namibia and whether participants had any opportunities to partake in such processes. The potential value of RME for the Namibian Education system is briefly outlined.

Chapter 3 is a systematic review and discussion of the literature that supplies the necessary information and perspectives on the issue of PD with specific emphasis on the influence on teacher's knowledge and practices, teachers' views and beliefs and the conditions and factors that might influence PD. The literature also supplies information on LS including the possible influence of LS on PD, the process of LS, the importance of LS on teachers' learning and development and the influence of LS on learners' learning. The aim of LS in PD within this study is also addressed. Information is further provided about the history and the principles of RME and the experiences of other countries with RME are discussed. The literature included some practical suggestions, e.g. how the theory of RME could be adapted and applied in PD for PSMTs and why it is suitable to use it as a theoretical framework. The criticism against the use of RME on the other hand was extremely valuable because it made me aware of issues which might create challenges in the Namibian situation. Lastly the literature review informed me about the influence that existing, long-held views and beliefs of participants on mathematics might have on this study.

Chapter 4 addresses the research methodology of this study. This chapter explained the research design, the research instruments that were used and why these particular instruments had been chosen, the sample of this study, ethical issues that were considered and how data was collected. Lastly a brief description of how the data would be analyzed was included.

Chapter 5 reports the actual findings of the data collection tools. The findings are presented in vignettes of participants' teaching in the spirit of RME. The limitations of this study as well as its verification are also addressed.

Chapter 6 contains a discussion and a summary on the findings with specific emphasis on answering the main research question

> '*What are the experiences of primary school mathematics teachers who participated in RME-based professional development?'*

and sub-questions of this study:

- *'How can Realistic Mathematics Education (RME) principles and Lesson Study (LS) contribute to the professional development (PD) of the primary school mathematics teacher (PSMT)?'*
- *'What are primary school mathematics teachers' views and beliefs about mathematics teaching?'*

The previous chapters have indicated that there is a necessity for effective continuous (on-going) PD for PSMTs in Namibia to improve the teaching and learning of primary school mathematics. This study establishes that the participants for the first time experienced an on-going RME-based PD that considered their background, experience, knowledge, views and beliefs as well as their teaching needs. This study reports on the experiences of primary teachers at one primary school in Windhoek, Namibia, with PD and LS. The findings of this study suggest that primary teachers' views and beliefs are challenged by being involved in PD that address their needs and experiences by being introduced to an adapted RME theory.

The developing insight into what Namibian PSMTs need to further develop effectively throughout their teaching careers raises many questions about PD. Questions like how PSMTs develop their understanding of the processes of teaching and learning and how these understandings can develop and change throughout their careers, are important for future developments of PD.

This study was a first attempt to address some of the above questions. It highlights the fact that Namibian PSMTs need to be engaged in on-going PD because more information regarding how teachers develop their understanding and their teaching is needed. The situations in different parts of the country also vary significantly. I argue that this study is an attempt to identify factors that have contributed to PSMTs' learning about mathematics teaching in an RME-based PD in a case-study situation and to consider how these might be incorporated into planning for future PD on a wider scale.

In this last chapter recommendations about the implementation of RME with specific emphasis on Namibia are made. The way forward and an overall conclusion will round off this study.

7.2 RECOMMENDATIONS

The previous chapters have pointed out that concerns about primary school mathematics in Namibia have been raised for more than two decades. The lack of attention and action to the PD of PSMTs has led Namibia into a cycle of underachievement in primary school mathematics. Urgent attention is needed to break this cycle.

Therefore, the following recommendations for future planning and action are based on the literature review (Chapter 3), the research findings (Chapter 5) and the discussions of findings (Chapter 6) of this study. However, these recommendations should be complemented by on-going research to continuously monitor progress and to ensure that the actions have the desired outcomes.

The recommendations will be done under separate headings in order to address all issues that were identified in this study. I will start with ‘Organizing Professional Development Sessions’ followed by ‘RME-based PD and the Prescribed National Mathematics Syllabus’. PD was a main factor in this study and in Namibia all interventions have to include the national policies and official documents regarding mathematics education. Other recommendations will follow later.

7.2.1 Organizing Professional Development (PD) Sessions

The following emanates from the empirical findings that PSMTs would like to get involved in PD to upgrade not only their mathematics knowledge but also to improve their teaching. The recommendations following in this regard are written in this format, in order to be used in guidelines which might be drawn up for school leaders who implement PD in their year plan.

To organize the PD of PSMTs in Namibia, the following can serve as hints:

- PD should
    - ✓ be organized as continuous (regular/on-going) activities for PSMTs in Namibia over a longer period of time.

    - ✓ be scheduled in the year plan by every primary school. The participants in this study were adamant that PD should be part and parcel of any curriculum reform.

    - ✓ be negotiated by the presenter (facilitator), the prospective participants and the management of the school. Since Namibian schools are organized into clusters where principals of schools meet on a regular basis, these PD activities could be scheduled for clusters which will ensure that a bigger number of PSMTs could attend the PD. The participants are teachers in the field and have limited time available depending on their circumstances. On the other hand, sufficient time (quite a lot of time) is necessary to train them properly. Time is thus an essential factor. PSMTs need time to really understand and apply concepts applied in PD.

- ✓ be well-planned to enable teachers to partake in the activities. Time should be used ‘wisely’ and effectively. Activities should be relevant and functional. Examples of exercises/problems should be worked out in advance. Materials to be used (teaching aids) as examples should be prepared in advance and be ready for use at a session.

- ✓ provide time for discussions, but it should not lead to a waste of time – discussions should always remain purposeful. Discussions are important because participants need to share their experiences, expertise and knowledge with one and another.

- ✓ work from the simple to the complex.

- ✓ concentrate on activities and on examples of calculations which are also needed in other school subjects. Mathematics is a human activity and participants need to realize the links between mathematics and other subjects to realize that it is all part of their as well as the learners’ real world.

- ✓ serve as a platform where participants’ concerns and challenges regarding their teaching are addressed. Discussions of current issues, e.g. effective assessment and Standardized Achievement Tests (SATs) results should serve as sharing experiences and expertise to enable own professional growth.

- ✓ at all times focus and interpret the National Mathematics Syllabus in terms of general skills and not so much on individual competencies.

- Teachers and teacher educators (lecturers) in PD should
  - ✓ be regarded as learners in all PD activities. This is necessary for participants to be able to experience all activities as worthwhile and also to be able to pay special attention to possible challenges they may encounter in their teaching. The first activities (problems to solve) should be relatively easy for participants to find solutions for.

  - ✓ Get confidence that they can master activities which will be a source of added interest and motivation because ‘success breeds success.’ Participants can be challenged by activities but preferably they should not get into uncomfortable situations where they may possibly be ridiculed.

  - ✓ initially work in groups to give participants some confidence. This study pointed out that if participants work in their school phase groups it results in cooperation and collegiality.

  - ✓ be convinced that the group work is about collaboration not competition. Teachers should become convinced of the idea that all teachers work for a common aim. However, groups should consist of participants from different school phases as each phase will bring different skills, subject knowledge, expertise and experiences to the group. This study’s findings are that the Lower Primary phase participants contributed with their innovativeness and useful ideas whereas the Upper Primary phase participants contributed with their superior subject knowledge. Teaching experience by participants in the different school phases can add to the effectiveness of any envisaged PD. Only later on the participants of the different phases should work separately.

  - ✓ be convinced that better understanding by the learners will lead to faster progress if participants are afraid that they will not finish their syllabus in time.

- ✓ be exposed to a wide variety of resources that they can apply in their teaching during PD. This will result in more effective classroom instruction.

The above is derived from the findings that teacher learning can occur through many different aspects of practice, e.g. experiences in their own classrooms, discussions with their colleagues and having a knowledgeable facilitator, e.g. teacher educator, who could facilitate the PD activities.

- School leaders should
  - ✓ provide time for participation in PD activities within teachers' contractual hours.
  - ✓ support teachers in embedding approaches they are beginning to adopt, e.g. RME.
  - ✓ support teachers in trying out new ideas for teaching and learning mathematics.

The findings reported that by having the support of the school management, with the principal and the HOD's attending the RME-based PD, the willingness of participating in PD gives teachers the necessary recognition for updating their mathematics knowledge and teaching.

- The presenter/facilitator of the PD should
  - ✓ do some situation analysis beforehand (the real-life situation of the school or cluster). It is important to determine which resources are available, if any, the subject and pedagogical level of the PSMTs (tertiary qualification of teachers), the performance level of the learners (e.g. SAT results) and the language situation at the school or cluster.
  - ✓ be well-acquainted with both mathematics content knowledge and mathematics teaching.

- ✓ include stimulating and challenging mathematical activities within the PD.

- ✓ include opportunities for teachers to develop knowledge about mathematics and ways of teaching drawing on relevant research, e.g. RME.

- ✓ pay explicit attention to learners' mathematical learning possibly involving relevant research, e.g. RME.

The findings reported on learners' creativity in finding solutions to context problems in the research lessons. RME principles played an important role in this study. Therefore, the RME approach could serve in any envisaged PD for PSMTs.

- Policy makers (National Institute of Educational Development (NIED) and Directorate National Examination and Assessment (DNEA)) should
  - ✓ recognize that all PSMTs should have opportunities to experience a wide range of teaching approaches, e.g. RME.

  - ✓ provide support for teachers to take a lead in offering PD for their fellow teachers.

  - ✓ encourage teachers to try out new ideas in the classroom by giving them 'permission' to do so.

  - ✓ advocate and implement the culture of PD in Namibia as required by the NPSTN (MoE, 2006: 106).

If teachers could be 'rewarded' either by way of receiving a certification or by monetary means it would motivate PSMTs to participate in PD.

- PD in which RME principles focus should

- ✓ demonstrate that the RME approach has the potential to upgrade PSMTs subject knowledge and their teaching. There are many similarities between the principles of RME and of learner-centred education. If necessary, participants should be convinced that by attending the PD activities their teaching can benefit from applying a mixed approach.

- ✓ for the time being until RME is maybe formally introduced, train PSMTs to focus more on similarities than differences in applying an adapted RME approach to suit the Namibian context. For example, this study's finding is that RME and learner-centred education supplement each other much more than they oppose each other (if at all). Although the current primary school mathematics textbooks are not written with RME in mind many exercises in the current textbooks were slightly adapted to suit the purposes of RME during this study.

- PD should address views and beliefs of participants.
  - ✓ In this study it is evident that if PSMTs engage in on-going and honest professional discourse, existing views and beliefs about mathematics teaching can be shared and changed or adapted. Discussing mathematics teaching requires language (e.g. terminology) that these teachers do not frequently use and are not used to do. However, this cannot be learned in a 'once off' session or one day or even a week of PD. Teacher educators should get involved in this discourse and offer PD to PSMTs that address their identified needs.

  - ✓ Teachers should view PD as a need where their concerns are taken seriously and addressed.

The findings of this study pointed out that if teachers are involved in the planning of PD activity, i.e. if the PD addresses the needs of the teachers, they do not mind to invest time in the PD.
This study reports on the influence the RME theory had on participants' teaching. A

recommendation regarding the future of the RME theory applied in PD will follow.

7.2.2 RME-based PD and the Prescribed National Mathematics School Syllabus

Any envisaged PD should always be based on the Namibian National Curriculum. After independence (21 March 1990) the school syllabi changed several times. The mathematics syllabus that was in use at the time of this study was such that we could easily implement RME principles and LS in our PD activities. However, the new syllabus implemented in January 2015 can even be more aligned to RME principles. It is therefore of the utmost importance that all PSMTs should be involved in PD based on RME principles to experience themselves what it entails to implement these principles in their daily lessons.

Teachers will always accept proposed changes more readily once they realize it is in line with the official school syllabi. By involving PSMTs in RME-based PD should ensure that these teachers update their primary mathematics knowledge as well as their teaching competences. However, this PD should be planned in such a way that it consists of a series of workshops that are offered on a continuous basis with special emphasis on the RME theory for a period of at least one school year.

It is important to note that PSMTs should receive recognition for attending these RME-based workshops by ways of a certificate or monetary compensation because it might then serve as a motivation to participate in these PD activities.

Consideration should be taken that several sessions would be necessary to expose participants to the RME theory. Participants will always have limitations concerning their time since most of them are teachers in the field. Therefore, support material, focusing on RME, should be organized beforehand and be ready at sessions.

The facilitators of sessions should be well acquainted with RME to be able to give well-directed and effective training to participants enabling them to also develop their own support material.

In countries like the USA, the UK and Indonesia where the RME approach was introduced and implemented, the participation of PSMTs in PD activities was a requirement (Cobb & Visnovska, 2008; Dickinson & Hough, 2012; Ilma, 2011; Widjaja & Heck, 2003). The evidence from these countries is that if teachers who are able to implement the RME approach in their teaching it will lead to greater learner involvement in mathematics (Dickinson & Hough, 2012). This leads to increased understanding of the underlying concepts and an improvement in problem-solving skills of learners which many Namibian learners apparently lack. Therefore, participants should be exposed to RME principles which they can include in their teaching.

The inclusion of RME principles in any PD activities envisaged for PSMTs should be considered because this could result in learners being interested and able to solve mathematical challenges in their daily life. The mathematics should come from the learner and not from the teacher. Learners should be encouraged to be part of the development of their mathematics rather than being told how to apply rules/methods (interaction principle).

Teachers should be exposed to and have practiced the RME approach themselves before they can implement it. The principle of 'guided re-invention' has to be taken care of in future RME-based PD. To equip PSMTs with the necessary skills to guide learners in the process that they have the feeling of 'having the lead in' will take time and cannot be achieved within offering only one workshop.

Teachers might find it very useful to be exposed to the level principle in RME-based PD. The findings have pointed out that participants were able to lead their learners to different levels in their teaching by making use of models (teaching aids). However, the emergence of models should occur in a natural manner and it takes time to develop this teaching skill to be able to guide learners accordingly.

Teachers should be involved in PD activities in which they are exposed to planning lessons collaboratively which should address the issue of making lessons enjoyable and interesting for learners. Teachers should provide opportunities in their lessons to get learners to explain their ideas as advocated by the RME theory. The shared expertise, experience and knowledge of the different participants attending the PD should enable them to address this issue.

In this study RME-based PD was also linked to LS. A recommendation on how LS can serve a very useful purpose in the process of PD will be explained next.

7.2.3 Lesson Study (LS)

In this study an adapted form of Lesson Study was applied and discussed because not enough time was available to implement more cycles of LS for participants to get sufficient practice in presenting and doing reflections.

The process of LS proved to be a successful tool to implement what was experienced and possibly learned in the workshops. However, to implement LS in Namibian schools will need careful planning. The teachers should be granted the opportunity to observe and comment on each other's lessons. The planning of research lessons is very valuable because all lessons are planned in groups. This will make individuals less afraid of failure. Contributions and even differences of opinion should be encouraged. The process of LS encourages participants to share their experience, expertise and knowledge with one another.

LS can be implemented successfully if it is supported by the management of the school and the Ministry of Education (MoE) because it can only serve a purpose if teachers are allowed to observe and critique each other's lessons. Currently the PSMTs' workload is of such a nature that there is no time available that they could do it. The MoE should look into this matter and appoint at least one additional mathematics teacher per primary school which would enable teachers to more readily implement the concept of LS.

Capable Education Officers from NIED responsible for drafting all school syllabi and Subject Advisors from the Ministry of Education (MoE) as well as teacher educators (lecturers) from the Faculty of Education from UNAM should assist with the training of teachers in the process of LS. In involving theses stakeholders care is taken that teachers get the experience of correctly interpreting the subject syllabi, of carefully planning research lessons and reflecting on the research lesson presented.

The presenter/facilitator of PD should initially be involved in reflections on research lessons to guide participants in doing proper reflections. Reflections should be relevant and focus on important issues otherwise the exercise would not really be worthwhile. Participants should be convinced that reflections are about their own development and not about their own evaluation of success or failure.

While planning research lessons PSMTs should address the following important steps:

- ✓ A suitable problem should be noted down for the lesson topic.
- ✓ Ensure that the problem is clearly stated – take note of language use.
- ✓ Devise a suitable strategy learners could apply to ‘understand’ the problem.
- ✓ Ensure that the problem is realistic and challenging for specific school Grade and level.
- ✓ Set an appropriate time frame to activities (e.g. how long should activities take – months, weeks).

The issue of mother-tongue instruction is beyond the scope of this study. However, during the planning and presenting of research lessons it became apparent that it plays a major role in the teaching and effectiveness of PSMTs. The following can be recommended concerning mother-tongue instruction.

7.2.4 Mother Tongue Instruction

The language problems for PSMTs and learners will still remain in Namibia but its effects can be reduced by ‘effective teaching’. ‘Effective teaching’ can be facilitated by teachers who can use a variety of approaches in which for example the RME principles play a role. However, this will take time to equip teachers to be able to do this. Opportunities to interact and talk with each other have to be created for the teachers. This study finds that better teaching can be brought about by involving PSMTs in PD that is offered on a continuous basis for at least a period of ten months (one school year). I argue that effective primary school mathematics teaching will result in learners who will perform better in mathematics.

The findings indicated that mother-tongue instruction has an influence on the performance of the learners. Mother-tongue instruction is especially relevant in Grades 1 – 5. Whereas many of the teachers can speak a particular mother-tongue fluently they often do not know the mathematics terminology in that language. Teacher educators from tertiary institutions, e.g. UNAM, should assist facilitators/presenters to ensure that participants are provided with for example a booklet with mother tongue vocabulary addressing mathematical terminology.

The possibility exists that for certain mother tongues spoken in Namibia the mathematics terminology has not yet been developed. Therefore, these teachers should initially make use of the English mathematical subject terminology but suitable words (terminology) in the particular language should be found as soon as possible.

The provision of proper learner workbooks should help to address the issue of mother tongue. The workbooks should be developed together between the textbook writers and language editors of the different languages. Attention should be paid to the correct use of subject terminology. Language lecturers at the University of Namibia (UNAM) could be approached to oversee the correctness and suitability of the translations.

The textbooks are often the only resource PSMTs have for planning their daily lessons. Therefore, it is of the utmost importance that correct language and mathematical terminology are used in these textbooks. A recommendation regarding textbooks follows.

7.2.5 Textbooks

The findings reported that teachers use the textbook as only resource in their teaching. Another finding was that teachers handle ‘word problems’ in isolation meaning that many times the context of the problem does not relate at all to the learners’ interest or experience.

The textbooks used in Namibia are not written according to the RME approach. This had a negative influence on the motivation of the participants in this study. PSMTs need their textbooks as a resource. I would like to argue that in Namibia the improvement of mathematics education significantly depends on the availability of suitable textbooks. This study points out how dependent participants initially were on the use of textbooks before the start of the intervention. Currently textbooks are the most important tools guiding PSMTs teaching. This is true for the content as well as the teaching methods.

In the Netherlands textbooks are purposefully written according to the RME approach (Van den Heuvel-Panhuizen, 2013). Future writers of textbooks should be made aware of the fact of the positive contribution that the RME principles had on the PD of PSMTs and should consider writing textbooks according to the RME approach.

The Namibian Government should take note that teachers need more than one resource they can rely on. Schools should be allowed to acquire from their allocated budget more than one suitable textbook per school Grade especially for teacher use. PSMTs should be guided how to use different textbooks as resources in their daily teaching.

Textbooks should focus on the reality of the learner. Therefore, textbooks should focus on the context in problem-solving activities. The narrow focus on plain calculations can limit the mathematical competence of learners because as this research has pointed out, the PSMTs' concerns are only about learners' skills in one type of calculation, the algorithm.

Primary school mathematics textbook writers should be well-acquainted with RME principles, e.g. by being exposed to similar PD activities as teachers in order to align the content and methods in the textbooks with the syllabus. Limited guidance was provided in the past to the participating PSMTs to improve their subject knowledge as well as their teaching and how to use textbooks as a teaching aid rather than as only source of information. Therefore, textbooks should be flexible enough to be slightly adapted by teachers for different situations (real life environments/level of learners/availability of resources/availability of models).

Concurrently with the development of textbooks mathematics workbooks for learner use should be developed for especially Grades 1 – 3 learners. The development and distribution of workbooks will have budgetary implications for Namibia. A solution could be that as every teacher receives a syllabus he or she should receive a workbook (or an officially developed and approved file with exercise sheets) of a good quality which will enable them to make copies for learners as they progress with the work. By providing workbooks for learners the PSMTs workload will be reduced because the issue of planning for additional worksheets as is the norm currently will not be necessary anymore.

PSMTs should be involved in regular primary school mathematics textbook evaluations. Teachers should be involved in such evaluations and should be able to evaluate what could be left out and whether concretizations of RME can be done, adjusted and/or additions can be provided. In an RME approach this constant adjustment is highly recommended. The involvement in the evaluation of textbooks will provide teachers with opportunities to include activities which they have experienced as being successful in their teaching.

This implies that teachers should be involved in having an input in textbooks. Teachers should be familiar with the material so that they could respond appropriately if learners would experience challenges. Learners can misunderstand what they read (language challenge) in the textbooks and the teacher should be able to respond to that.

It is important for learners to develop mental strategies. Textbooks should, therefore, contain a variety of activities for learners to practice their mental skills. Different kinds of activities can also guide teachers to use different teaching methods.

Another finding of this study is that teachers' numeracy and mental skills need to be improved. The following can be recommended in this regard.

7.2.6 Numeracy Tests and Mental Strategies

Mental strategies are important building blocks in becoming numerate. In this study attention was paid to developing mental and computational skills of learners. For example, estimation is a very useful and important real-life skill and plays an important role in RME. To improve mental calculation of learners teachers must be equipped with the necessary knowledge how best to integrate it in their teaching. A finding reported that teachers reflected that their own mental skills left much to desire. Therefore, PSMTs should possess adequate skills to solve problems mentally.

All mathematics teachers who enter the teaching profession should pass a skills test in numeracy. The reason for this recommendation is that part of the numeracy test should include mental calculation skills including both memory and strategies to ensure that all PSMTs have developed an understanding of number sense and the number system. Before entering the teaching profession as mathematics teachers all graduate mathematics students and other applicants should pass a compulsory numeracy test.

Teachers must possess an acceptable level of mental agility to be able to calculate mentally in daily life. PSMTs must be capable to recall their knowledge and application skills of numerical information to find answers to problems without using the pocket calculator in front of the learners.

Assessment was addressed in this study on request of the participants. Though it was not a main aim of this study the following recommendation serves.

7.2.7 Assessment

Assessment served in this study but due to time constraints not enough attention was paid to this important issue. The findings have reported that a teacher’s performance is measured against the outcome of the SATs results. Therefore, teachers are in dire need to upgrade formative and summative assessment skills. PD activities must ensure that teachers are equipped with knowledge how to assess their learners during the year (formative assessment) and at the end of the year (summative assessment).

PSMTs should attend PD on a continuous basis to enable them to conduct assessment that also includes all three cognitive levels, knowledge, comprehension and application as required for the SATs examinations at the end of Grade 5 and Grade 7.
PSMTs should ensure that their assessment tasks enable learners to demonstrate what they know rather than what they do not know. Therefore, teachers should not be

concerned about tempo; they should rather provide time so that learners have time to think. The assessment tasks should have problems that have multiple solutions which could be found through multiple strategies.

Teachers should encourage learners into a mind-set that there is not a right way to solve a specific problem and there is not necessarily only one correct answer. This should ensure learners to be motivated to try out different strategies to arrive at an answer which at this stage contrasts starkly with conventional exercises currently used in Namibian primary schools.

Regular meetings, which include all PSMTs of a school together with the school management and the education officers of the DNEA department, should be conducted at least once a year. These meetings are necessary in order to upgrade the teachers' abilities to set proper and valid assessment tasks. However, education officers at NIED and at DNEA should consider reforming assessment procedures for primary school learners. Care should be taken when assessment tasks are developed that learners should be assessed against criteria which are drawn up to determine whether a learner meets them or rather not continue with norm-referenced assessment. Criterion-referenced assessment should be advocated in primary school education. This will enable each individual learner to be measured against a set of criteria and not against the norm where an average determines whether the performance is 'good' or not. However, this requires a major mind change and teachers should be engaged in PD to be able to set assessment tasks against well drafted and relevant criteria for each task.

Learners should also be assessed through the contribution they make in class. Mathematics should be about how the answers are obtained rather than the answers themselves. Problems posed to learners should always address the reality of the experiences of the learners.

To equip learners with the necessary skills to be successful in their assessment tasks will require from the teachers to apply a combination of approaches. A recommendation in this regard follows.

7.2.8 A Combination of Approaches (Strategies)

In the Namibian context the learner-centred approach is prescribed. The RME approach aligns to a great extent with this approach and by using a combination of these approaches (i.e. mix of approaches) it can be beneficial to learners. However, imposing the RME approach on unwilling PSMTs will serve no purpose. Therefore, I would like to recommend that to develop PSMTs' mathematics knowledge and teaching they should be involved in the type of PD applied in this study, i.e. RME and LS.

The mathematics educators in the Faculty of Education of UNAM, once acquainted with the principles of RME, should facilitate on-going workshops to enable more teachers to participate in PD. These teachers who participated in RME-based PD should then be utilized as facilitators of workshops in their clusters in their towns. By doing this, more and more teachers should become familiar with the RME approach. In the end it might be that the MoE could accept the RME approach as being an alternative to the one currently in practice.

Teachers who are capable and willing to serve as facilitators in RME-based PD should have to be rewarded in some or other way, e.g. they could be released from extra-mural activities.

Time for effective PD will remain a factor as the findings have pointed out. Administrative duties of PSMTs have to be addressed. A recommendation in this regard follows.

7.2.9 Administrative duties

As the findings pointed out the PSMTs have a very full teaching load. A positive way of reducing the workload should be that their administrative 'paper work' would be reduced to a minimum. Primary school teachers have to fill in an enormous amount of forms for each learner especially in Grades 1 – 4. Teachers' performance is evaluated against these forms and therefore teachers regard the filling in of these forms as more important than preparing for quality lessons.

The MoE should ensure that all schools should have proper computer programmes available which would address the content of the forms. Filling in of forms electronically would already be a big improvement in reducing the amount of administrative time spent on each learner.

A number of recommendations were put forward. The question that arises is

'What is the way forward?'

The next sub-section will address this question.

7.3 THE WAY FORWARD

I argue that if we want successful implementation of the new primary school mathematics reform it is important that PSMTs feel ownership of a reform programme. The new primary school curriculum, with the implementation date January in 2015, has integrated RME principles in the Junior Primary (former Lower Primary phase) mathematics syllabus. Therefore, the type of on-going PD that was done during this study will compliment any envisaged PD activities for PSMTs. It is hoped that positive learner outcomes in the Junior Primary phase will motivate the Senior Primary (former Upper Primary phase) phase syllabus developers to also embrace the RME principles in future.

The participants reported that the context and related activities in this study made them positive towards applying an RME approach in their daily lesson. They were part and parcel of decisions taken regarding their teaching. Learners experienced a range of different activities during the research lessons and they were involved in discussing the solutions to a variety of problems. Formal statements of objectives given at the start of a lesson and the traditional teaching as described in Chapter 5 can be a hindrance rather than a help in the RME approach. For this reason PSMTs need to be well prepared, well organized and have appropriate resources for activities readily available. Therefore, the emphasis should be on PD for all PSMTs to equip them for successfully implementing the new syllabi.

For committed teachers who believe in upgrading their subject knowledge and teaching RME is an ideal approach to be used in on-going PD**.** However, to develop effectively and to involve more PSMTs PD will have to become an on-going process. In this research the PD sessions were conducted in a manner to model and illustrate how RME principles can be adapted to suit the Namibian context and to enhance PSMTs' mathematical content knowledge for teaching over a period of one school year.

In Namibia not enough is known about the effect of a mix of approaches/strategies, e.g. using in learner-centred strategies RME principles in lessons, as suggested in the recommendations on learners. There is, therefore, a definite scope for further research in this regard. I hope that the use of RME will become more widespread with the implementation of the new curriculum and that its results will make more teachers feel confident to embrace this different way of working in their classrooms.

In the same way RME gives learners the opportunity to work on their own solutions, there is also the opportunity for teachers, teacher educators (e.g. lecturers at the Faculty of Education), subject advisors, researchers, developers and textbook (and workbook) authors to include their own interpretations in the core ideas of RME.

A suggestion is that teacher educators from the Faculty of Education of UNAM could be approached to assist in updating PSMTs mathematics and teaching. I reason that the teacher educators are important stakeholders in any curriculum reform. On-going PD will enable teachers to communicate with each other and discuss challenges experienced with their practice. Teachers need to be open to new ideas and ways of thinking about how learners effectively learn mathematics. By collaborating with each other they might find solutions which will not only benefit their own personal practice but also allow learners to benefit from it.

To realize the improvement of PSMTs' knowledge and teaching there has to be a concerted and coordinated effort for on-going professional development (in-service training). This has to be supported by focused development research and formative evaluation to ensure that 'local' relevance would be obtained. The RME-based PD could serve as a start for future training projects.

The use of RME principles in Namibian schools needs to be viewed as a long term project with learners being introduced to this approach in Grade I in 2015. There is no way in which teachers can simply apply RME principles without having been thoroughly trained in how to use RME materials and how learners are expected to respond and be guided in RME lessons.

However, primary school mathematics teaching will not improve without leadership. In every primary school the principal and the HOD's need to take leadership of the initiative to enhance mathematics teaching and learning. Members of national management teams, i.e. NIED and the DNEA, need guidance on evidence that RME is effective and that it is worthwhile to train teachers accordingly through PD.

This study serves as an example of what can be achieved with PD. It will be the responsibility of the management of primary schools to encourage and support their colleagues, monitor and discuss progress regularly and ask for intervention when challenges or uncertainties arise. The efforts needed should not be underestimated as the change touches the roots of mathematics education in Namibia.

PSMTs who are willing to use RME methods may face criticism that they do not do proper mathematics since the textbooks are not yet written in alignment with RME principles. The literature review (Van den Heuvel-Panhuizen, 2013) clearly pointed out this type of criticism. However, through PD teachers can be trained and prepared to respond to such criticism. On-going support for teachers who use RME methods is therefore, essential.

Widjaja and Heck (2003) report that for applying the RME approach in the Indonesian classroom there are still many issues that have to be sorted out. They report that it is still an issue for learners to take a more active role in learning. Furthermore, they report that it is also very difficult to change traditionally-minded teachers' views and beliefs. I have reported about teachers' views and beliefs before and after the intervention as well as the role of the learners in the Namibian classrooms. I foresee similar challenges facing Namibia's PSMTs as reported by the authors mentioned above. However, a change of mind may well be achieved as this study clearly points out.

I will take the opportunity to present the outcome of this study on RME-based PD at the annual educational conference held by the Faculty of Education of UNAM. I am also a facilitator at the Mathematics Congress which is held in Swakopmund annually. It is an ideal opportunity to train teachers in the use of RME principles since from all over the country teachers will be attending. In the sessions attended by the Junior Primary phase teachers I already introduced RME principles in the themes 'measurement' and 'problem solving' in 2014 and 2015. The feedback of these teachers was very positive and a start to spread the philosophy of RME has already been made.

7.4 CONCLUSION

This study has provided data on the experiences and teaching of PSMTs of one primary school in Namibia before and after an intervention based on RME principles and LS.

In this research I set about introducing RME and LS, provided materials and worked with the participants as they used them in their different classrooms. PSMTs had the opportunity to interact together to discuss their own and their learners' reactions to the materials and research lessons and in doing so interrogate their views and beliefs about primary mathematics teaching and learning. Opportunities for teachers to share and discuss practice within and across different schools are rare in Namibia and should be welcomed.

There were some obstacles to overcome at the start of this study. Nevertheless, the study had many positive effects on the teaching-learning process in the classrooms. The overall finding of this study is that to professionally develop teachers is no simple task that can be achieved with a single PD activity like for example a one-day-workshop. It requires the search for techniques and strategies which will be convincing enough to induce important changes in the teachers' conceptions of mathematics and mathematics teaching, conceptions which are deeply engrained. The findings of this research indicate that, although being a complex issue, teachers are willing and able to adapt their views and beliefs to see mathematics education as a human activity.

The ethnographic design of this study contributed to the professional development activities. In this RME-based PD the collaboration between the participants and me developed into a good professional relationship over a period of almost a year. I gained the trust of the participants in order to be informed about their mathematics learning needs and fully comprehend them. Being part of the process and gathering data through various tools I was able to verify the participants' actual understanding of concepts related to mathematics teaching.

Learning flowing from the experience in participating in this RME-based PD provided a powerful medium for PD. This was apparent from this study that participants started to reflect upon their experiences of teaching and learning about primary school mathematics. The LS process provided a highly motivating structure for planning and teaching a lesson in which participants talked for hours about subject matter, logistics, the curriculum and relevant context materials. Observing in the workshops how RME principles can be applied in lessons enabled participants to shift their thinking from a focus on teacher performance to a focus on effective learning by learners.

The RME-based PD and the process of LS transformed our working relationships and conversations with each other. In addition to what the PSMTs experienced in the PD I found that RME and LS have shifted their paradigm about mathematics significantly. In the end I argue that this was a most beneficial learning and professional experience for the PSMTs.

In this study I was aware of the fact that participants would initially show themselves in the most positive light. In general the classroom activities should be representative of everyday teaching but could this ever be achieved? Instead of striving for this, this ethnographic study accurately mirrored what is attainable in classroom practice from the perspectives of the PSMTs by attending a year of RME-based PD activities.

RME is an approach to mathematics education developed in the Netherlands but this study documents that this approach is not something being impossible to adapt to a Namibian primary school in Windhoek. The influence of RME and LS in different countries has been documented in Chapter 3. Many countries such as Indonesia, the USA and South Africa have adopted and implemented the RME theory in their education system even if it is only applied through PD. I found the positive feedback of the participants to be a motivation to continue with RME-based PD in order to improve PSMTs knowledge and teaching.

I would like to argue that the results of this study point out that the PSMTs such as those in this study, may benefit from further PD programmes that value the understanding and affective factors that teachers bring to task and that help teachers to reflect on their experiences by implementing the RME-based PD and LS approach. Teachers bring their own views and beliefs along to any PD and any ‘new’ ideas/strategies/approaches might create anxiety. It takes time to overcome these possible fears and concerns and to be able to experience new challenges any PD brings along. Furthermore, there is scope for PSMTs to increasingly take personal responsibility for generating and refining their understanding of the classroom situation.

In conclusion this case study reports that the RME-based PD required considerable time and that additional time had to be found to also conduct research lessons through the process of LS. The time was well organized and utilized. Furthermore, it reports that the RME-based PD was carefully structured and purposefully directed, focusing on both content and pedagogy. The results show that an RME-based PD can improve the performance of PSMTs in developing lesson material on RME and implementing this material in their teaching. Participants began to question their beliefs about what was effective teaching and comment on the dilemma caused by matching the RME approach (needs time to implement) with the highly examination-driven school culture in Namibian classrooms.

I reason that the concern about ‘good results’ and the need for schools to continually develop in mathematics in Namibia hamper the freedom of teachers to apply a combination of approaches and for learners the freedom to learn in various interesting ways. The tremendous pace at which mathematics topics are currently handled at primary school level prevent learners from making sense of mathematics. This study reports that the RME theory focuses on mathematics as a human activity. By assessing learners against relevant assessment criteria for every task might be a possible solution that learners can demonstrate their learning and understanding by successfully achieving these criteria. Currently learners are measured against the norm which might result in de-motivation and withdrawal in attempting mathematical problems.

The management of the participating school regularly made me aware of the fact that the SATs had to be written by all Grades 5 and 7 learners in October 2014 and therefore should receive sufficient attention during the workshops. Topics like number concepts and fractions were dealt with in detail. The performance levels of the SATs were discussed and every participant teaching Grade 5 and 7 knew what was expected of a learner to be categorized in the below basic, basic, above basic and excellent performance level categories according to required competencies. Participants felt at ease while learners wrote the test. Participants were aware of the fact that not only mathematical knowledge is tested but that learners also need to be able to apply skills to solve everyday examples. The participants mentioned that learners were definitely able to solve these kinds of problems since it was one of the main focuses during our workshop sessions. Participants paid attention to the idea of realistic context for the prescribed content throughout the year. However, whether this study had a definite effect on the learners' performance in the SATs cannot be reported since the results had not been published by the time I completed this last chapter.

In this study the participating PSMTs were in the end able to build on learners' experience and everyday activities. They could incorporate the learners' cultural and economic backgrounds and thus implement RME principles in their daily teaching. They were able to create meaningful context for problem-solving activities and offer opportunities for their learners for active participation. By becoming reflective about their own teaching they developed positive beliefs about mathematics education and about themselves as being a mathematics resource to their colleagues. The implementation of RME is a complex innovation that will require considerable PD and training for teachers to apply it effectively.

However, it is important to note that PSMTs will need the help of researchers or instructional designers to develop the local instruction theories they will need in order to implement RME in Namibia. Together they might create a situation in which learners enjoy doing mathematics and experience it as human activity while at the same time re-inventing it.

A possible cooperation between the Faculty of Education of UNAM and primary schools would create contact sessions in which collaboration between PSMTs and teacher educators could serve an important aim, namely to provide for opportunities for PSMTs to engage in on-going PD which would address their needs regarding mathematics and teaching. If these activities are properly coordinated and planned it might result in a learning community and a sense of collegiality between teacher educators and PSMTs will be established.

I maintain that the importance of effective teaching cannot be overstated in any society. In a world that is rich in information and communication technologies learners need problem-solving skills and an ability to apply knowledge to new and different situations. The extent to which learners develop these skills will depend on the quality of teaching they experience at school.

Teaching is a complex and challenging task. Teachers need in-depth subject knowledge on how learners learn the content and an understanding of classroom environments that optimize learning. In this study PSMTs had access to an on-going PD to develop and improve the necessary skills and understandings by being exposed to the RME theory. I would like to argue that like in any other profession teachers need to be continuous learners who see their own learning as being fundamental rather than something that is incidental or optional.

After this study had come to an end the participating PSMTs were evidently satisfied, feeling more motivated and giving positive feedback about what was happening in their classes and what they were able to do now. Participants had become aware of ways mathematical ideas can ‘grow’ and develop in learners through the application of e.g. the guidance principle. Much of the evidence that the RME-based PD supplied effectively came from the participants themselves. They described their own learning in terms of increased awareness, improved knowledge in mathematics and in ways of teaching mathematics and especially the motivation towards trying out new ideas. However, it has to be taken into account that the participants were still experiencing the effect of this research. What will happen in the classrooms of the participants after some time has passed is beyond the scope of this research.

Nevertheless, I feel inspired by my experience and I have derived a lot of energy from this study. I am convinced that in investing in professional development and teacher learning is the key to ensure that schools become learning communities where teachers work together, learn from each other and share best practices on teaching and learning as this study has proved. Through collective work of teachers and researchers and by creating a shared professional knowledge will secure and sustain school improvement in Namibia.

APPENDICES

UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvennoot • your knowledge partner

APPENDIX A

STELLENBOSCH UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

Realistic Mathematics Education and Professional Development: A Case Study of the Experiences of Primary School Mathematics Teachers in Namibia

Your school has been asked to participate in a research study conducted by BARBARA ILONA PETERS (BSc (US); MTech(TUT)), from the CURRICULUM STUDIES DEPARTMENT at Stellenbosch University. The investigation results will contribute to a PhD thesis.
Your school was selected as a possible participant in this study because the focus of the study is on professional development of primary school mathematics teachers.

1. PURPOSE OF THE STUDY

The research seeks to determine what the contribution is of the theory of Realistic Mathematics Education principles adapted and applied in professional development to primary school mathematics teachers.

2. PROCEDURES

The following will be done during the study:

Grade 1 to grade 7 teachers participating in Workshops:
The following will be handled in workshops:
The development of understanding as opposed to rote learning: guided reinvention through progressive mathematisation (horizontal and vertical mathematisation); focus on relational and conceptual understanding
The development of realistic and relevant objectives for learners: creating meaningful learning context that actively involve learners; identifying purposeful activities in meaningful context
The development of lesson plans to be able to put more emphasis on problem solving and less emphasis on computation and arithmetic
Lesson presentations/ Observation
The researcher would like to attend lessons presented to learners by teachers. It would be of advantage if colleagues of participants could attend some of each other's lessons.

Lesson reflections
The researcher is interested in how you reflect on your own teaching. If at all possible it would be good if colleagues could reflect as well on each other's lessons.

The research will be conducted over a period of 11 weeks (1 term).

1. **POTENTIAL RISKS AND DISCOMFORTS**

There are no foreseeable risks involved in partaking in this research.

2. **POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY**

This research will equip teachers with additional pedagogical content knowledge and skills needed to educate primary school mathematics learners. Professional development activities will assist in the daily planning of lessons. Learners' participation in class activities might increase due to the fact that teachers will address the content in a realistic context. Different use of methods and models will enhance learning and understanding in learners.
Such a professional development may provide evidence-based intervention strategies that could be implemented to curb the high failure rate in school mathematics as pointed out by the Standardized Achievement Tests (SAT) 2012.
Since the initial professional development will be developed in Windhoek successful programme components may be replicated and may provide a base from which to diffuse intervention to other regions in Namibia.

3. **POTENTIAL RISKS AND DISCOMFORTS**

There are no foreseeable risks involved in partaking in this research.

4. **PAYMENT FOR PARTICIPATION**

Participants take part on a voluntarily basis. No payment.

5. **CONFIDENTIALITY**

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of:

- ✓ Your name is not used in the final draft of the thesis, instead special coding of data will be used.
- ✓ Notes, interview transcriptions, transcribed notes and any other information that could identify you, will be stored on a password-protected personal computer, which will be kept in a safe at the researcher's home.
- ✓ Any information gathered from you and transcribed, will be made available to you on request.
- ✓ Video-recordings will be at all times accessible to you. They will be accessible to other participants only if prior consent is obtained from you. At the end of the research these recordings will be destroyed.
- ✓ Information gathered for this research will be used only for the purpose of this research and publications that may result from the research.
- ✓ In any publication that may result, no personal details of participants will be used.
- ✓ All materials gathered will be destroyed when no longer needed for the research.

- ✓ Information from this research will be made available to the Ministry of Education on request.

6. PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you do not want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so

7. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact Ms Barbara Ilona Peters, 081 239 2237, bpeters@unam.na. You can also contact my promoter Dr F Gierdien, 0027218082289, University of Stellenbosch.

8. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

The information above was described to ………………………………

by Barbara Ilona Peters in English and *I ………………………………am* in command of this language

or it was satisfactorily translated to me. I, ……………………………… was given the opportunity to

ask questions and these questions were answered to my satisfaction.

____

Name of Principal/ Name of Participant

______________________________ ____________

Name of School DATE

I have been given a copy of this form.

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY
jou kennisvennoot • your knowledge partner

APPENDIX B

Approval Notice

New Application

26- Nov -2013

Peters, BARBARA BI
Proposal #: DESC_Petersb2013

Realistic Mathematics Education and professional development: A case study of primary school mathematics teachers in Title: Namibia

Dear Ms BARBARA Peters,
Your DESC approved **New Application** received on **01-Nov-2013**, was reviewed by members of the **Research Ethics Committee: Human Research (Humanities)** via Expedited review procedures on **25-Nov-2013** and was approved.

Please note the following information about your approved research proposal:
Proposal Approval Period: **25-Nov-2013 -24- Nov -2014**

Please take note of the general Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

Please remember to use your **proposal number** (**DESC_Petersb2013**) on any documents or correspondence with the REC concerning your research proposal.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Also note that a progress report should be submitted to the Committee before the approval period has expired if a continuation is required. The Committee will then consider the continuation of the project for a further year (if necessary).

This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki and the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health). Annually a number of projects may be selected randomly for an external audit.

National Health Research Ethics Committee (NHREC) registration number REC-050411-032.

We wish you the best as you conduct your research.

If you have any questions or need further help, please contact the REC office at 0218839027.

Included Documents:

Interview schedule

Approval letter

Informed consent forms

Research proposal

Observation Schedule

DESC form

Permission letter REC

application

Sincerely,
Susara Oberholzer
REC Coordinator

Research Ethics Committee: Human Research (Humanities)

APPENDIX C

Research: PROFESSIONAL DEVELOPMENT

ABBA PRIMARY SCHOOL

DATE: January 2014

NAME: ______________________________

AGE: _____

QUALIFICATION: ______________________________

____

____

POSITION AT SCHOOL: ______________________________

SCHOOL GRADES TEACHING: ______________________________

YEARS OF EXPERIENCE: ______________________________

PSEUDONYM: ______________________________

SIGNATURE: ______________________________

APPENDIX D

INFORMATION SESSION

(This was presented as a Power Point Presentation – followed by a discussion)

Introduction:

Provide background information regarding myself.

Elaborate on reasons why I will be 'part of them' during the whole school year.

What can you expect?

- ✓ This Professional Development (PD) is a training programme that provides opportunities to practice various skills, not only during the workshop sessions but also during normal class periods.

- ✓ Engaging in the workshop sessions is very important, because all sessions 'build on' each other – they are interlinked.

- ✓ Participation in this study is voluntarily. Participants names will at all times be protected (anonymously). All information will be handled confidentially.

- ✓ This PD will focus on the need to learn together, to actively engage with colleagues and to build on existing knowledge and experiences. All workshop sessions will, therefore, have a strong element of participation if they are to work properly.

- ✓ There will be a strong focus on learning something "new" – how to incorporate Realistic Mathematics Education (RME) principles into your lessons. How will we do that? You will learn what Lesson Study (LS) is and why we will 'try it out'.

- ✓ You are encouraged to take notes in a diary. This will help you and me in order to reflect about the sessions.

Write down at least 5 syllabus issues that you would like to be addressed.

- Discuss whether the research can address these issues

What will you learn if you participate?

From the above you can see the concepts RME and LS? Do you have any knowledge about them?

You will learn about:

- Realistic Mathematics Education – more information will be provided at the next session
- Lesson study – more information will be provided at a next session

Why should you know these concepts – will they add value to my teaching?

The topic of my thesis:

Realistic Mathematics Education and Professional Development: A Case Study of Primary School Mathematics Teachers in Namibia.

Focus of this professional development will be:

- To build a stronger mathematical foundation – we will explore concepts and ideas
- To experience how to possibly improve teaching skills
- To experience how to support learners' learning
- To experience and to share information regarding our teaching
- To experience to plan together lessons and present these then individually
- To reflect then on these lessons in order to improve on what challenge we experienced

APPENDIX E

LOG of WORKSHOPS: Duration: 14:00 – 17:00

No	DATE: 2014	TYPE OF WORKSHOP
1	17 January	Introduction and Overview of Study Activity Tangram
2	30 January	What is the Knowledge Quartet? Activity " Problem solving -Kraal"
3	13 February	RME Detailed Explanation of RME Examples of Number Frames – Number Strings- Box with ten counters – Friends of five, ten and twenty Activity 3x3 square
4 LS(1)	27 February	LS Detailed Explanation of LS Mathematization – what does it mean? Planning of Research Lesson No. 1
5 LS(2)	13 March	Discussion of first Research Lesson Mathematization re-emphasized Planning of Research Lesson No. 2
	20 March	Start of long weekend – no workshop
6	27 March	Report back of Research Lesson Counting in 2's, 3's, 4's and 10's for Grade 2 & 3 – Stepping Stones – Snaky Strips – Discussion of previous workshop questions -Odd and Even Numbers - Colouring in of Odd and Even Numbers
7 LS(3)	3 April	'Odd and Even Numbers' Planning of Research Lesson No. 3
8	10 April	Report back on Research Lessons Multiplication Tables – how to assist learners – find ways to connect logically
9	4 June	Reflection – what were our experiences so far?
10	11 June	How to set Balanced Question Papers -Cognitive Levels
	18 June	No workshop – Myself attending Assessment Workshop
	25 June	No workshop – Teachers' Sport Activities
	2 July	No workshop – UNAM activities

	9 July	UNAM RECESS
11	16 July	Fractions – Multiplication Tables – Common Fractions–Fraction Strips- Equivalent Fractions – Decimal Fractions – Activity on Fractions – Domino Game
	21 July – 30 August	Test Series and School Holidays Participants requested having afternoons available
12 LS(4)	2 October	Fractions continue Planning of Research Lesson No. 4
13	9 October	Reflection on Research Lesson No. 4 How to develop Additive Thinking
	October – November	General Discussions on SAT Preparation and Examination Question Papers

APPENDIX F_1

Tangram

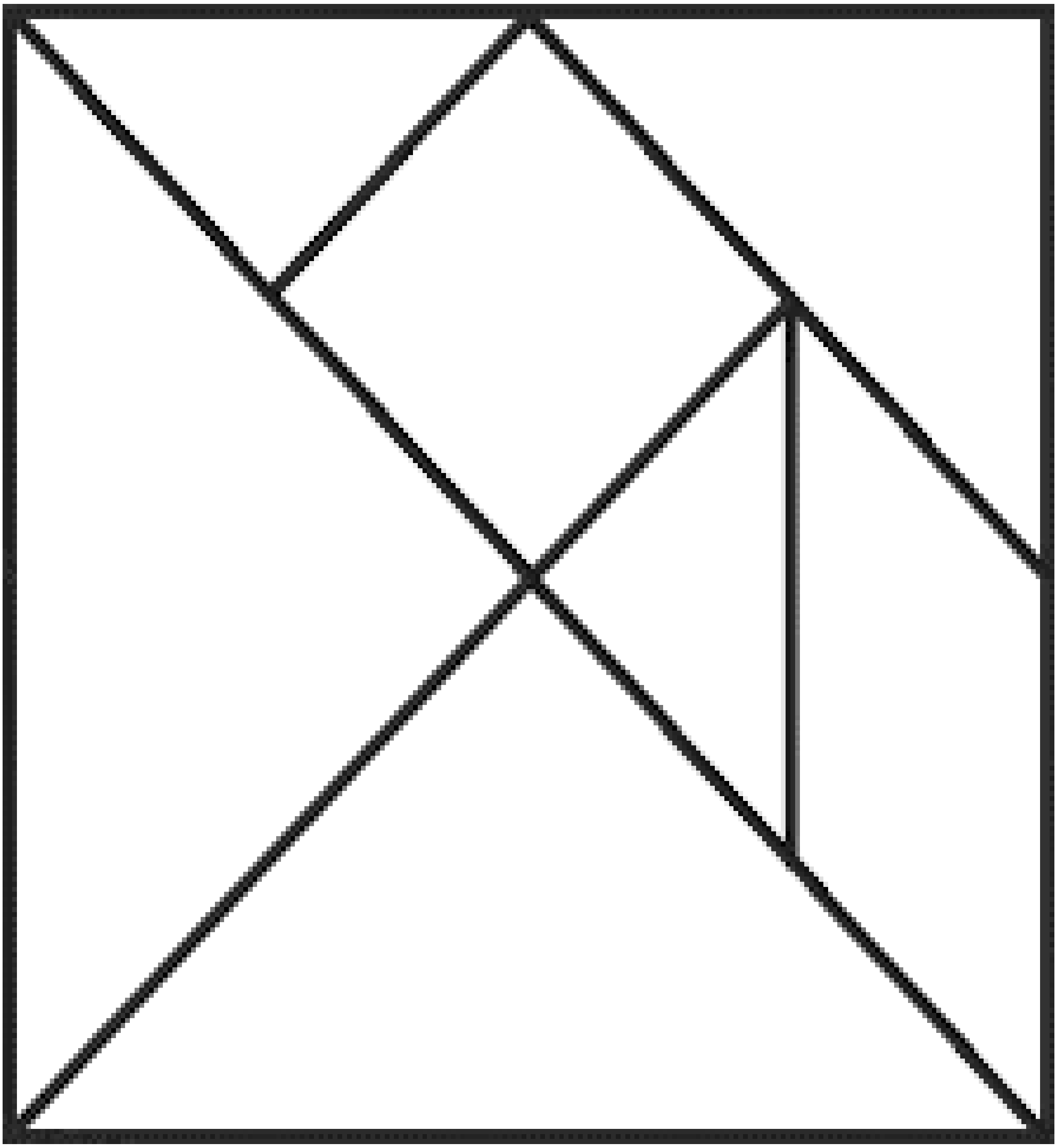


Figure 1: Tangram (http://www.fun-stuff-to-do.com)

APPENDIX F_2

CAT TANGRAM

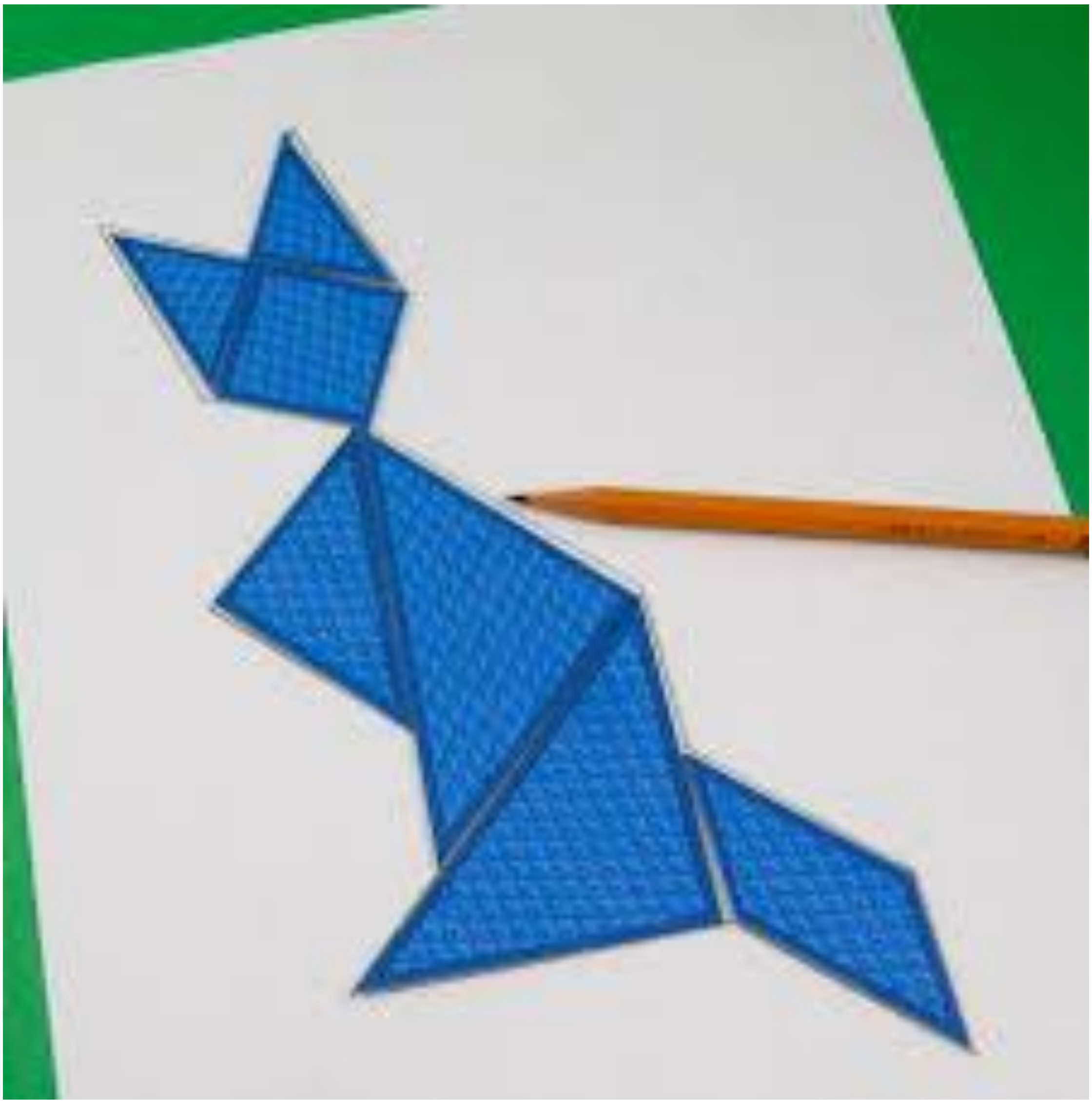


Figure 2: Example of a Cat (http://www.fun-stuff-to-do.com)

APPENDIX G

KNOWLEDGE QUARTET

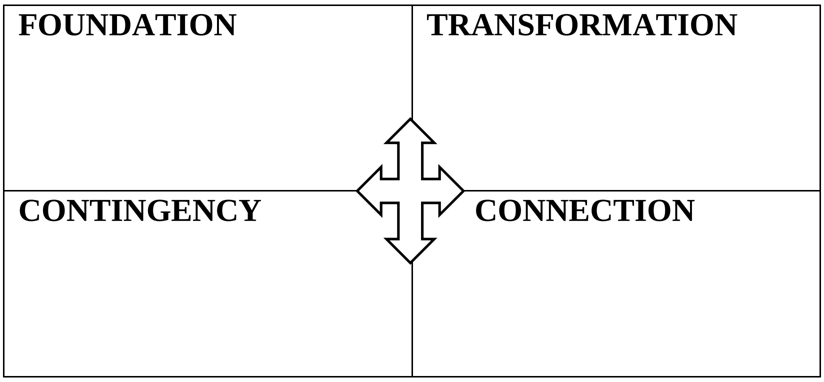
(This information was presented as a Power Point Presentation – followed by a discussion)

The development of the Knowledge Quartet (KQ) (Rowland, Turner, Thwaites & Huckstep, 2009)

- What is the role of the mathematics teacher's content-related knowledge in the classroom?
- What is the influence of 'wrong' content concepts conveyed?
- What is the influence of 'positive experiences' in mathematics for Pre-Primary, Lower and Upper Primary for the future of the learner?

The four Dimensions of the KQ

- Foundation
- Transformation
- Connection
- Contingency



Foundation

- Teacher's theoretical (knowledge acquired at school) background and beliefs
- Being able to make conceptual connections in his/her teaching
- Knowledge and understanding of mathematics itself
- Knowledge of mathematical pedagogy
- Beliefs about mathematics – beliefs about why and how mathematics is learnt

Transformation:

- Gets to core what it means to *teach* mathematics
- The *capacity* of a teacher to transform the content knowledge he/she possesses into forms that are pedagogically powerful.
- Distinguish: 'knowing some mathematics for yourself' and 'knowing in order to be able to help someone else' to *learn* it.
- Transformation to take place through representations which could be:

✓ illustrations,
✓ examples,
✓ explanations and
✓ demonstrations

Connection:

- Coherence of planning teaching across an episode, lesson or series of lessons
- Mathematics known for its coherence as a body of knowledge – the cement that holds it together is ***reason.***
- ***An effective teacher will excel in a "connectionist" orientation. (Always able to relate to real life!)***
- What does connection include?

✓ Sequencing of topics of instruction
✓ Ordering of tasks and exercises
✓ Making good choices based on knowledge of structural connections within mathematics – awareness of the relative cognitive demands of different topics and tasks.

Contingency:

- Things might arise that were not planned for or anticipated
- Greater knowledge will lead to fewer surprises when teaching
- Knowledge enables teacher to anticipate and plan for greater number of learner responses
- 'think on one's feet' – about *contingent action*

APPENDIX H

PROBLEM SOLVING

What about the following?

> It is auction time. The farmer wants to sell sheep at the auction. Mia observed the following:
>
> There are 10 heads in a 'kraal'. There are sheep and men in the 'kraal'. There are 26 'legs' in the 'kraal'. How many men and sheep are in the 'kraal'?

- Can you find a solution?
- Do you think it is a realistic problem situation for learners?
- Can you change/ adapt the problem?
- Could I have asked more questions regarding this one problem?
- Is there unnecessary information in the problem?
- Is this number sense or numeracy?
- Is this counting?
- Which mathematical operations (addition/subtraction/division/multiplication) are involved?
- Can there be different answers? If, why?
- Can there be different models/strategies to arrive at the answer?
- In your view, is it a suitable problem to find a solution for?
- With your experience do you regard this problem as being suitable for Grade 2/3/4/5/6/7?
- In your view, what is the difference in presenting problems to learners as *'naked' or* as everyday problems?

APPENDIX I

REALISTIC MATHEMATICS EDUCATION (RME)

(This information served as background knowledge for participants regarding what RME entails. I presented this as a Power Point Presentation. A discussion followed afterwards.)

- Mathematics should be 'realistic' – what does this mean?
- Realistic = meaningful, everyday life, making sense
- Comes from Dutch " sich REALIZEren"

The 6 Principles of RME (discuss each one shortly)

- The use of context

  Here the importance of contextual problems serves as application and as starting points from which the intended mathematics can comes out.

- The use of models

  Attention is paid to the development of models (or the teacher can use already developed models – the teaching aids that will be distributed throughout the research), or schematic drawings and symbolisations rather than offering the 'rule'/ 'method' or formal mathematics right away.

- The use of learners' own productions and constructions.

  The ultimate aim is that learners should be able to come up with their own constructions that will lead them from their own informal to the more standard formal methods

- The interactive character of the teaching process

  This implies that there are negotiations, interventions, discussions and co-operation amongst learners and the teacher to ensure that a constructive learning process is established in which learners' informal strategies are used as a bridge to attain the more formal strategies.

- The intertwinement of various learning strands

  The holistic approach implies that learning strands cannot be dealt with as separate entities. The use of everyday life examples, coming from other learning strands is exploited in problem solving (word problems).

- Guidance principle

  The teacher guides the learner didactically and efficiently from one level to another level of thinking through mathematization.

  What are these levels and what is mathematization?

Where to now?

- Many of us have difficulties understanding mathematics – this maybe the result of being uncertain about our own thinking and reasoning skills and this result again in a low self-esteem.

- Memorization of methods and 'tricks' of calculations and not really understanding the four basic operations are disastrous.

- Check the following: We teach our learners to 'add a 0 to any number if we multiply by ten' – ok – what about it?

  Check: 5 x 10 = 50 and 2,5 x 10 = 2,50????

- This could be a result why our learners become confused, most probably their misconceptions are not corrected, neither discussed.

- We will try in this workshop to concentrate on 'understanding the concepts'.

- We would like to build on learners' confidence by developing reasoning and thinking about physical number situations.

- Understanding develops through discussion, sharing views about what we have seen and experienced, thought and done.

- Learners should also realize that their own thinking is valid and worthwhile – their self-esteem is built.
- Primary learners should always ‘explore’ number by ‘doing activities’ - use a variety/ range of physical and visual resources.
- Learners should enjoy mathematics.
- The point of departure is not that every day-life problems will, by definition, be experientially-real to learners, nor that experientially-real problem situations necessarily have to deal with real-life situations. For example we can use a story, e.g. fairy tales, playing a video, using the daily newspaper
- Realistic is to be interpreted as referring to experientially-real, not every day life reality

APPENDIX J

LESSON STUDY (LS)

This was part of the theoretical background knowledge for participants regarding LS. I did a Power Point Presentation. A discussion followed.

What is lesson study?

'An activity carried out by a number of teachers of a certain subject in collaboration with educational experts to improve the quality and content of their teaching'

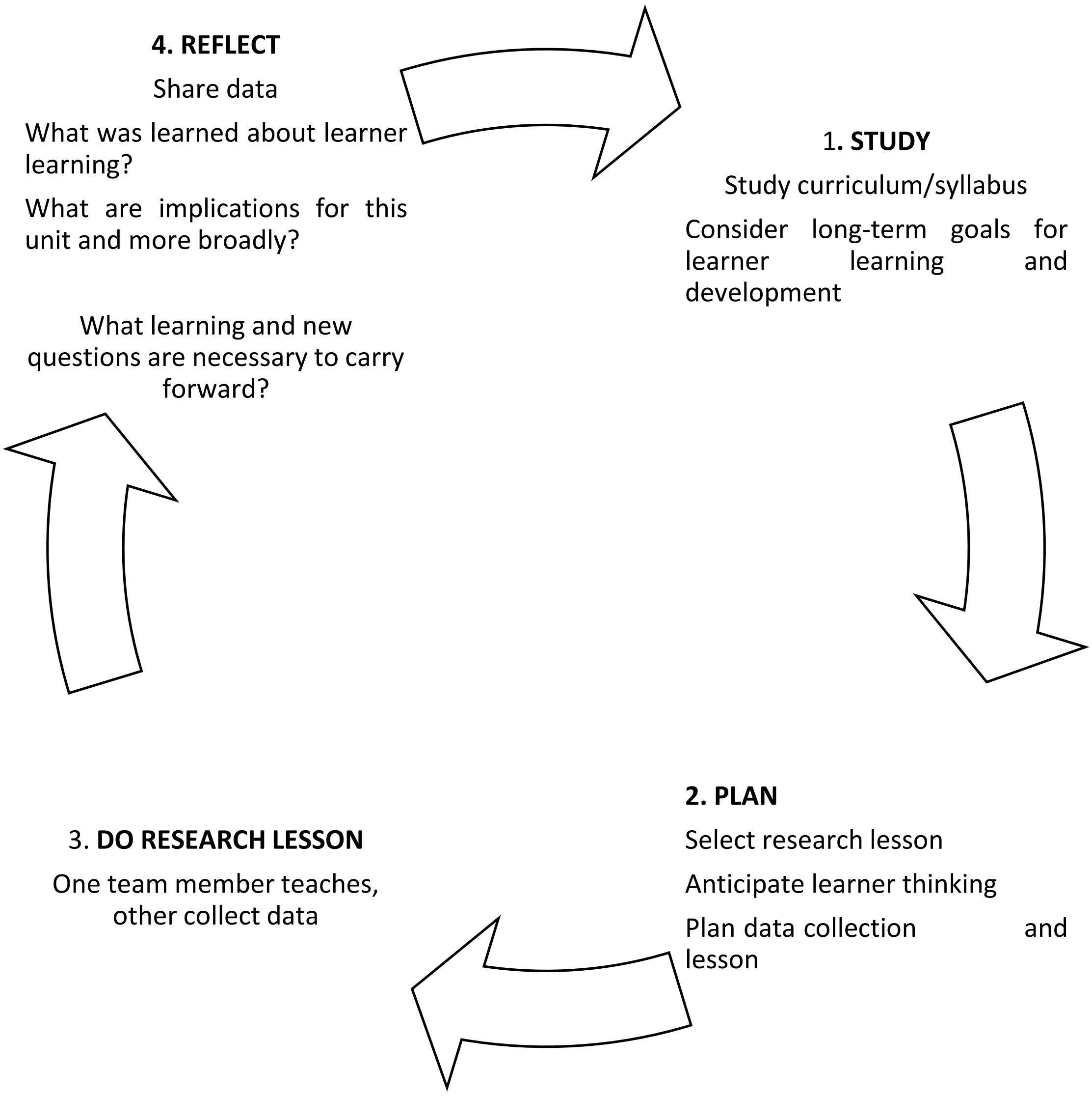
AIM of this Professional Development to include Lesson Study

- Unite mathematics teachers of both primary phases.
- Focus to increase mathematical knowledge.
- Focus to improve methods of teaching.

Process of Lesson Study

- Plan collaboratively
- Teach lesson
- Observe each other's lesson (if possible)
- Reflect on lesson
- Draw conclusions
- Change/ revise/ refine lesson

The following schematic presentation will better explain the process


4. REFLECT
Share data
What was learned about learner learning?
What are implications for this unit and more broadly?
What learning and new questions are necessary to carry forward?
1. **STUDY**
Study curriculum/syllabus
Consider long-term goals for learner learning and development
2. PLAN
Select research lesson
Anticipate learner thinking
Plan data collection and lesson
3. **DO RESEARCH LESSON**
One team member teaches, other collect data

Why is it worthwhile to implement this concept in the RME-based professional development?

- Understanding develops through discussion, sharing views about what we have seen and experienced, thought and done.
- Learners should also realize that their own thinking is valid and worthwhile – their self-esteem is built.
- Primary learners should always 'explore' number by 'doing activities' - use a variety/ range of physical and visual resources.
- By reflecting on a presented lesson a critical look at what was 'good' and what 'needs improvement' might contribute to our own personal growth.

APPENDIX K_1

RESEARCH LESSON (1)

Lesson Preparation

Grade 2 & 3

10 – 14 MARCH 2014

School: ABBA

TOPIC: NUMBER CONCEPT DEVELOPMENT
COUNTING

LESSON DURATION: 40 MINUTES

Learning objectives (National Syllabus: 2005):

- Learn to count with and without objects
- Learn recognition and re-arrangement skills to handle spatial relationships and patterns (subitizing)

Approaches (National Syllabus: 2005):

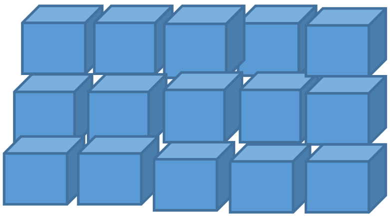
- Count concrete objects up to 20
- Count concrete objects in 2's up to 20
- Count concrete objects backwards from 20 to 0
- Recognize by estimating the number of objects up to 10 (subitizing)
- Recognize that different arrangements of objects can represent the same number

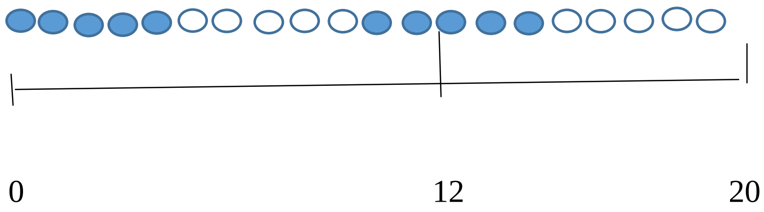
Basic Competencies (National Syllabus: 2005):

- Order, sequence, spatial relationships within number range 0 – 20

Mathematical Content:

- Counting – range: 0 – 20
- Subitizing: Numbers 1 -10
- Solving contextual problems: Range 1 – 20

DURATION	TEACHER ACTIVITY	LEARNER ACTIVITY Possible difficulties to be experienced / possible misconceptions?
+/- 10 Minutes	**Introduction:** Friends of ten – show a number and learners must find the "friend' E.g. 3 7 Buttons: Subitizing E.g  Show several buttons, individual learners to give answer Present learners with building blocks stacked up like:  Class is divided into groups of 6. How many blocks are there? Break them up and count them. Was your answer correct? Ask one learner to count blocks one-by-one (rational counting.)	Learners should not experience any problems Learners might count 'faces' and not blocks Majority of learners should have it correct. Learners should not have any problems

	• There are 15 blocks. How many more blocks are needed to have 20 blocks? • You take away 8 blocks from 15 blocks. How many blocks are left?	
+/- 15 minutes	**Number context:** String of 20 beads  • Put washing peg between bead 12 and 13 • Draw line underneath of bead strings • Emphasize position of 0 – there are no beads before it and mark 20 shows there are 20 beads before it. • Give contextual examples – ask learners – how many learners are you in two groups? Using string of beads above • Where would I find the number 8, 15, 2, 19, 7, 14…? Point at them. • Represent these positions on the number line. • How can I present 12 in 'tallying' i.e. ~~1111 1111~~ 11 Check answer on string of beads • How can I present 17 in tallying?	
		Learners might not experience difficulties – can see model in front of them
	• Can I present 12 differently? • What about 12 = 5 and 5 and	

	2 • Or 12 = 10 and 2 Check on string of beads • Write now 17 and 9 in a different form by using 10's , 5's and 1's Check on string of beads Find the following missing numbers in the sequence: 2; xx; 4; xx; 6; xx; xx 16; 14; xx; xx; 8; xx 1; 3; 5; xx; 9; xx; 13 Fill in all numbers on number line – use different colours that learners can 'see'	Guide learners who experience challenges
+/- 10 Minutes	• Let us count in 2's – demonstrate on the bead strings Individual learners count in 2's: 2; 4; 6; 8 • Can we count backwards in 2's - demonstrate on the bead strings Learners count individually <u>Mathematizing</u>	1; **2;** 3; **4**; 5; **6**; 7; **8**; 9; **10**; etc. (soft; **loud**) Individual learners should be able to demonstrate – not really a challenge

	Complete the following (Write on chalkboard and ask groups first to find 'missing' numbers; call then individual learners to the chalkboard) • 20, 18, xx, xx, 12,xx • 8, 10, xx, xx; xx, 18 • 1, 3, xx, xx, 9, 11, xx • 19, 17, 15, xx, xx, 9 • Indicate with the washing peg the place of 6, 9, 17 on the bead string. <u>Contextual problems</u> There are six groups of learners in the class. There are three learners in each group. ✓ How many learners are in the class? ✓ How many learners will be in a group if twelve learners join the class? Mia's sister is 17 years old. ✓ How old was she six years ago?	Learners may use number frames or bead strings to help with solutions. Learners will hopefully reason like : xxx xxx xxx xxx xxx xxx – 18 learners 6 groups add one learner each will result in 4 learners in a group. xxx**x** xxx**x** xxx**x** xxx**x** xxx**x** xxx**x** 6 groups add another learner xxxx**x** xxxx**x** xxxx**x** xxxx**x** xxxx**x** xxxx**x** Add another learner to each group - there will be 5 learners in each group. <u>Second problem</u> Learners will hopefully count backwards

		16,15,14,13,12,11 or 2014 (17yrs) = now 2013(16 yrs) 2012(15yrs) 2011(14yrs) 2010 (13yrs) 2009 (12yrs) 2008 (11yrs)
+/- 5 minutes	Clean up – Guide individual learners who might still experience challenges	

RME principles applied:

- Activity principle – learners develop their own problem solving strategy
- Reality principle - Problem solving related to their reality.
- Level principle – they might use models to derive at answer – all had Building Blocks ('Uni' blocks) in front of them

APPENDIX K_2

RESEARCH LESSON (2)

Lesson Preparation

Grade 2 & 3

17 - 26 March 2014

School: ABBA

TOPIC: NUMBER CONCEPT DEVELOPMENT

Number Patterns: Computation

LESSON DURATION: 60 MINUTES

Learning objectives (National Syllabus: 2005):

- Learn to add and subtract small numbers

Approaches (National Syllabus: 2005):

- Add and subtract numbers in the range 1 and 20 where the first number lies between 1 and 20 and the second between 1 and 4
  - ✓ By counting on
  - ✓ Flowcharts/ tables with missing output numbers

Basic Competencies (National Syllabus: 2005):

- Order, sequence spatial relationships, place value

<u>What are learners able to do?</u>

- Learners can recite number sequence up to 20 – forwards and backwards
- Learners can count in 2's up to 20 – forwards and backwards
- Learners can put numbers up to 20 in context by giving real-world meaning
- Learners can structure numbers up to 20 by using groups of five and ten
- Learners can place any number on empty number line from 0 to 20.

<u>Mathematical content;</u>

- Addition and subtraction: numbers 1 – 20
- Have to find 'missing numbers'

<table>
<tr><td>DURATION</td><td>TEACHER ACTIVITY</td><td>LEARNER ACTIVITY
Possible difficulties to be experienced / possible misconceptions?</td></tr>
<tr><td>+/- 10 Minutes</td><td>Revise:
Josef is 12 years old, how old was he 3 years ago?

I read 7 pages of a book and my sister reads 15 pages. How many more pages did my sister read?</td><td>Learners might do it like

12 -1-1-1-= 11,10,9

Some might do it
12 take away 3 = 9

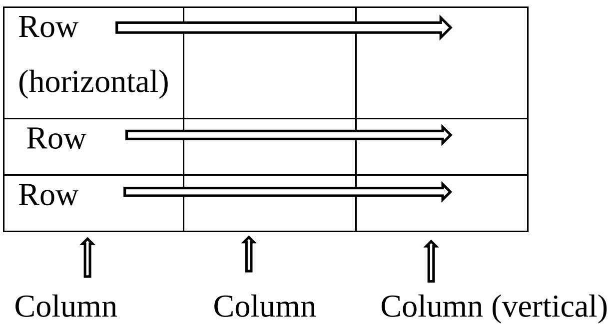
Some might do it like
8,9,10,11,12,13,14,15
equals 8pages
Other might do it
from 7 to 15 is 8
Or; 15 take away 7 is 8</td></tr>
<tr><td>+/- 35 minutes</td><td colspan="2">Learners work in groups – though every learner can do activity on its own – only one member will report back.

Learners will have bead strings (20 beads) and 20 counters available on their desks
Calculation by counting:
3 + 5 + …. = 15
7 + 2 + … = 15
6 + 1 + …. = 15

Calculation by structuring:
3 + … + 4 = 15
….+ 6 + 2 = 15</td></tr>
</table>

9 + 5 + ….= 15

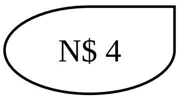
The reason for doing this exercise is that learners will hopefully realize the combination of numbers to get a sum of 15



Show what row, column and diagonal means

Activity:

Every learner receives a 3 x 3 square and 9 'bags of money', N$1; N$2; N$3; N$4, N$5; N$6; N$7; N$8and N$9

Learners have to place bags of money (e.g. 

in the square

in such a way that each number appears only once and will always add up to N$ 15 horizontally, vertically and diagonally. 'Plain' numbers 1 – 9 can also only used instead of the 'bags of money'.

The numbers are written on chalkboard in a vertical and horizontal display e.g. 1; 2; 3; 4; 5; 6; 7; 8; 9 or

1

2

3

4

5

6

7

8

<table>
<tr><td></td><td colspan="2">9</td></tr>
<tr><td></td><td>Hopefully learners will realize to put the number of first counters out like
<table><tr><td></td><td></td><td></td></tr><tr><td>7</td><td>5</td><td>3</td></tr><tr><td></td><td></td><td></td></tr></table>
Learners to be reminded of activity done above: calculation by counting and calculation by structuring.</td><td>A lot of guidance will be necessary.
Learners will start by ‘trial and error’
Some might realize to put 5 in the middle
Some might be totally lost and one row can be filled in with guidance.
Learners to be shown the examples they have started the lesson with</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>+/- 10 Minutes</td><td>Learners report back and demonstrate how they found a solution
Hopefully some different answers will come out</td><td></td></tr>
<tr><td>+/- 5 minutes</td><td>Clean up – Guide individual learners who might still experience challenges</td><td></td></tr>
</table>

The lesson might take much longer. Arrangements were made for a double period.

RME principles included:

Guidance principle – some groups will need to be guided from teacher

Interaction principle – learners will discuss, argue and try out strategies – they will have to derive at an uniform decision

Activity principle – learners will find their own way to solve the problem situation

APPENDIX K3

RESEARCH LESSON (3)

Lesson Preparation

Grade 2, 3, & 4

7 - 11 April 2014

School: ABBA

TOPIC: **NUMBER CONCEPT DEVELOPMENT**

Odd and even numbers

LESSON DURATION: 60 MINUTES

Learning objectives (National Syllabus: 2005):

- Learn to recognize odd and even numbers.

Approaches (National Syllabus: 2005):

- Recognize that odd numbers end in 1; 3; 5; 7 and 9
- Recognize that even numbers end in 0; 2; 4; 6 and 8

Basic Competencies (National Syllabus: 2005):

- Order, sequence spatial relationships, place value

<u>What are learners able to do?</u>

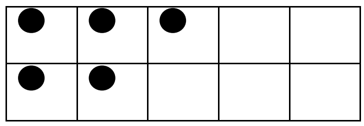
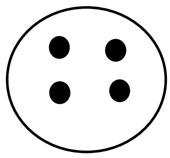
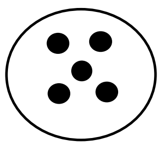
- Learners can recite number sequence up to 50 – forwards and backwards
- Learners can count in 2's up to 50 – forwards and backwards
- Learners can put numbers up to 50 in context by giving real-world meaning
- Learners can structure numbers up to 50 by using groups of five and ten
- Learners can place any number on empty number line from 0 to 50.
- Learners can indicate any given number up to 50 on the 100-chart.

<u>Mathematical content:</u>

Learners work in groups.

Ten frames, twenty frames, counters, bead strings and building blocks are available to be used.

Teachers bring 'loose' socks along to be paired.

DURATION	TEACHER ACTIVITY	LEARNER ACTIVITY Possible difficulties to be experienced / possible misconceptions?
+/- 10 Minutes	Start by activity to 'pair socks' There are 'partners' and 'no partners' The following numbers are given 7; 1; 8; 4; 5 Learners are asked to group each of the numbers into two equal groups. Two circles are provided to put the counters into, if they so wish. Learners have to report what they discover – one group member to report For Grades 3 & 4 numbers are increased to 17; 11; 18; 15 Give now numbers from 10 – 20 to determine odd and even, e.g. 11 = 5 + 5 +1 odd 12 = 6 + 6 even (or 5 + 5 + 2)	Learners might do it like: Learners may use ten frame (or twenty frame)  Or counters to put into circles Even  
+/- 25 minutes	Hopefully learners will derive at: All numbers that end in 1; 3; 5; 7 and 9 are odd.	

	All numbers that end in 0, 2, 4, 6 and 8 are even. Use chant: 2; 4; 6; 8; 10 even numbers let's say again 1; 3; 5; 7; 9 odd numbers, oh my Display on hand out (the 100-chart) Groups to colour in all even numbers in read for said number range. E. g 1 - 30 Groups to colour in all even numbers in green for said number range Find answers to the following problems: • Is today's date an even or odd number? • Jack is 24 years old. Is 24 an odd or even number? • Add 3 and 3. Is the answer odd or even? • Add 13 and 12. Is the answer odd or even? • Add 14 and 15. Is the answer odd or even? • Add 2 and 6. Is the answer odd or even? • Add 12 and 16. Is the answer odd or even? • Subtract 2 from 7. Is the answer odd or even? • Subtract 3 from 17. Is the answer odd or even? • Subtract 8 from 16. Is the answer odd or even?

+/- 20 Minutes	Learners report back and demonstrate how they found a solution Summary: from your answers check whether the following is true or false: If I add two odd numbers the answer will always be even? Try to motivate your answer.	Hopefully learners will be able to motivate answer that 3 + 3 = 2 + 1 + 2 + 1 ====equal groups They will see the structure of an odd number as "even + 1"
+/- 5 minutes	Clean up – Guide individual learners who might still experience challenges	

The lesson might take much longer. Arrangements were made for a double period.

RME principles included:

Guidance principle – some groups will need to be guided from teacher

Interaction principle – learners will discuss, argue and try out strategies – they will have to derive at a uniform decision

Activity principle – learners will find their own way to solve the problem situation

APPENDIX K_4

RESEARCH LESSON (4)

Lesson Preparation

Grade 4; 5 & 6

6 – 10 October 2014

School: ABBA

TOPIC: COMPUTATION

Fractions

LESSON DURATION: 60 MINUTES

Learning objectives (National Syllabus: 2005):

- Understand basic mathematical concepts to identify fractions from halves to tenths

Approaches (National Syllabus: 2005):

- Name the fractional parts of a whole and the fractional part of a collection of objects
- Name the relationship between fractional parts and a whole
- Use fractional notation
- Use the common fractions in everyday situations.

Basic Competencies (National Syllabus: 2005):

- Express orally and in mathematical symbols the common fractions from halves to tenths as partial quantities of a whole and the fractional parts of a collection of objects

For Grades 5 & 6:

- Use the correct terminology of fractions such as numerator and denominator
- Treat denominators of fractions as divisors e.g. a/b as a ÷ b, whereby b represents the whole number of parts into which a whole is to be divided.

<u>What are learners able to do?</u>

- Learners know the equivalent fractions like 1 = 2/2 = 4/4
- Learners can identify a half, a quarter, one third, one fifth and one tenth.

<u>Mathematical content:</u>

- Equivalence
- Comparison

Learners work in groups.

Fraction strips are distributed. One set (5 strips) for each group.

DURATION	TEACHER ACTIVITY	LEARNER ACTIVITY Possible difficulties to be experienced / possible misconceptions?
+/- 20 Minutes	Start by folding strips into their parts. Name each part on the strip. Teacher guides this activity that all can follow. Learners ask to do the following: • One strip, leave it as is. This is ‘a whole’ • Fold next strip into two parts – what do we call one part • How do we write a half? (notation) • Go about until learners have halves, quarters, thirds, fifths and tenths. Do comparison: Learners answer first in their groups and later one learner reports back. Teacher is not demonstrating – it is expected that learners will use strips to explain their answers. • Is a half bigger or smaller than a quarter? • Is a fifth bigger or smaller than	Learners might hopefully answer A half ½ ¼; 1/3; 1/5; 1/10 Learners will hopefully use their strips. Learners might be able to come up with correct solutions. Learners must

<table>
<tr>
<td></td>
<td>a tenth?
• Is a tenth bigger or smaller than a third.
• Is a quarter bigger or smaller than a third?
• Is the following true of false – ½ is the same as 2/4?

What do we derive at from these questions?(Teacher will have all answers on Chalkboard)

The bigger the number of equal parts in a whole the smaller the parts are. – demonstrate!
Grade 5 & 6 mention names :
Total number of parts a whole is divided into is called Denominator
The parts that are ‘used’ are called the Numerator</td>
<td>demonstrate their answers in the end.</td>
</tr>
<tr>
<td>+/- 25 minutes</td>
<td colspan="2">Complete together with learners the equivalence diagram
Each learner will have an empty equivalence diagram – parts are indicated, but learners have to fill in for example ½ , 1/4 etc.

<table>
<tr><td>1/2</td><td>□/ 4</td><td>5/ □</td><td>3/ □</td><td>□/ 10</td></tr>
<tr><td>1/ 5</td><td>□/ 10</td><td></td><td></td><td></td></tr>
<tr><td>1/ 3</td><td>□/ 6</td><td></td><td></td><td></td></tr>
</table>

Then questions like:
• ½ = □/ 4</td>
</tr>
</table>

- 1 = □/ 7
- ¼ = □/8
- 2/3 = □/9

Write the correct sign: <; = or >

- 1/5 □ ¼
- 3/5 □ ¾
- 7/8 □ 9/10
- 2/10 □ 1/5

Find a solution for:

- ½ + ¼ =
- ½ + 1/3 =
- ¾ - ½ =
- 3/5 – 1/10 =

Equivalence: Use multiplication chart e.g.

x	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Guide learners for ½ + 1/3 and then only those who experience challenges

- ½ = 2/4
- 3/5 = 6/10

(denominators the same)

Learners might not be able to find the answer of

- ½ + 1/3
- ¾ - ½
- 3/5 – 1/10

Guidance needed might be Learners can use fraction strips (might be easier) or equivalence table.

+/- 15 Minutes	Learners report back and demonstrate how they found a solution A last challenge: You have three slices of bread. How will you share these three slices of bread between four friends?	Learners might realize to cut every slice into 4 pieces and then share equally. Or They might realize divide two slices into two parts and the last slice into four parts.
+/- 5 minutes	Clean up – Guide individual learners who might still experience challenges	

The lesson might take much longer. Arrangements were made for a double period + break time.

RME principles included:

Guidance principle – some groups will need to be guided from teacher

Interaction principle – learners will discuss, argue and try out strategies – they will have to derive at a uniform decision

Activity principle – learners will find their own way to solve the problem situation

APPENDIX L

ACTIVITY

3 x 3 SQUARE

Problem solving:

You have nine bags of money containing the following amounts:
N$ 1,00; N$2,00; N$3,00; N$4,00; N$5,00; N$6,00; N$7,00; N$8,00 and N$9,00.

You want to hide the bags in a 3x3 grid so that each row and column, whether horizontal, vertical or diagonal has N$ 15,00.

3 x 3

SOLUTION?

N$ 8,00	**N$ 1,00**	**N$ 6,00**
N$ 3,00	**N$ 5,00**	**N$ 7,00**
N$ 4,00	**N$ 9,00**	**N$ 2,00**

Solution?

- Is this number sense or numeracy?
- Is this counting?

- Which mathematical operations were used: addition/subtraction/division/multiplication?
- Can there be different answers? If, why?
- Can there be different models/strategies to arrive at the answer?

SOLUTION 2:

N$ 6,00	**N$ 1,00**	**N$ 8,00**
N$ 7,00	**N$ 5,00**	**N$ 3,00**
N$ 2,00	**N$ 9,00**	**N$ 4,00**

SOLUTION 3:

N$ 4,00	**N$ 9,00**	**N$ 2,00**
N$ 3,00	**N$ 5,00**	**N$ 7,00**
N$ 8,00	**N$ 1,00**	**N$ 6,00**

What can I derive from these answers?

- Do ALL problems have only ONE correct answer?
- How will I find time to check all answers?
- What can I learn from learners/peers?

- **Important note:**

The point of departure is not that every day-life problems will, by definition, be experientially-real to learners, nor that experientially-real problem situations necessarily have to deal with real-life situations.

Realistic is to be interpreted as referring to experientially-real, not every day-life reality

APPENDIX M

KQ AND RME

(This content served several times during the workshop sessions, discussions between groups and myself especially while planning research lessons. Served as Power Point Presentation during planning of research lessons)

FOUNDATION:

Do we

- Have a *clear and coherent belief* about purpose of mathematics education and why learners have to learn it? **RME – Level Principle**

- Use appropriate teaching strategies to promote required mathematical *understanding* in learners? **RME – reality principle**

- Concentrate on understanding rather than on procedures? **RME – guidance principle**
- Make use of his/her own resources? **RME- Level Principle**
- Show care in writing mathematical expressions correctly, e.g. use the = sign correctly?
- Demonstrate knowledge of quick mental methods?
- Use mathematical language correctly?

TRANSFORMATION:

Do we

- Use equipment (e.g. abacus) correctly to explain process in number where appropriate? **RME- Level Principle**

- Select app forms of representation, e.g. use a number line when teaching subtraction? **RME – activity & level principle**

- Choose appropriate examples when demonstrating an idea, e.g 2 x 3?

- Guide towards clear explanations of ideas or concepts? **RME – guidance principle**

CONNECTION:

Do we

- Make links to previous lessons and other subjects? **RME – intertwinement principle**
- Make links between mental and oral starter and the main part of the lesson?
- Recognize the conceptual application of mathematical ideas for learners they are teaching? **RME – reality, level, intertwinement principle**
- Appear to be aware of the different levels of difficulty in a topic? **RME – Level principle**

CONTINGENCY:

Do we

- Respond appropriately to learners' comments, questions and answers? **RME – Interaction principle**
- Cope adequately with questions from learners? **RME – Interaction principle**
- Deal appropriately with learners' responses to activities? **RME – Interaction principle**
- Make on-going assessment of learners' understanding during a lesson?

APPENDIX N

Activity Tangram

Example of Participants' Products

Figure 3: PSMTs' Work

APPENDIX O_1

QUESTIONS REGARDING SATs

This content served as a Power Point Presentation. Discussions between groups and myself followed.

How many levels are there and what does the different levels mean?

- Bloom's Taxonomy: Encouraging Higher Cognitive Thinking in Primary Classrooms

  There are 6 levels:

✓ Knowledge – level 1

✓ Comprehension – level 2

✓ Application – level 3

✓ Analysis – level 4

✓ Synthesis – level 5

✓ Evaluation – level 6

(Analysis, Synthesis, Evaluation:) Not applicable on primary school level

<u>Explanation</u>

First 3 levels in SAT for 2013

- Knowledge – 25 % - recall of information, discovery, observations, listening, locating, naming – e.g. plain 'naked' problems like: Determine 36 x2

- Comprehension – 37,5% - understanding, translating, summarize, demonstrate and discuss – e.g. 'order from the largest to the smallest' or ' measure to the nearest meter'

✓ Application – 37,5% - apply knowledge, problem solving – e.g. 'Joy has a N$ 50,00 note, two N$ 10, 00 notes and six 50c coins. How much money does she have?'

The SAT tests set by MoE prescribe a ratio of:

Knowledge: Comprehension: Application = 25%: 33%: 42%

- differs a little bit from year to year

MARKS	KNOWLEDGE	COMPREHENSION	APPLICATION
20	5	7	8
40	10	13	17
60	15	20	25
Total: 120	**30**	**40**	**50**

- **At Primary school level the suggested levels are: 30% : 50% : 20%**

MARKS	KNOWLEDGE LEVEL 1	COMPREHENSION LEVEL 2	APPLICATION LEVEL 3
20	6	10	4
40	12	20	8
60	20	30	10
Total: 120	**38**	**60**	**22**

Remember:

- Cognitive levels and levels of difficulty may differ for the same question set for different Grades.
- It is difficult to determine these levels – experience of colleagues might help.
- There will be disagreement that should be discussed and explored.

Examples of Questions regarding SAT

Measuring, Comparing and Ordering: Length, Mass, Capacity

- Estimate size of everyday objects: Comprehension
- Read instruments that measure length, mass and capacity in fractional units of tenths and hundredths: Knowledge
- Compare and order different lengths, masses and capacities stated in not more than two consecutive units: Application

APPENDIX O_2

QUESTIONS REGARDING SATs

This content served as a Power Point Presentation. Discussions between groups and myself followed.

Why are the SAT results so important for school management?

- SATs have 2 objectives:
- ✓ The school receives diagnostic information
- ✓ To keep track of the school's growth from year to year

- SATs as you know are administered in Grade 5 and Grade 7 in alternate years
- ✓ In 2014 Grade 5 and Grade 7 will be tested
- Three tests containing 50 operational questions will be administered
- Majority of competencies in subject syllabi will be assessed.

What is expected of a primary school mathematics teacher to know about SATs?

- 4 Performance Levels:

Below Basic Achievement: Learner demonstrates **insufficient** knowledge and skills across all themes in syllabus.

Basic Achievement: Learner demonstrates **sufficient** knowledge and **limited** skills across all themes in syllabus.

Above Basic achievement: Learner demonstrates **proficient** knowledge and skills across all themes in syllabus.

Excellent Achievement: Learner demonstrates **excellent** knowledge and **advanced** skills across all themes in syllabus.

- **Lowest performing competencies are:** (Ferdous, 2012)

- ✓ Solve problems which involves conversions between units using whole numbers

- ✓ Convert common fractions to decimal fractions (round off up to third decimals)
- ✓ Multiply and divide fractions (including mixed numbers) by fractions
- ✓ Convert decimal fractions to common fractions in their simplest form (excluding recurring decimals)
- ✓ Word problems – solve real life problems requiring calculations on almost all topics in syllabus

At the end of October 2014 we might answer the question

'Will our learners be in a position to maybe perform better in SATs?'

And

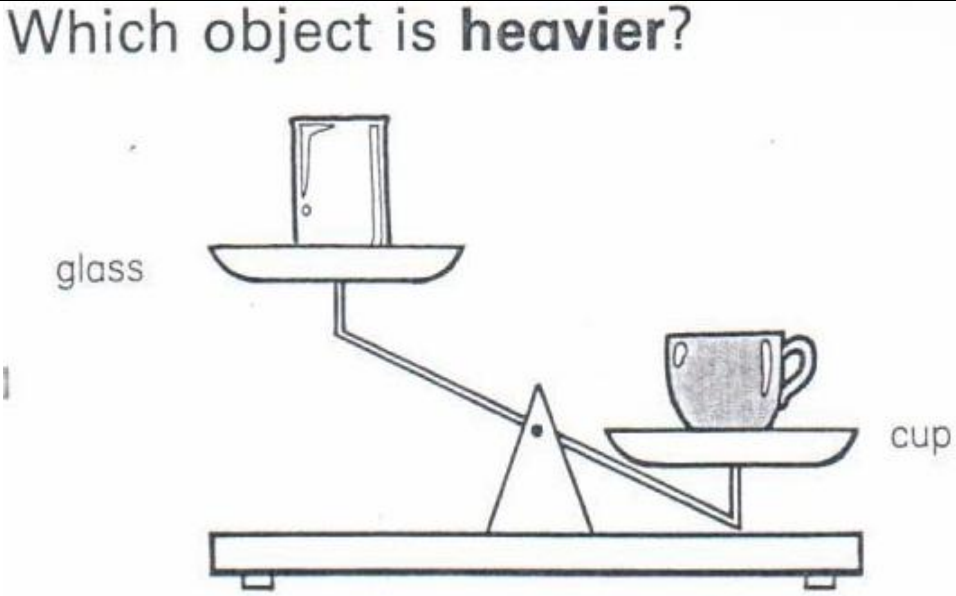
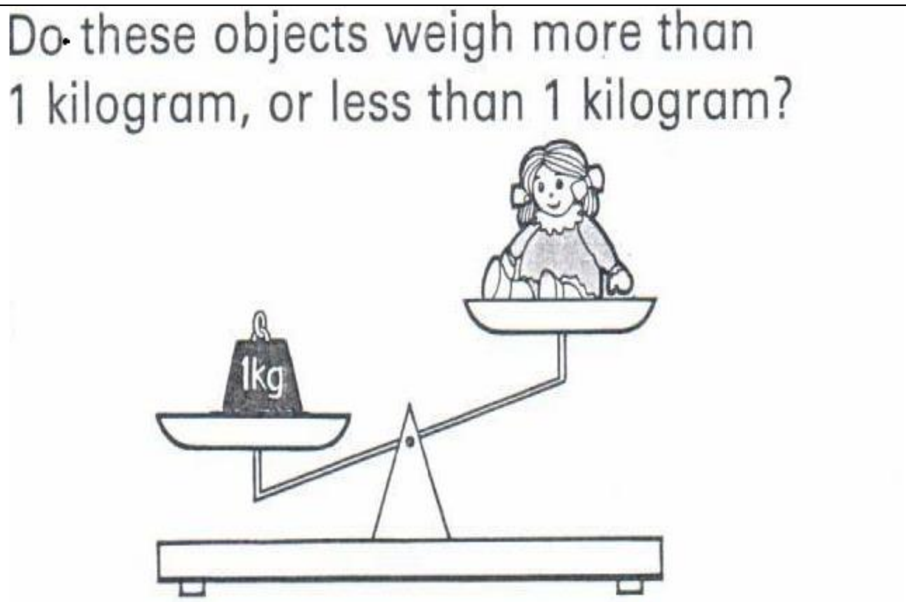
"What have I learned/ not learned to help my learners to better understand the mathematics content prescribed in the syllabus?'

APPENDIX O_3

COGNITIVE LEVELS

WORKSHEET

Classify each of the following questions/items according to the cognitive level for Grade 3 and Grade 4:

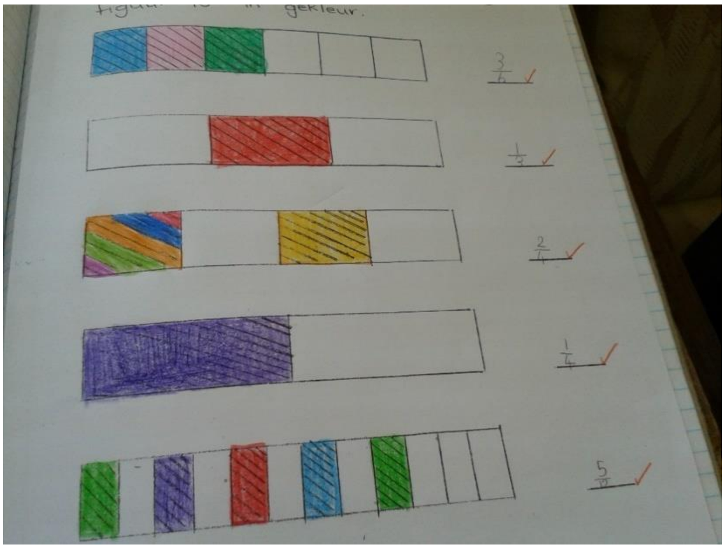
<table>
<tr><td rowspan="2">Question/ Item</td><td colspan="2">Cognitive level</td></tr>
<tr><td>Grade 3</td><td>Grade 4</td></tr>
<tr><td>1.</td><td></td><td></td></tr>
<tr><td>
</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>

2.
3. Measure the length of this line: ____________________</td><td></td><td></td></tr>
</table>

4. How many minutes in one and a half hour?		
5. A plumber has different pieces of pipe: 6m; 7m; 5m; 11m; 16m Which three pieces of pipe should he join to get a length of 28 m?		
6. How long is it from 4:30 p.m. to 6:10 p.m.?		
7. Write the time that is one hour earlier than four o'clock.		
7. How much change from a N$ 20,00 note will you receive if you have bought the following items: A chocolate costing N$ 1,50 A bread costing N$ 6,50 1 litre of milk costing N$ 11, 50		
8. A one litre bottle of coke can fill 4 glasses. How many glasses can be filled with three litres of coke?		
9. Use a clock face to indicate the time 10 to 7		
10. Write the fewest coins needed to pay exactly N$ 5,70.		
11. There are different groups of coins you can use to pay N$ 5,70. Write down three groups of coins.		
12. John is now seven years old and his mother is thirty years old. What is the difference of their ages **next year**?		

APPENDIX P_1

Fraction Activities



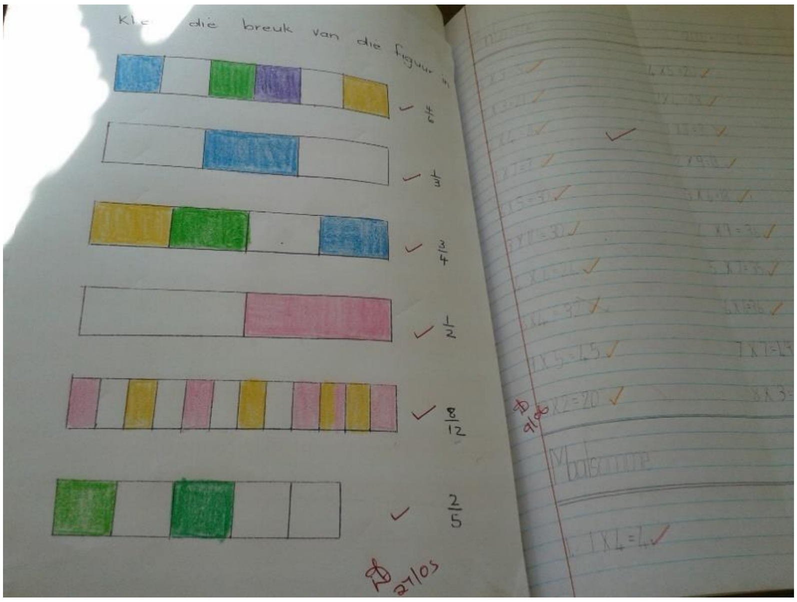


Figure 4: Fraction Strips

APPENDIX P_2

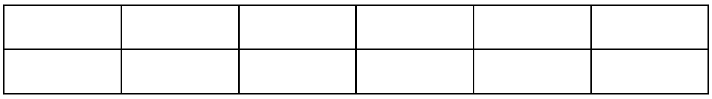
Fraction Activities

Colour in the right fraction for each strip:

3/5

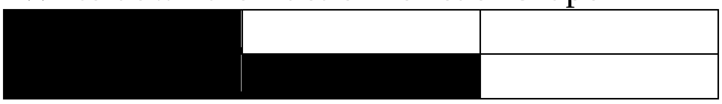
4/7

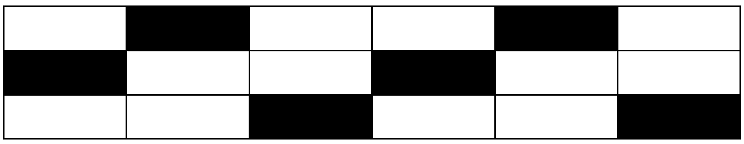
4/12



3/8

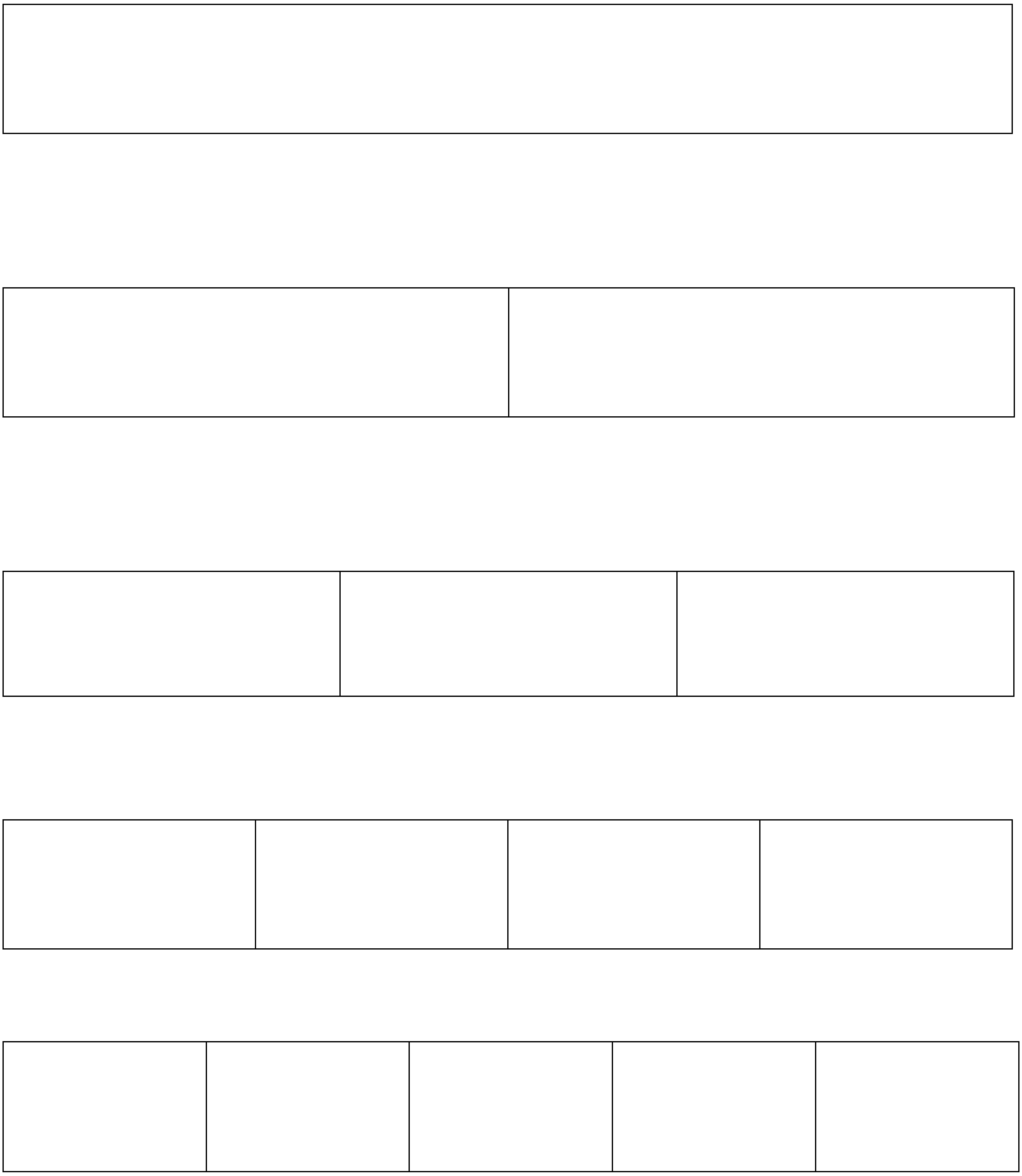
Write down the fraction for each shape





APPENDIX P_3

FRACTION STRIPS



APPENDIX Q_1

FRACTIONS

Activity

Divide 3 slices of bread equally between the four of you.

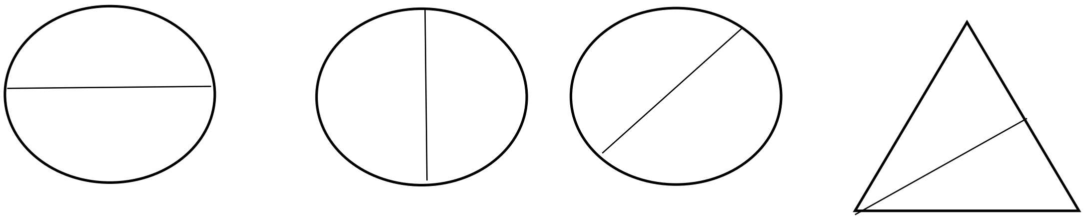
- How will I go about solving this problem?
- Do I have any questions in my mind?
- Demonstrate your solution

What about the following?

In the classroom are 38 rows with floor tiles. Every row has 56 separate floor tiles. How many tiles are in the classroom?

- How will I go about solving this problem?
- Questions in my mind?
- What knowledge helped me?
- What previous experiences helped me to solve this problem?

What about the following?



Do all parts present a half?

APPENDIX Q2

FRACTIONS

Activity

What fraction of the shape is coloured?

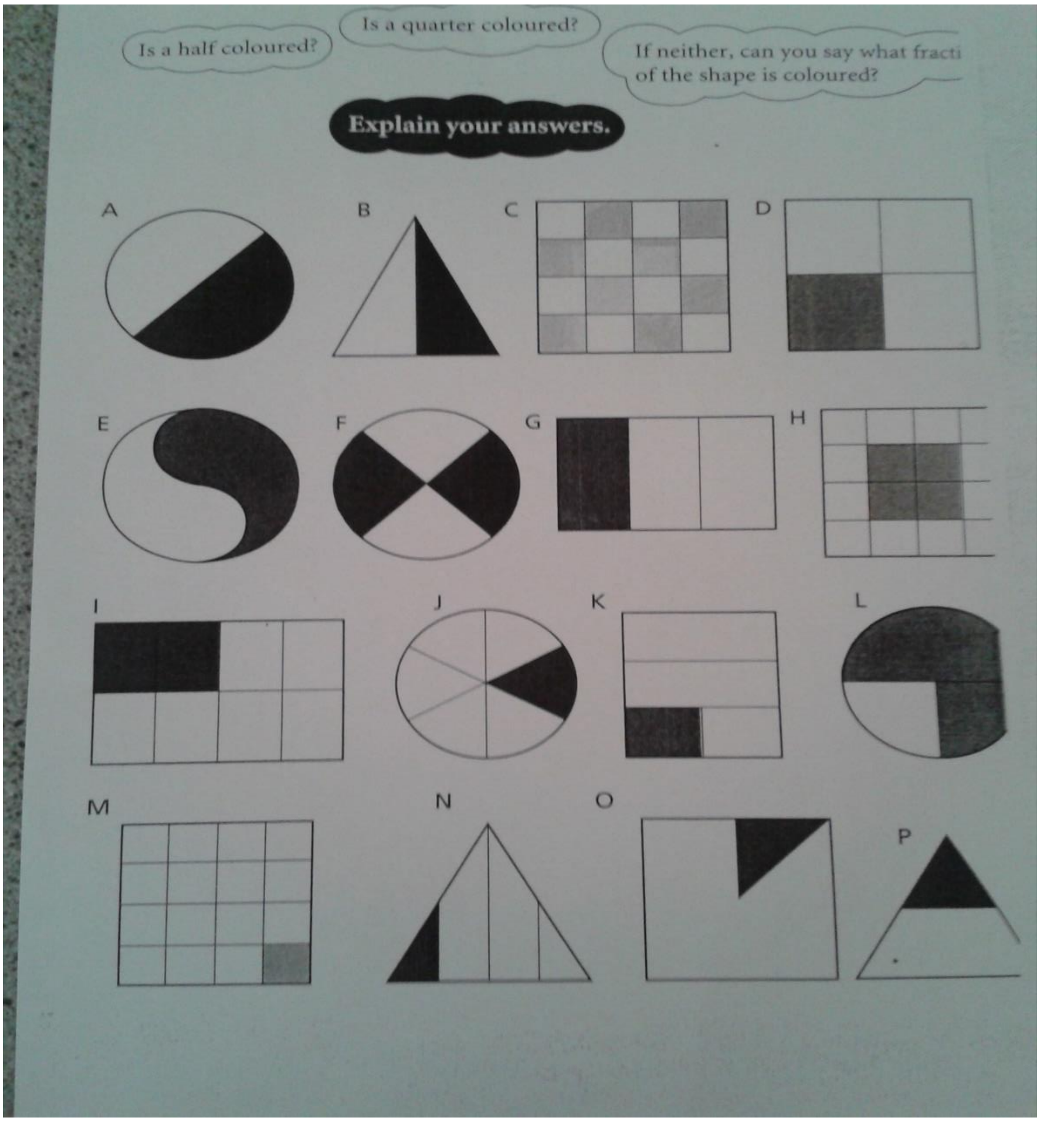


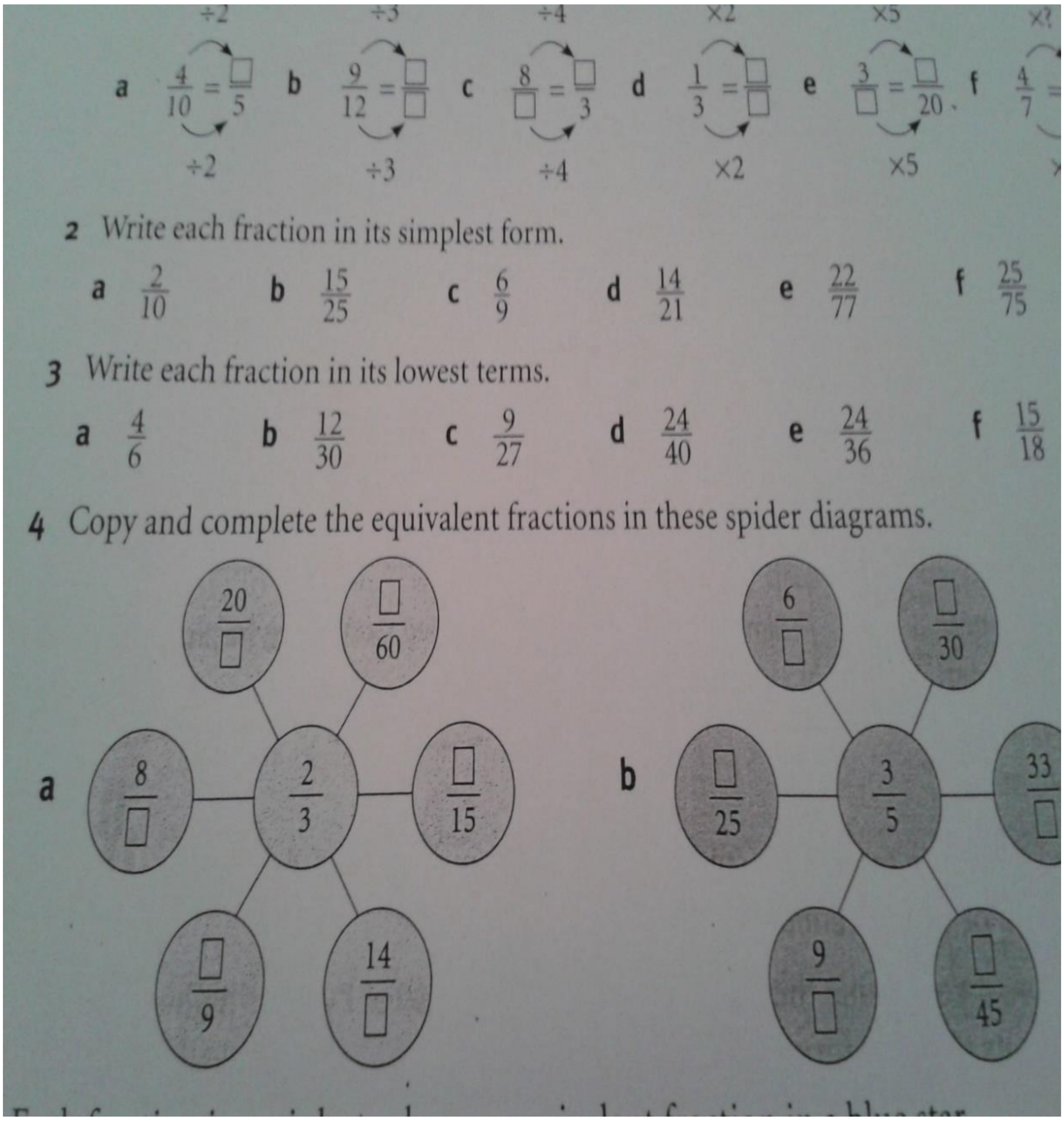
Figure 5: Example of Fraction Activity (Briten, 1997)

APPENDIX Q3

FRACTIONS

EXAMPLE

Exercises which could be included in daily lessons


a $\frac{4}{10} = \frac{\square}{5}$ (÷2) b $\frac{9}{12} = \frac{\square}{\square}$ (÷3) c $\frac{8}{\square} = \frac{\square}{3}$ (÷4) d $\frac{1}{3} = \frac{\square}{\square}$ (×2) e $\frac{3}{\square} = \frac{\square}{20}$ (×5) f $\frac{4}{7}$

2 Write each fraction in its simplest form.

a $\frac{2}{10}$ b $\frac{15}{25}$ c $\frac{6}{9}$ d $\frac{14}{21}$ e $\frac{22}{77}$ f $\frac{25}{75}$

3 Write each fraction in its lowest terms.

a $\frac{4}{6}$ b $\frac{12}{30}$ c $\frac{9}{27}$ d $\frac{24}{40}$ e $\frac{24}{36}$ f $\frac{15}{18}$

4 Copy and complete the equivalent fractions in these spider diagrams.

Figure 6: Example of Fraction Exercises (Byrd, Byrd & Pearce, 2012)

APPENDIX R_1

TEACHING AIDS (MODELS)

100 CHART (Two examples)

A

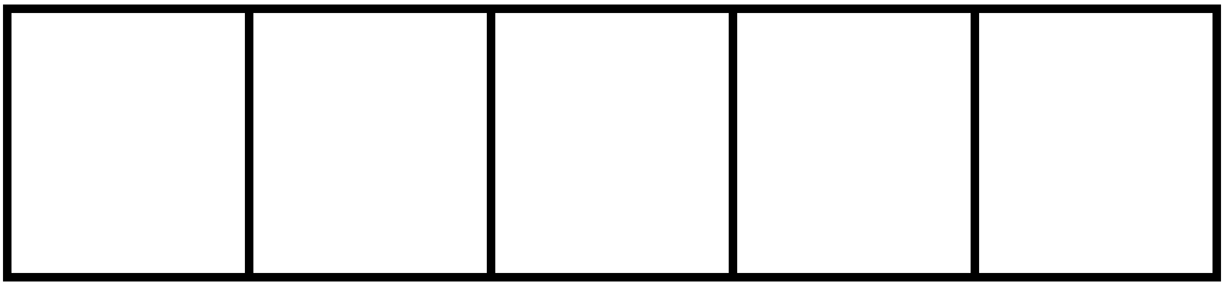
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

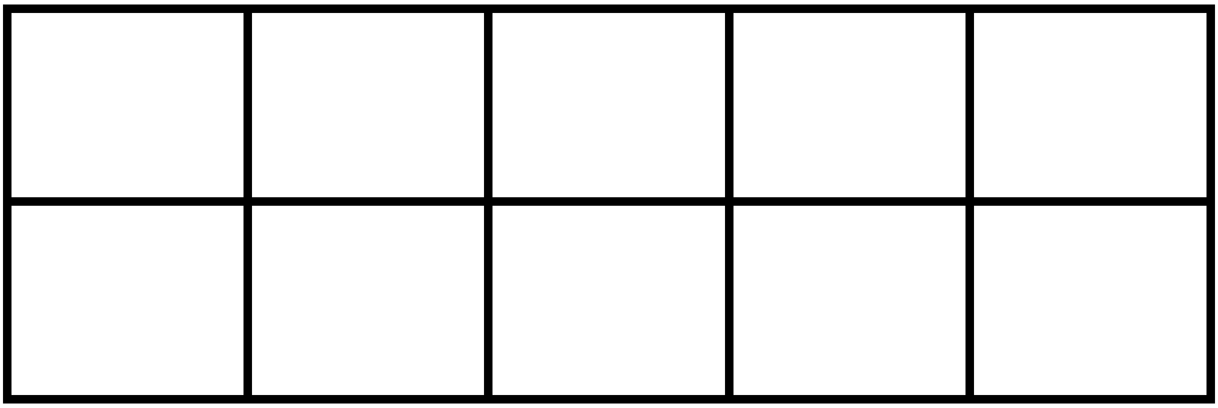
B

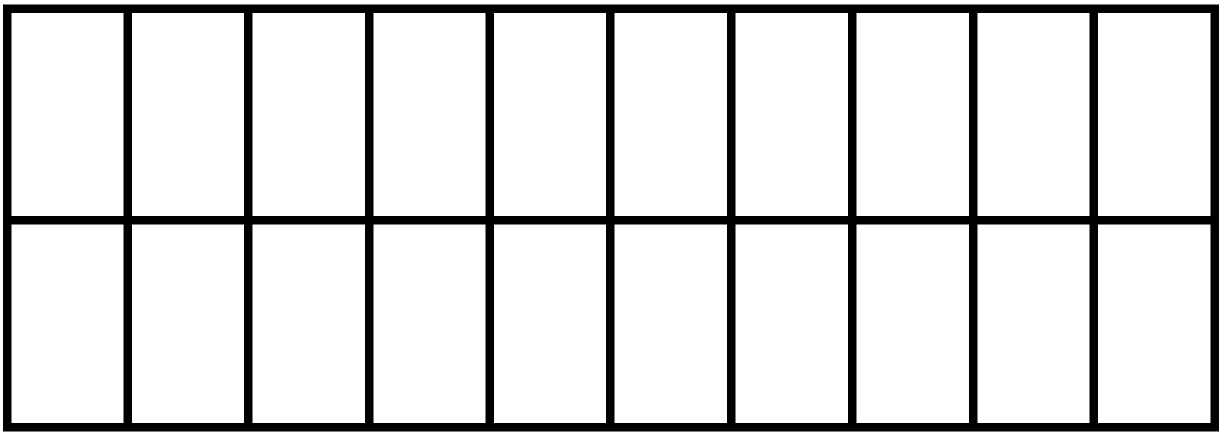
0	1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18	19
20	21	22	23	24	25	26	27	28	29
30	31	32	33	34	35	36	37	38	39
40	41	42	43	44	45	46	47	48	49
50	51	52	53	54	55	56	57	58	59
60	61	62	63	64	65	66	67	68	69
70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89
90	91	92	93	94	95	96	97	98	99

APPENDIX R_2

FRAMES







APPENDIX R_3

MULTIPLICATION TABLE

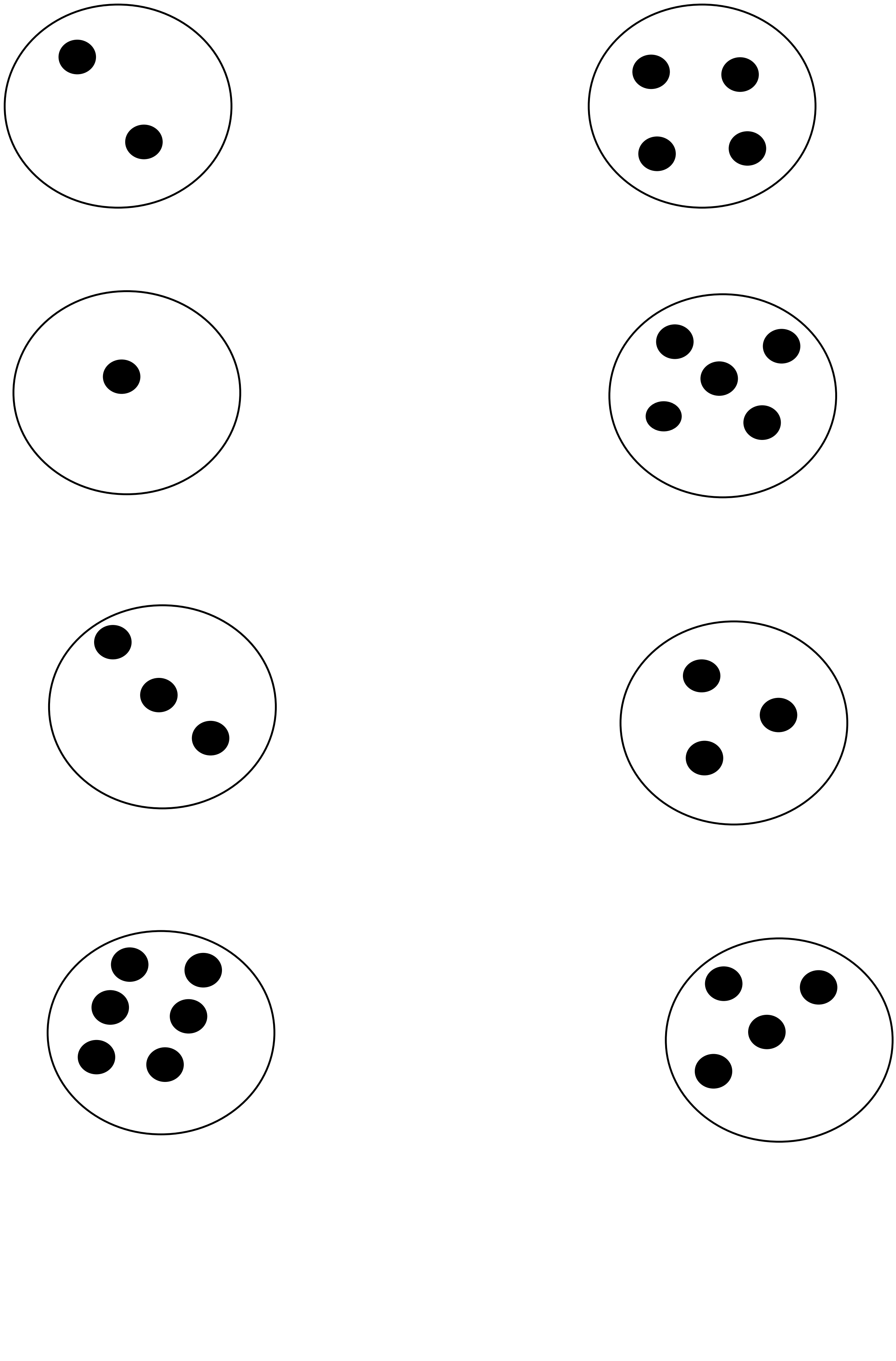
X	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0												
2	0												
3	0	3							24				
4	0												
5	0												
6	0			18									
7	0												
8	0		16				48					88	
9	0												
10	0				40			70					
11	0												
12	0		24			60							

ALTERNATIVE FORMAT (EQUIVALENCE)

X	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	1	2	3	4	5	6	7	8	9	10
2			6			12				
3		6			15			24		
4	4			16						
5			15				35			
6				24		36				
7		14			35					
8										
9	9				45			72		
10		20					70			

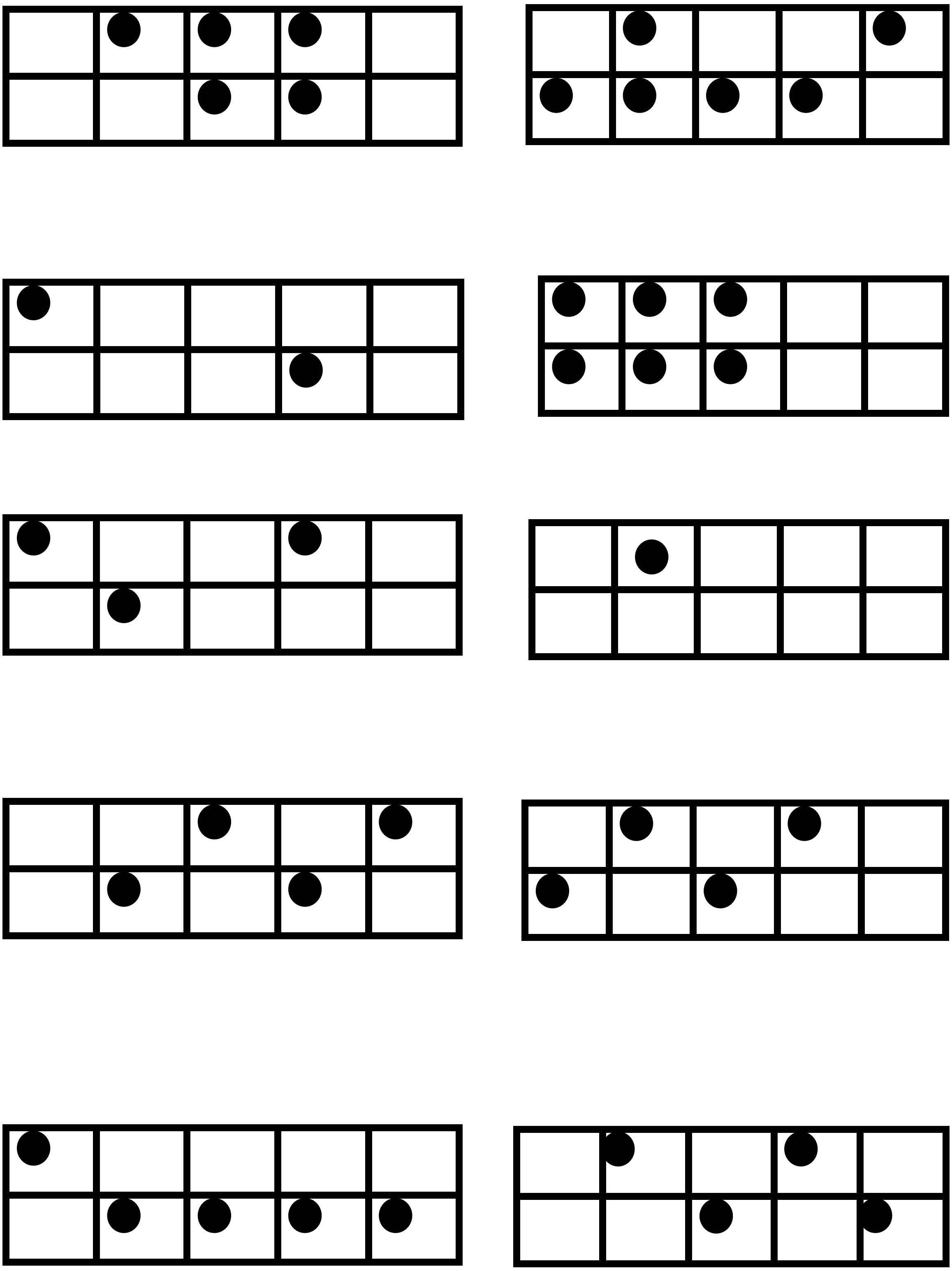
APPENDIX R4

SUBITIZE



APPENDIX R_5

SUBITIZE



APPENDIX R_6

ODD AND EVEN

3		7				15	
8			14				22
9		13				21	
12			18				
	4		8				16
		5	7			13	
31		27			21		
48		44			38		

Counting

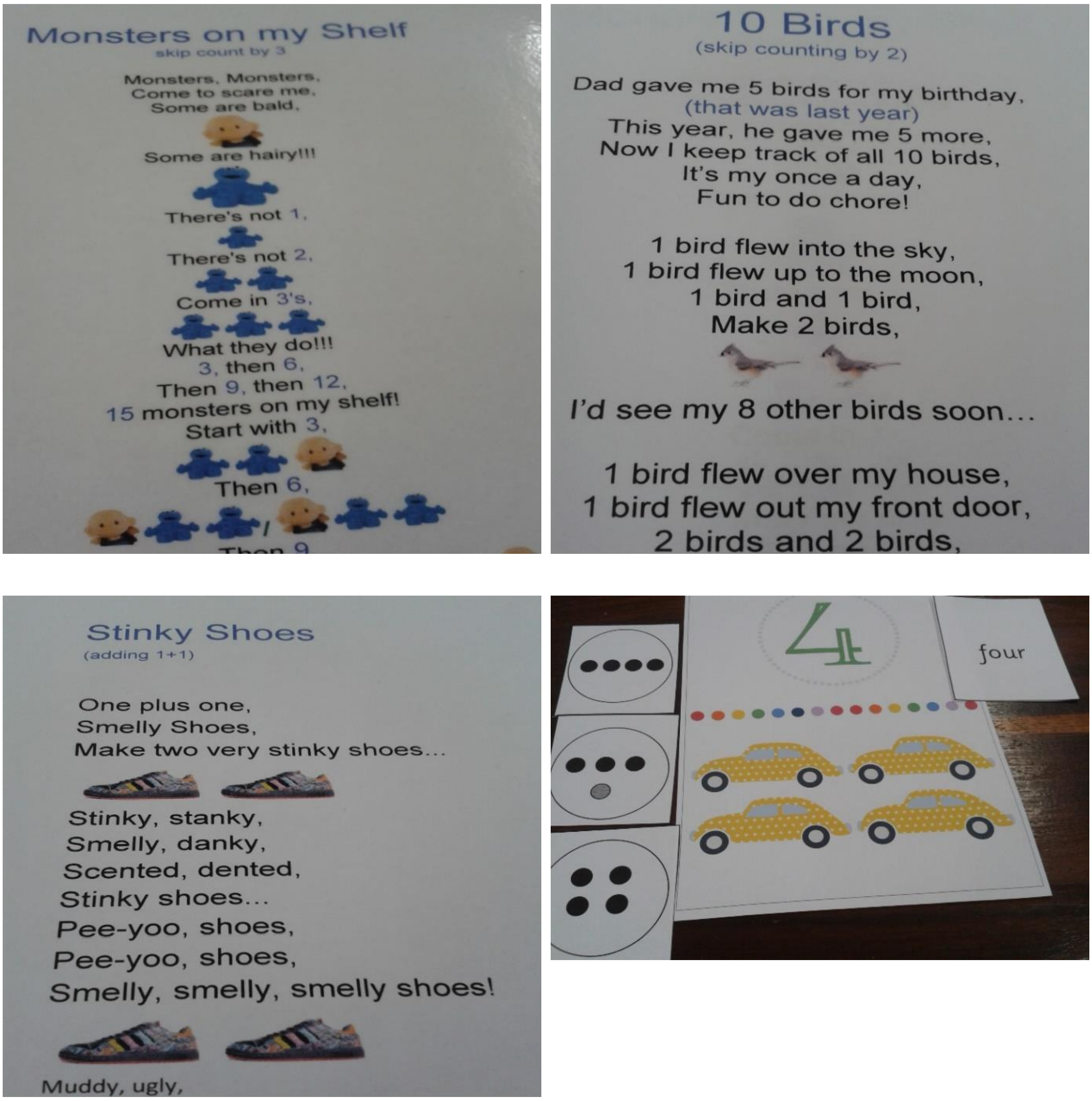


Figure 7: Counting

APPENDIX R_8

Worksheet: addition and subtraction: **Grade 2 & 3**:

Learners may use counters or frames if necessary: **10 Minutes**

Complete as many sums as possible:

6 + ☐ = 9	2 + ☐ = 13	**3 +** ☐ **=** 11
9 **-** ☐ = 4	13 **-** ☐ = 9	17 **-** ☐ = 13
8 + ☐ = 13	5 + ☐ = 14	7 + ☐ = 16
☐ + 5 = 11	☐ + 8 = 12	☐ + 7 = 12
☐ **-** 4 = 5	☐ **-** 9 = 3	☐ **-** 3 = 8
12 – 7 = ☐	15 – 3 = ☐	18 – 9 = ☐
13 + 5 = ☐	11 + 6 = ☐	9 + 7 = ☐
13 + ☐ = 18	13 **-** ☐ = 9	☐ + 11 = 13
☐ **-** 11 = 2	5 + 11 = ☐	☐ + 11 = 14
19 – 11 = ☐	☐ **-** 5 = 10	6 + ☐ = 12

APPENDIX R_9

Worksheet: addition and subtraction: **Grade 2 & 3**:

Learners work in groups: Cut out cards, then jumble and play matching game: Addition is opposite of subtraction: **10 Minutes**

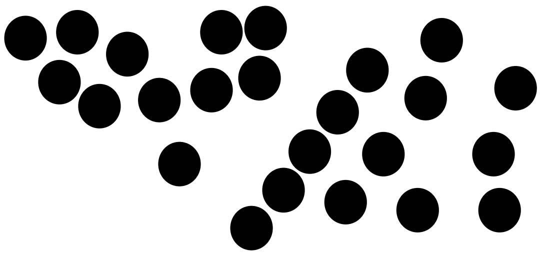
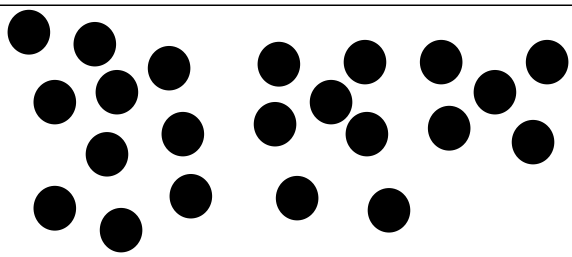
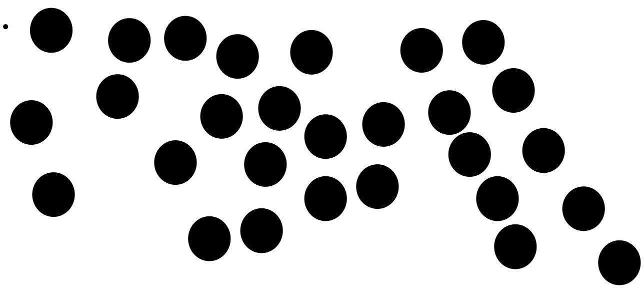
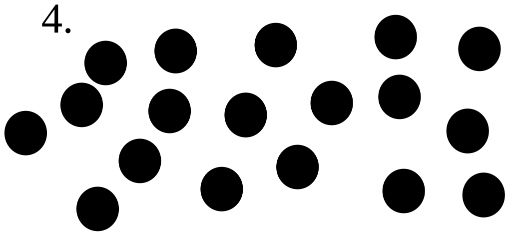
3 + 2 = 5	5 **-** 2 = 3
6 + 10 = 16	16 – 10 = 6
14 + 5 = 19	19 – 5 = 14
11 + 10 = 21	21 – 10 = 11
13 + 12 = 25	25 **-** 12 = 13
16 + 30 = 46	46 – 30 = 16
20 + 23 = 43	43 – 23 = 20
24 + 35 = 59	59 – 35 = 24
26 + 32 = 58	58 – 32 = 26
21 + 21 = 42	42 – 21 = 21

APPENDIX R$_{10}$

Worksheet: Dots before your eyes: **Grade 2 & 3**:

Learners work in groups: Cut out cards, then every group member is completing one card and after a few minutes group members check answers: **10 Minutes**

Count dots by drawing hoops around each group of 10.

1.		How many dots?
2.		How many dots?
3.		How many dots?
4.		How many dots?

APPENDIX R11

Worksheet: Multiplication

Learners work in groups: Cut out cards, and match: **10 Minutes**

70	10	36	9	20
30	24	18	24	54
14	21	48	35	24
2 x 5 =	3 x 8 =	6 x 4 =	3 x 7 =	3 x 3 =
5 x 4 =	9 x 2 =	10 x 7 =	9 x 4 =	8 x 6 =
9 x 6 =	7 x 5 =	3 x 10 =	2 x 7 =	12 x 2 =

APPENDIX R12

TEACHING AIDS

Figure 8: Counting Objects

Figure 9: Counting: "Strings of"

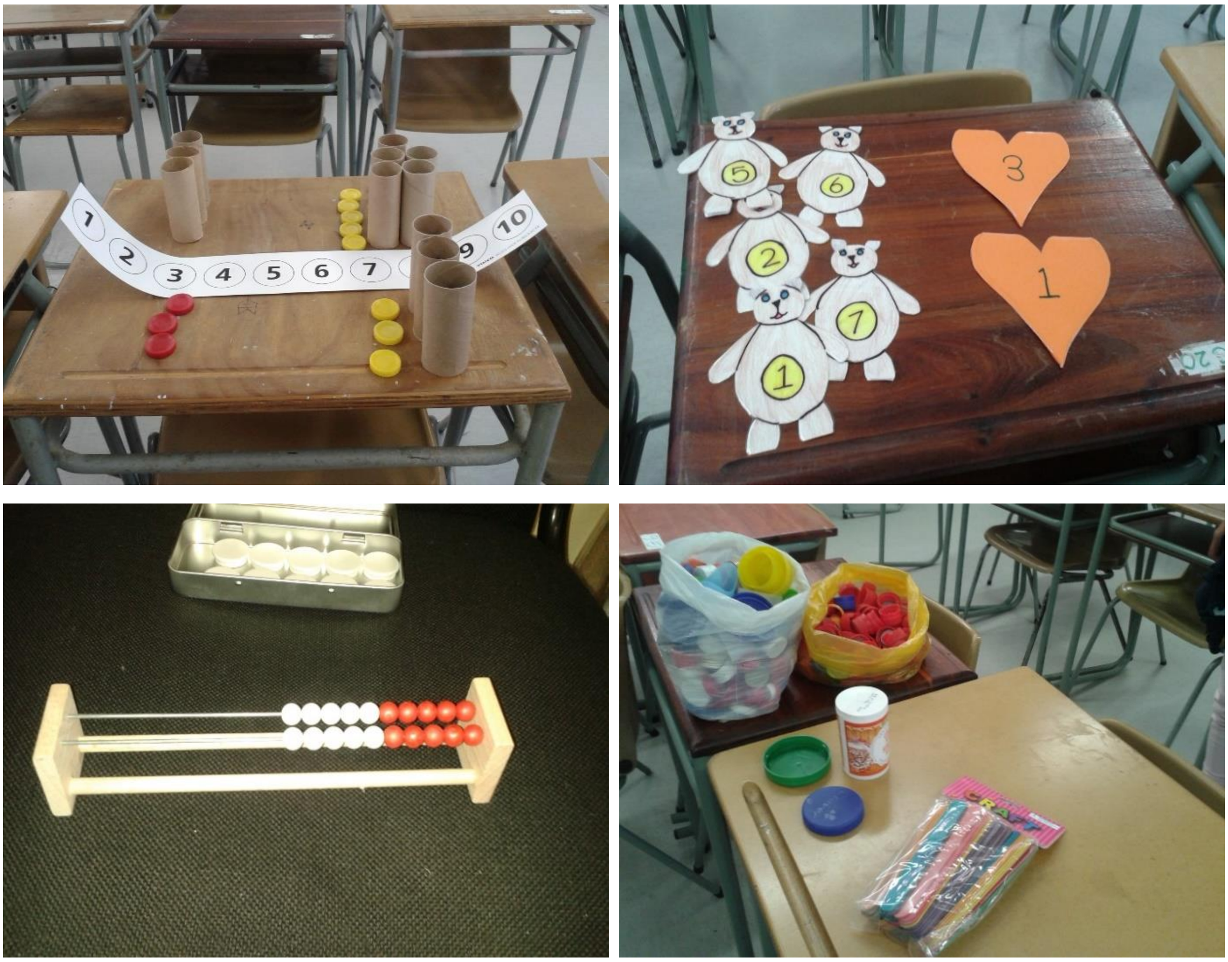


Figure 10: Counting to Calculation (top left & bottom)
Top right: friends of ten – bears; friends of 5- hearts

Figure 11: ‘Friends of Five’ (top) / ‘Friends of Ten’ (bottom)

APPENDIX S

KNOWLEDGE FOR TEACHING PRIMARY SCHOOL MATHEMATICS

Make a list of some of the 'things' you think a Pre-primary; Lower and Upper primary teacher needs to know in order to teach mathematics.

Participants' contribution:

- Being patient
- Being knowledgeable
- Being creative
- Being numerate
- Use correct terminology
- Have teaching aids available
- Be motivated
- Be prepared every day
- Have passion

Some ideas after discussion and guidance from researcher:

- Knowledge of calculation strategies
- Understanding of concepts
- Knowing how to use resources, e.g. hundred grids
- Knowledge of prescribed curriculum

Do you still remember the seven categories of teacher knowledge? Can you name some?

- General pedagogical knowledge
- Knowledge of learners
- Knowledge of context
- Knowledge of the purpose of teaching and learning

- **Subject-matter knowledge**
- **Pedagogical content knowledge**
- **Curriculum knowledge**

Did we have some of these in our group?

Why are the last three highlighted?

APPENDIX T

LEARNERS'WORK

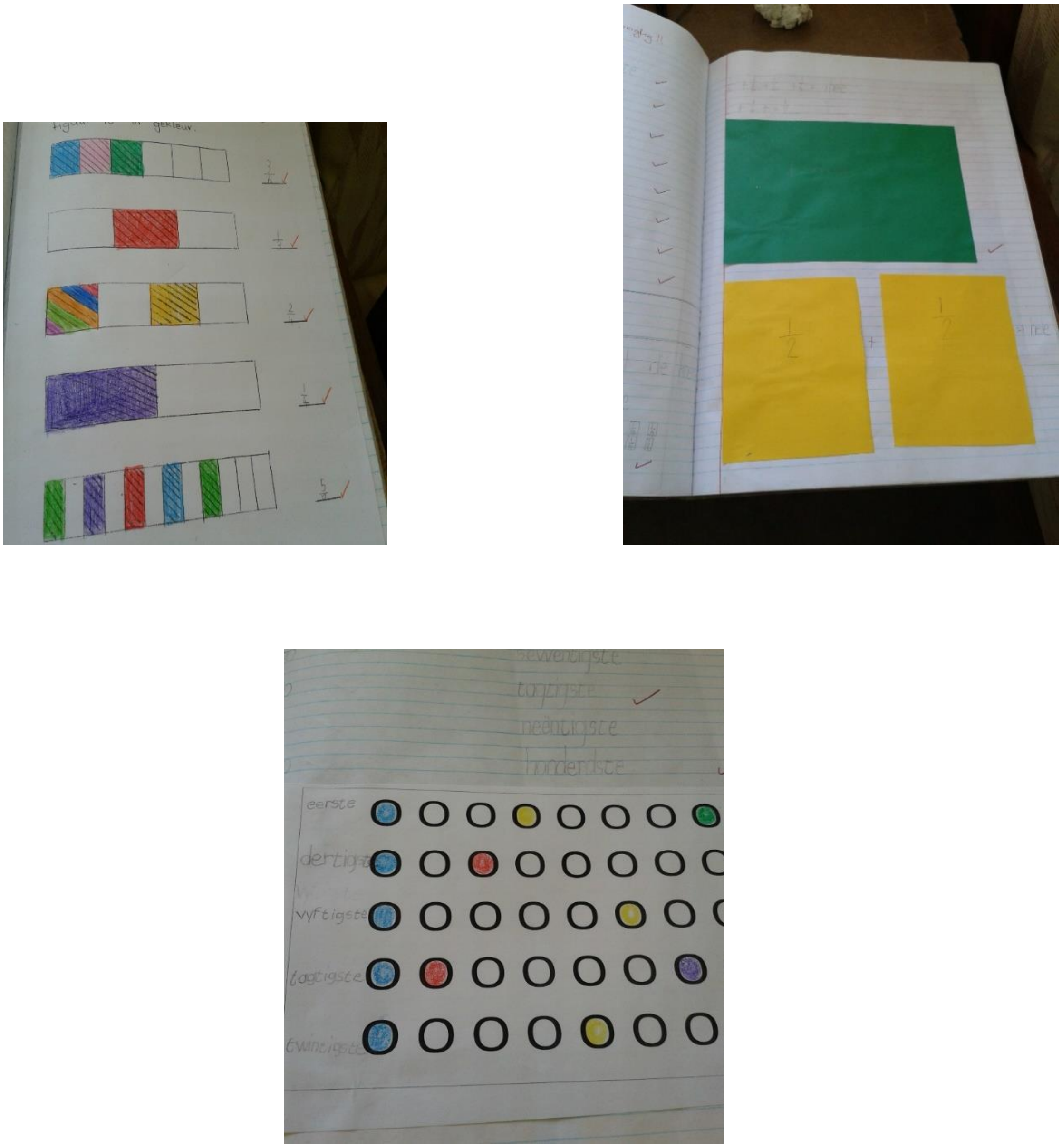


Figure 12: Example Learners Work

APPENDIX U

DEVELOPING ADDITIVE THINKING – GRADES 1 -7

(Presented as a Power Point Presentation)

What is additive thinking?

- It is a thought process
- It views numerical quantities as collections of ones that need to be put together or broken apart
- It connects part-part-whole and Place Value ideas with counting

How to teach?

- Historically you taught addition and subtraction separately.
- We used formal algorithms to teach, rather than conceptually understand addition and subtraction
- With RME principles it is possible to teach both at the same time.

Context for addition and subtraction

- Why do we add or subtract?
- What is 'addition' and 'subtraction'?
- Add - 'how much altogether'
- Subtract - 'how much is/are remaining'
- Learners normally want 'more' or 'get more' and not 'take away' – they have already an understanding of 'more' and 'less' (Number sense?)

Look at the following problems

- Maria has some marbles. She gave three away. Now she has 8 marbles. How many marbles did Maria have to start with?
- Toivo has 5 marbles. Simon gave him some more. Now Toivo has 8 marbles. How many marbles did Simon gave him?

- Timo has 9 marbles. Johannes has 3 more than Timo. How many marbles does Johannes have?

Consider and discuss (RME principles?)

Tobias and Olivia had together N$ 100,00. They bought sweets and fruit juice. How much money did they had left?

- Does this question have an answer?
- What is involved in answering this question?
- Why is it important to include these types of problems in your lesson? What about arguing, discussing and reasoning?

Brainstorm other situations like the above which might generate similar opportunities for problem solving

What did you see?
Addition contexts

Parts known	Example	Visibility of operation
Join	I have 5 cards. I was given 6 more. How many cards do I have altogether?	Transparent
	I have some cards. I gave 4 away. Now I have 7 cards. How many cards did I have to begin with?	Hidden
Combine	I have 5 blue bottle tops and 7 red bottle tops. How many bottle ops do I have altogether?	Transparent
	Toivo has 3 cards. Johannes has 4 more cards. How many cards does Johannes have?	Hidden

Subtraction context

Whole-part known	Example	Visibility of operation
Take away (separate)	I have 7 cards. I gave 2 cards to Sam. How many cards do I have left?	Transparent
	I have 14 cards. If Sam is given 6 more cards he will have the same number of cards as I. How many cards does Sam have?	Hidden
Missing addend	I have 3 cards. I want a full set of 12 cards. How many cards do I need?	Transparent
	I have some cards. Sam gave me 3 more. I have now 7 cards. With how many cards did I started?	Hidden
Difference (Compare)	I have 6 cards. Sam has 4 cards. How many cards do I have more than Sam?	Transparent
	I have 9 cards. I have 3 more than Sam. How many cards does Sam have?	Hidden

<u>Strategies up to 20</u>

- Count on
- Count back (subtraction)
- Doubles/near doubles
- Make 'tens'

<u>Strategies for 2-digit Subtraction</u>

- 83 – 47

  = 83 – 40 – 7 **Jump strategy**

- 83 -47

  = 47 + **30** + **6** = 83 **Addition strategy –** have you thought about it?

Subtraction

	83		**76**		T O
-	47	-	40		8(*7*) 3(*13*)
	43		36	-	4 7
-	7				**7 13**
	36			-	4 7
					3 6

Strategies for 2 –digit addition

- E.g. 43 + 28

  = 40 + 20 + 3 +8 **Parts/split**

- 43 + 28

  = 43 + 20 + 8 **Jump "tens"**

- 43 + 28
  = 40 + 30 – 2 **Compensation**

REFERENCES

Angula, N. (2011). *The elusive quest for education excellence in post-independent Namibia: The challenges of diversification and implementation.* Paper delivered at Namibia National Conference on Education, 27 June 2011. Windhoek: Ministry of Education

Askew, M., Brown, M., Rhodes, V., Wilian, D. & Johnson, D. (1997). *Effective teachers of numeracy in primary schools: Teachers' beliefs, practices and pupils' learning.* Paper presented at the British Educational Research Association Annual Conference: September 11 – 14 1997: University of York. Retrieved November 2013 from http://www.leeds.ac.uk**.**

Askew, M. (1999). It ain't (just) what you do: effective teachers of numeracy. *Issues in teaching numeracy in primary school*, ed. I. Thompson, 91 – 102. Buckingham: Open University Press.

Avalos, B. (2010). Teacher professional development in teaching and teacher education over 10 years. *Teaching and Teacher Education* 27 (2011) 10-27. Retrieved November 2014 from http://www.elsevier.com/locate/tate**.**

Ball, D.I. & Cohen, D.K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. L. Darling-Hammond & Sykes (Eds.), *Teaching as the learning profession (pp. 3-31).* San Francisco, CA: Jossey-Bass.

Barnes, H. (2005). The theory of realistic mathematics education as a theoretical framework for teaching low attainers in mathematics: The Association for Mathematics Education of South Africa (AMESA) *Pythagoras*, 61(6), 42 - 57.

Bazeley, P. (2013). *Qualitative data analysis practical strategies.* London: SAGE Publications.

Bennell, P. and Sayed, Y. & Hailombe, O. (2008). *Teacher supply and demand for primary and secondary schooling in Namibia.* Advisory Council on Teacher Education and Training. Windhoek: Ministry of Education.

Benner, S. (2010). *Promising practices for elementary teachers: Make no excuses.* London: SAGE Publications.

Bennett, N. & Carre, C. (Eds.). (1993). *Learning to teach.* London: Routledge.

Beswick, K. (2008). Influencing teachers' beliefs about teaching mathematics for numeracy to students with mathematics learning difficulties. *Mathematics Teacher Education and Development*, 2007/2008, (9) 3-20.

Bezemer, J. (2003). Dealing with multilingualism in the arithmetic class: An ethnographic case study of a Dutch primary school. *European Research in Mathematics Education.* Retrieved January 2015 from http://www.dm.unipi.it/~didactical/CERME 3/.../TG10_cerme3.pdf.

Borko, H. (2004). Professional development and teacher learning: mapping the terrain. *Educational Researcher*, 33(8), 3-15. Retrieved November 2014 from: http://edr.SAGE Publications.pub.com/cgi/content/abstract/33/8/3.

Boz, N. (2008). Turkish pre-service mathematics teachers' beliefs about mathematics teaching. *Australian Journal of Teacher Education*, 33(5), 194-222.

Bresler, L. (1996). Ethical issues in the conduct and communication of ethnographic classroom research: Studies in art education. *A Journal of Issues and Research*, 1996, 37(3), 133-144.

Briten, P. (1997). *Mastermaths 1.* Oxford: Oxford University Press.

Brodie, K. & Shalem, Y. 2011. Accountability conversations: Mathematics teachers' learning through challenge and solidarity. *Junior Mathematics Teacher*

Education (2011) 14:419-439. DOI 10.1007/s10857-011-9178-8. Retrieved July 2014 from http://link.springer.com/article.

Brousseau, G. & Gibel, P. (2005). Didactical handling of students' reasoning processes in problem solving situations. *Educational Studies in Mathematics*, July 2005, 59 (1-3), 13-58. Retrieved October 2012 from http://link.springer.com/article.

Buhari, B. (2011). *Lesson Study and Realistic Mathematics Education: A Conceptual overview.*
Retrieved November 2012 from: http://bustangbuhari.wordpress.com.

Byrd, G., Byrd, L. & Pearce, C. (2012). *Cambridge Checkpoint Mathematics Coursebook.* Cambridge: Cambridge University Press.

Cerbin, B. (2011). *Lesson Study: Using classroom inquiry to improve teaching and learning in higher education.* Wisconsin: Stylus Publishing.

Cerbin, B & Kopp, B. (2006). *Lesson study overview.* Retrieved 4 July 2013 from http://www.uwlax.edu.

Charalambous, C.Y., Panaoura, A & Philippou, G. (2009). Using the history of mathematics to introduce changes in pre-service teachers' beliefs and attitudes: insights from evaluating a teacher education program. *Educational Studies in Mathematics, 72(2), 161 – 180.*

Chauvot, J. & Turner, P. 1995. *The Developing Role of Teacher: One Preservice Secondary Mathematics Teacher's Beliefs and Experiences.* Paper presented at the Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education. National Science Foundation, Washington, D.C.

Cheung, K.C. & Huang, R.J. (2010). *Contribution of Realistic Mathematics Education and theory of multiple intelligences to mathematics practical and integrated*

applications: Experiences from Shanghai and Macao in China. The International Commission on Mathematical Instruction (ICMI). The fifteenth ICMI Study: The Professional Education and Development of Teachers of Mathematics (Strand II).
Retrieved November 2012 from http://www.realisticmath.com.

Chrzanowska, J. (2013). *Using workshops in qualitative research for greater consumer involvement and increased client buy-in.* Retrieved June 2014 from http://www.marketresearchworld.net.

Chval, K., Abell, S., Pareja, E., Musikul, K. & Ritzka, G. (2007). Science and mathematics teachers' experiences, needs, and expectations regarding professional development. *Eurasia Journal of Mathematics, Science & Technology Education,* 2008, 4(1), 31-43. Retrieved November 2014 from http://www.ejmste.com.

Clegg, A. (2007). *Some reflections on the 2007 mathematics results.* Report submitted to National Institute of Educational Development (NIED), Okahandja: Namibia.

Clegg, A. (2008). *Comments on the report of the ACTET Consultancy to develop guidelines on teacher education reform.* An unpublished report submitted to National Institute of Educational Development (NIED), Okahandja.

Clegg A. & Courtney-Clarke M. (2009). *Consultancy to develop a strategic plan to strengthen the content knowledge, skills and methodology of mathematics teachers at primary and secondary schools in Namibia.* Report submitted to the Ministry of Education in July 2009. Windhoek: Ministry of Education.

Cobb, P. & Visnovska, Q.Z. (2008). *Learning from and adapting the theory of Realistic Mathematics Education.* Retrieved May 2013 from http://www.educationdidactique.revues.org/276.

Cohen, C. (1994). *Administering education in Namibia: The colonial period to the present.* Windhoek: Namibia Scientific Society.

Cohen, L., Manion, L. & Morrison, K. (2007). *Research methods in education.* London: Routledge.

Confrey, J. & Kazak, S. (2006). A thirty-year reflection on constructivism in mathematics education in PME. In A. Gutiierrez, P. Boero (Eds.) in *Handbook of Research on the Psychology of Mathematics Education: Past, Present and Future, 305-345.* Rotterdam: Sense Publishers.

Coombe, C, Bennell, P, Uugwanga, P & Wrightson, T. (1999). *Ten-year plan for educator development and support in Namibia: The Plan 2000 – 2010.* Windhoek: Ministry of Basic Education and Culture.

Crebbin, W., Villet, C., Keyter, C., Engelbrecht, F. & Van Der Mescht, H. (2008). *Consultancy to develop guidelines on teacher education reform.* Windhoek: Advisory Council on Teacher Education and Training.

Creswell, J.W. (2003). *Research Design. Qualitative, quantitative and mixed methods approaches.* 2nd Edn. Thousand Oaks: SAGE Publications.

Daniel, M.F., Lafortune, L, Pallascio, R. & Sykes, P. (1993). *A primary school curriculum to foster thinking about mathematics.* Retrieved September 2013 from http://www.ffst.hr.

Dede, Y. & Uysal, F. (2012). Examining Turkish pre-service elementary teachers' beliefs about the nature and the teaching of mathematics. *International Journal of Humanities and Social Science,* 2(12) 125 – 135. [Special Issue – June 2012]. Retrieved October 2013 from http://www.ijhssnet.com.

De Lange, J. (1995). Assessment: No change without problems. In: Romberg, T.A. (Eds.). (1995). *Reform in School Mathematics and Authentic Assessment,* (87-172) New York: Sunny Press.

De Lange, J. (1996). Using and applying mathematics in education, in A.J. Bishop, K. Clements, C. Keitel, J. Kilpatrick and C Laborde (Eds.). *International Handbook of Mathematics Education: Part one (p. 49-97).* Dordrecht: Kluwer Academic Publishers.

Denzin, N.K. & Lincoln, Y.S. (Eds.). (2011). *The SAGE Publications handbook of qualitative research,* Los Angeles: SAGE Publications.

Dickinson, P. & Hough, S. (2012). *Using realistic mathematics education in UK classrooms.* Retrieved 24 April 2013 from http://www.mei.org.uk/files/pdf/RME_Impact_booklet.pdf.

Drageset, O.G. (2010). The interplay between the beliefs and the knowledge of mathematics teachers. *Mathematics Teacher Education and Development*, 2010, 12(1), 30-49.

Du Pisani, A. (1986). *SWA/Namibia: The Politics of continuity and change.* Johannesburg: Jonathan Ball Publishers.

Easton, L.B. (2009). *An introduction to lesson study.* Florida and the Islands Regional Comprehensive Centre. Retrieved July 2013 from www.ets.org/flice/pdf/Nov4LessonStudyPacketOhe.pdf

Eisenhart, M.A. (1988). The ethnographic research tradition and mathematics education research. *Journal for Research in Mathematics Education*, 19(2), 99-114. Retrieved November 2014 from http://www.jstor.org/stable/749405.

Ellis, J. (2010). The national education system: Namibia. Chapter in Baker, E. Peterson, P. & McGraw, B. *International Encyclopaedia of Education.* 3rd ed. Elsevier: Oxford.

Ernst, P. (1991). *The Philosophy of mathematics education.* Hampshire: Falmer Press.

Fauzan, A., Slettenhaar, D. & Plomp, T. (2002). Traditional mathematics education vs. realistic mathematics education: Hoping for changes. In P. Valero & O. Skovsmose (2002) (Eds.). *Proceedings of the 3rd International Mathematics Education and Society Conference.* pp. 1-4. Copenhagen: Centre for Research in Learning Mathematics. Retrieved November 2014 from http://www.doc.utwente.nl/92796/1/Fauzan02traditional.pdf.

Ferdous, A. (2012). *The Namibia's National Standardized Achievement Tests (SATs, 2012). The Grade 7 Follow Up Results.* Windhoek: Ministry of Education.

Fischer, G. (2010). *The Namibian educational system.* Windhoek: Friedrich Ebert Stiftung.

Fourie, G. (1999). *The Basic Education Teacher's Diploma (BETD): In-Service (INSET) Programme.* Namibia Case Study. SAIDE. Retrieved January 2015 from http://www.colfinder.net/materials/Supporting_Distance_Education_Through_Policy_Development

Forde, C., McMahon, M., McPhee, A.D. & Patrick, F. (2006). *Professional development, reflection and enquiry.* Los Angeles: SAGE Publications.

Freudenthal, H. (1968). Why to teach mathematics so as to be useful. *Educational Studies in Mathematics*, 1(3-8).

Freudenthal, H. (1973). *Mathematics as an educational task.* Dordrecht: Reidel Publishing Company.

Freudenthal, H. (1978). *Weeding and Sowing: Preface of a Science of Mathematics Education.* Dordrecht: Reidel Publishing Company.

Freudenthal, H. (1983). *Didactical phenomenology of mathematical structures.* Dordrecht: Reidel Publishing Company.

Freudenthal, H. (1991). *Revisiting mathematics education: China lectures*. Dordrecht: Kluwer Academic Publishers.

Freudenthal Institute (FI) Utrecht University & National Institute for Curriculum Development (SLO). (2001). *Children Learn Mathematics: A Learning-Teaching Trajectory with Intermediate Attainment Targets For Calculation with Whole Numbers in Primary School*. Ed.: Van den Heuvel-Panhuizen, M. Utrecht: FI

Furinghetti, F. & Pehkonen, E. (2002). Rethinking characterizations of beliefs. In G. Leder, E. Pehkonen & G. Törner (Eds.). *Beliefs: A hidden variable in mathematics education?* (pp. 60-78). Dordrecht: Kluwer Academic Publishers.

Garet, S.M., Porter, A.C., Desimone, L., Birman, B.F. & Yoon, K.S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, Winter 2001, 38(4), 915-945.

Genzuk, M. (2003). *A synthesis of ethnographic research*. Retrieved April 2014 from http://www-bef.usc.edu/~genzuk/Ethnographic_Research.html.

Gerring, J. (2004). What is case study and what is it good for? *The American Political Science Review*, 98(2), 341-354.

Gierdien, M.F. (2008). Teacher learning about probabilistic reasoning in relation to teaching it in an Advanced Certificate in Education (ACE) programme. *South African Journal of Education*, 28(19 - 38).

Glasgow, N.A. & Hicks, C.D. (2003). *What successful teachers do: research-based classroom strategies for new and veteran teachers?* London: SAGE Publications.

Good, T.L. & Grouws, D.A. (1987). Increasing teachers' understanding of mathematical ideas through in-service training. In *Phi Delta Kappan*, 68(10), 778-783. Retrieved February 2013 from http://www.jstor.org/stable/20403505.

Government of the Republic of Namibia. (2005). *The strategic plan for the education and training sector improvement programme (ETSIP).* Windhoek: Ministry of Education.

Gravemeijer, K. & Terwel, J. (2000). Hans Freudenthal: A mathematician on didactics and curriculum theory. *Journal of Curriculum Studies*, 2000, 32(6), 777-796. Retrieved November 2013 from http://www.tandf.co.uk/journals

Gravemeijer, K.P.E. (1994a). *Developing Realistic Mathematics Education.* Culenborg: Technipress.

Gravemeijer, K.P.E. (1994b). Educational development and developmental research in mathematics education. *Journal for Research in Mathematics Education*, 1994, 25(5), 443-471. Retrieved November 2012 from http://www.jstor.org/discover.

Guskey, T.R. & Yoon, K.S. (2009). *What works in professional development?* Retrieved November 2014 from http://www.Phideltakappan,2009-k12.wa.us.

Hadi, S. (2002). *Effective teacher professional development for the implementation of realistic mathematics education in Indonesia.* A PhD-Thesis. Retrieved November 2013 from http://doc.utwente.nl./58708/

Hadi, S., Plomp, T. & Suryanto. (2002). *Introducing realistic mathematics education to junior high school mathematics teachers in Indonesia.* Retrieved November 2013 from http://jodogyan.org/2011///04/02/realistic-mathematics-education.

Handal, B. (2003). Teachers' mathematical beliefs: A review. *The Mathematics Educator*, 13(2) 47-57.

Hanks, P. (Ed.), Long, T.H. & Urdang, L. (1983). *Collins Dictionary of the English Language.* London: Collins.

Hargreaves, A. & Fullan, M.G. (Eds.) (1992). *Understanding teacher development.* New York: Teachers College Press.

Haylock, D. & Cockburn, A.D. (2008). *Understanding mathematics for young children.* Fully revised and expanded edition. Los Angeles: SAGE Publications.

Hesse-Biber, S.N. & Leavy, P. (2011). *The practice of qualitative research.* 2nd Ed. Los Angeles: SAGE Publications.

Hickendorff, M. (2013). Explanatory latent variable modelling of mathematical ability in primary school: crossing the border between psychometrics and psychology. Proefschrift. *Tijdschrift voor Didactiek der β-wetenschappen,* 30 (2013) No.1 & 2.

Hoey, B.A. (2014). *What is ethnography?* Retrieved April 2014 from http://www.brianhoey.com/General%20Site/general_defn-ethnography.htm

Holtman, L., Julie, C., Mbekwa, C., Mtetwa, D. & Ngcobo, M. (2011). A comparison of preferences for real-life situations that could be used in school mathematics in three SADC Countries. *Southern African Review of Education*, 17: 120-137.

Howard, P. (1995). *Ethnography in a Mathematics Education Context: Field notes as Part of Reflection and Analysis.* Australian Catholic University. Retrieved January 2015 from ttp://www.Merga.net.au/documents/RP_Howard_1995.pdf.

Hurd, J. & Licciardo-Musso, L. (2005). *Lesson study: Teacher-led professional development in literacy instruction.* Retrieved July 2013 from http://www.lessonstudygroup.net.com.

Ilma, R. (2011). *Professional Development of mathematics primary school teachers in Indonesia using lesson study and Realistic Mathematics Education approach.* Retrieved July 2013 from http://www.icsei.net.com.

Julie, C. (2004). Can the ideal of the development of democratic competence be realised within realistic mathematics education? The case of South Africa. *The Mathematics Educator*, 2004.14(2), 34-37.

Kaiser, G. (2002). *Educational philosophies and their influence on mathematics education: An ethnographic study in English and German mathematics classrooms.* ZDM 2002. 34 (6). Retrieved January 2015 from http://www.subs.emis.de/journals/ZDM/zdm/026a2.pdf.

Kamupingene, T. (2002). *Education for all: National Plan of Action: 2002 – 2015.* Retrieved June 2014 from http://www.planipolis.iiep.unesco.org

Kleve, B. (2009). *Use of focus group interviews in mathematics educational research.* Proceedings of Congress of European Research in Mathematics Education 6, January, 28 – February, 1, 2009. Retrieved June 2014 from http://ife.ens-lyon.fr

Kröger, R., Schuler, S., Kramer, N. & Wittmann, G. (2012). *Beliefs of Kindergarten and primary school teachers towards mathematics teaching and learning.* Retrieved November 2013 from http://www.cerme8.metu.edu.tr

Krueger, R.A. (1994). *Focus groups: A practical guide for applied research.* (2^{nd} Ed.) Los Angeles: SAGE Publications.

Kwon, O.N. (2002). *Conceptualising the realistic mathematics education approach in the teaching and learning of ordinary differential equations.* Retrieved November 2012 from http://www.math.uoc.gr.

Lategan, D. & Silver, E. (2010). *Maths for life: Grade 5.* Windhoek: Macmillan Namibia.

Leatham, K.R. (2006). Viewing mathematics teachers' beliefs as sensible systems. *Journal of Mathematics Teacher Education*, (2006) 9:91 – 102. Retrieved October 2013 from http://mathed.byu.edu

LeCzel, D.K. (2004). *Namibia basic education support: BES II/BES 3 Transition conference final report narrative summary.* Windhoek: Academy for Educational Development.

Leder, G.C., Pehkonen, E & Törner (Eds.). (2002). *Beliefs: A hidden variable in mathematics education.* Dordrecht: Kluwer Academic Publishers.

Lester, F. K. (2009). *Theories of mathematics education*. Berlin: Springer.

Leu, E. & Ginsburg, M. (2011). *First principles: Designing effective education programs for in-service teacher professional development.* Retrieved July 2013 from www.equip123.net/docs/E1-FP_IN-SVC_TDP_DIGESTY.pdf

Lewis, C. 2000. *Lesson study: The core of Japanese professional development*. Invited Address to the Special Interest Group on Research in Mathematics Education. American Educational Research Association Meetings, New Orleans. April 28, 2000. Retrieved July 2014 from http://www.lessonresearch.net.

Lincoln, Y.S. & Guba, E.G. (1985). *Naturalistic inquiry.* Beverly Hills, CA: SAGE Publications.

Maaβ, J & Schlöglmann. (2009). *Beliefs and attitudes in mathematics education.* Rotterdam: Sense Publishers.

Mai, J. (2009). *Ethnographic interviews: Interviewing and observing users.* Retrieved June 2014 from https://confluence.sakaiproject.org

Marshall, C. & Rossman, G.B. (2011). *Designing qualitative research.* 5th ed. Los Angeles: SAGE Publications.

McAleavy, T. (2012). *Exploring different approaches to teaching primary maths.* Retrieved January 2013 from http://www.guardian.co.uk

Mc Leod, K. & Guthrie, C. (2010). *Van Hiele's Levels of Geometric Reasoning.* Retrieved December 2013 from http://www.4.uwm.edu.

Menon, U. (2011). *Realistic mathematics education.* Retrieved October 2012 from http://jodogyan.org/2011///04/02/realistic-mathematics-education/

Merilainen, M. & Pietarinen, J. (2002). *Primary Teachers' Professional Development in the Context of Small Rural schools.* Paper presented at the European Conference on Educational Research, University of Lisbon, 11 – 14 September 2002. Retrieved January 2015 from http://www.leeds.ac.uk/educo/documents/00002188.htm

Merriam-Webster Online Dictionary. (2009). *Case study.* Retrieved March 2015 from http://www.merriam-webster.com/dictionary/case%20study.

Mills, D. & Morton, M. (2013). *Ethnography in education.* Los Angeles: SAGE Publications.

Ministry of Basic Education and Culture & Ministry of Higher Education, Vocational Training, Science and Technology. Republic of Namibia. (1998). *Broad Curriculum for the Basic Education Teacher Diploma.* Okahandja: National Institute for Educational Development.

Ministry of Basic Education, Sport and Culture. Republic of Namibia. (2001). *Strategic plan, 2001 – 2006.* Windhoek: Directorate of Planning and Development.

Ministry of Basic Education, Sport and Culture. Republic of Namibia. (2004). *National report on the development of education in Namibia.* Okahandja: National Institute for Educational Development.

Ministry of Education. Republic of Namibia (2005a). *End of primary (Grade 7) examination: Moderation reports on the marking of the 2004 examination answers scripts.* DNEA circular 114/2005. Okahandja: National Institute for Educational Development.

Ministry of Education. Republic of Namibia (2005b). (MoE) *Mathematics syllabus: Grades 5 – 7: Upper Primary*. Okahandja: National Institute for Educational Development.

Ministry of Education. Republic of Namibia. (2005c). (MoE). *Curriculum for the Lower Primary Phase: Grades 1 – 4.* Okahandja: National Institute for Educational Development.

Ministry of Education. Republic of Namibia (2006a). *Upper primary mathematics facilitator's training workshop.* OTRC 04-06 & NIED 25th – 27th July 2006. Okahandja: National Institute for Educational Development.

Ministry of Education. Republic of Namibia. (2006b). *National Professional Standards for Teachers in Namibia.* Windhoek: National Qualification Authority.

Ministry of Education. Republic of Namibia. (2009). *The Basic Education Teacher Diploma (BETD) Pre-Service: Broad Curriculum.* Okahandja: National Institute for Educational Development.

Ministry of Education. Republic of Namibia. (2010). *The National Curriculum for Basic Education*. Okahandja: NIED.

Ministry of Education. Republic of Namibia. (2013). *Assessment of Teacher Training and Development Needs to Ensure Education for All.* Needs Assessment Report. Paris: UNESCO.

Ministry of Education. Republic of Namibia. (2014a). *The National Standardized Achievement Tests, 2013: The Grade 5 Follow Up Results.* Windhoek: Directorate of National Examinations and Assessment.

Ministry of Education. Republic of Namibia. National Institute for Educational Development. (2014b). Basic *Education Curriculum Reform from 2015 – 2022.* Presentation done at AGDS Lehrertagung Omaruru, May 2014.

Ministry of Education. Republic of Namibia. (2014c). *The National Standardized Achievement Tests 2013: The Grade 5 Follow up Results.* Windhoek: Directorate of National Examinations and Assessment.

Ministry of Education. Republic of Namibia. (MoE). *Junior Primary Phase syllabus Grades 1- 3 for implementation 2015.* Okahandja: National Institute for Educational Development.

Ministry of Education and Culture. Republic of Namibia. (1993). *Toward Education for All: A Development Brief for Education, Culture and Training.* Windhoek: Gamsberg Macmillan.

Moffett, P. & Corcoran, D. (2011). *An evaluation of the implementation of Realistic Mathematics Education within primary schools in the North and South of Ireland: Final Report.* Retrieved November 2012 from http://scotens.org/?p=2369

Moodley, M, Njisane, R.A, Presmeg, N.C. (1992). *Mathematics education for in-service and pre-service teachers.* Pietermaritzburg: Shuter & Shooter.

Murata, A., Hart, L. & Allston, A. (2011). *Lesson study research and practice in mathematics education.* New York: Springer.

Nambira, G., Kapenda, L., Tjipueja, G. & Sichombe, B. (2009). *Performance of learners in mathematics at upper primary phase in Okahandja District:*

Examining Reasons for Low Performance. Okahandja: Research Unit Division: Professional Development & Research.

Ndinda, M.J. (2011). *Effects of in-service training of mathematics teachers on students' performance in Kenya certificate of secondary education examination in Machakos District, Kenya.* University of Nairobi Digital Repository. Retrieved November 2012 from http://erepository.uonbi.ac.ke:8080/handle/123456789/3106.

Ndlovu, M. (2014). The Effectiveness of Teacher Professional Learning Programme: The Perceptions and Performance of Mathematics Teachers. *Pythagoras,* 35(2) 1 - 10. December 2014. Retrieved January 2015 from http://dx.doi.org/10.4102/pythagoras.v35i2.237.

New Era. (2014). 20(115), 6. 22nd September 2014. *Implementation of the Revised Curriculum for Basic Education.* Windhoek: Democratic Media Holdings (Pty) Ltd.

Ngololo, E. (2012). *Continuing professional development needs analysis report.* Windhoek: University of Namibia.

Nisbet, S. & Warren, E. (2000). Primary school teachers' beliefs relating to mathematics, teaching and assessing mathematics and factors that influence these beliefs. *Mathematics Teacher Education and Development,* 2000, 2: 34-47. Retrieved November 2013 from http://www.merga.net.au.

Novak, J.D. (1998). *Learning, creating, and using knowledge.* New York: Routledge.

Nyambe, J. & Griffiths, J. (1998). *Deconstructing educational dependency: Insights from a Namibian college of teacher education.* Okahandja: National Institute for Educational Development.

Olsen, W. (2012). *Data Collection: Key Debates and Methods in Social Research.* Los Angeles: SAGE Publications.

O'Reilly, K. (2009). *Key concepts in ethnography.* London: SAGE Publications.

Patton, M.Q. (2002). *Qualitative research & evaluation methods.* 3rd ed. London: SAGE Publications.

Patyus, R., Van der Westhuizen, G. & Roos, H. (2010). *Mathematics in context: Grade 7.* Windhoek: Longman Namibia.

Pehkonen, E. (2004). *State of the art in mathematical beliefs research.* In M. Niss (Ed.). Proceedings of the 10th International Congress on Mathematics Education. Roskilde, Denmark: Roskilde University.

Peters, B. (2006). *Teaching strategies of mathematics teachers in Windhoek.* M-Tech-Ed. Thesis. Pretoria: Tshwane University of Technology.

Polya, G. (1957). *How to solve it.* 2nd ed. Princeton: University Press.

Programme for International Student Assessment (PISA). (2012). *PISA 2012 Results: What students know and can do: Student performance in mathematics, reading and science.* Vol. 1. Paris: PISA, OECD Publishing.

Ramatlapana, K.A. (2012). *Provision of in-service training of mathematics and science teachers in Botswana: Teachers' Perspectives.* Retrieved January 2013 from http://www.ubrisa.ub.bw/handle/10311/561.

Reece, I. & Walker, S. (2006). *Teaching, Training & Learning: A Practical Guide.* 6th ed. Oxford: Business Education Publishers.

Republic of South Africa. *Bantu Education Act No. 47 of 1953*. Retrieved January 2015 from http://www.sahistory.org.za/bantu-education-act-no-47-1953

Romberg, T. (2006). *The promises of realistic math education.* Wisconsin Center for Education Research. Retrieved November 2012 from http://www.wcer.wisc.edu/news/coverstories/

Rowland, T, Turner, F., Thwaites, A. & Huckstep, P. (2009). *Developing primary mathematics teaching.* Los Angeles: SAGE Publications.

Sánchez, M. (2012). *Dialogue among in-service teachers in an internet-based mathematics education programme.* IMFUFA, NSM, Roskilde University Denmark. Retrieved November 2012 from http://www.math.uoc.gr.

Sbaragli, S. (2006). Primary school teachers' beliefs and change of beliefs on mathematical infinity. *Mediterranean Journal for Research in Mathematics Education,* 5 (2), 49-76. Retrieved November 2013 from http://www.math.unipa.it.

Schoenfeld, A.H. (2006).What doesn't work. *Educational Researcher*, 35(2) 13-21. March 2006. Retrieved November 2013 from http://www.p4mriskipgarut.files.wordpress.com.

Searle, J. & Barmby, P. (2012). *Evaluation report on the realistic mathematics education pilot project at Manchester Metropolitan University*. Executive Summary. Retrieved November 2014 from http://www.mei.org.uk/.../rme_evaluation_final_report.pdf

Sembiring, R.K., Hadi, S. & Dolk, M. (2008). *Reforming Mathematics Learning in Indonesian Classrooms through RME.* ZDM Mathematics Education (2008), 40:927-939. Retrieved from http://www.springerlink.com.

Sembiring, R.K., Hoogland, K. & Dolk, M. (2010). *A decade of PMRI in Indonesia.* Utrecht: Bandungo.

Serow, P. & Callingham, R. (2008). *The Introduction of Interactive Whiteboard Technology in the Primary Mathematics Classroom: Three Case Studies.* Proceedings of the 31st Annual Conference of the Mathematics Education Research Group of Australasia. M. Goos, R. Brown & K. Makar (Eds.), ©MERGA Inc. 2008.

Shilongo, E. (2004). *Historical overview of educational assessment in Namibia.* Reform Forum, September 2004. Okahandja: NIED. Retrieved November 2013 from http://www.nied.edu.na/publication/journals/journal18/Article4.doc.

Shulman, L.S. (1987). *Knowledge and teaching: foundations of new reforms.* New York: Macmillan.

Sierhuis, M. (1996). *Selective Ethnographic Analysis: Qualitative Modelling for Work Place Ethnography.* Retrieved January 2015 from http://www.researchgate.net.

Sifuna, D.N. & Kaime, J.G. (2007). The effect of in-service education and Training (INSET) programmes in mathematics and science on classroom interaction: A case study of primary and secondary schools in Kenya. *Africa Education Review.* 4(1), 104-126. Retrieved May 2013 from http://www.tandfonline.com.

Southern and Eastern Africa Consortium for Monitoring Educational Quality. (2011a). *Quality of Primary School Inputs in Namibia: Policy Brief. No. 2 October 2011.* Retrieved February 2014 from www.sacmeq.org.

Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ). (2011b). *Trends in Achievement Levels of Grade 6 Learners in Namibia.* Policy Brief. No. 1. September 2011. Retrieved April 2014 from http://www.sacmeq.org.

Streefland, L. (1985). Wiskunde as activiteit en de realiteit als bron. *Nuwe Wiskrant*, 5(1) 60 - 67.

Streefland, L. (1991). Fractions in Realistic Mathematics Education: A paradigm of developmental research. *Mathematics Education Research Journal*, 3(2), 50-56.

Swarts, P. (2008). *Comments: Consultancy to Develop Guidelines on Teacher Education Reform: Discussion Document, April 2008*. Received as an unpublished Internal Circular at Windhoek College of Education June 2008.

Taylor, A. R., Anderson, S., Meyer, K, Wagner, M.K & West, C. (2005). *Lesson study: A professional development model for mathematics reform.* Retrieved July 2012 from: http://www.ruraleducator.net.

Telese, J.A. 2010. Middle School Mathematics Teachers' Professional Development and Student Achievement. *The Journal of Educational Research*, 105:102-111.

Tella, A. (2008). Teacher variables as predictors of academic achievement of primary school pupils' mathematics. *International Electronic Journal of Elementary Education* 1(1), October 2008. Retrieved July 2013 from www.iejee.com.

Temiz, T. & Topcu, M.S. (2013). Pre-service teachers' teacher efficacy beliefs and constructivist-based teaching practice. *European Journal of Psychology of Education,* 28(4), 1435-1452.

The Namibian. 26:6. 20 January 2013. *Is G Symbol in Grade 12 a pass or not?* Windhoek: Democratic Media Holdings (Pty) Ltd.

The Namibian. 28:10. 7 March 2014. Political Perspective: *We are about to celebrate 24 years of independence*. Windhoek: Democratic Media Holdings (Pty) Ltd.

The Namibian. 28:6. 22 August 2014. *Millennium Development Goals suffer from experimentation… as world looks beyond 2015.* Windhoek: Democratic Media Holdings (Pty) Ltd.

The Namibian. 29:1. 16 January 2015. *Windhoek Schools won't settle for less.* Windhoek: Democratic Media Holdings (Pty) Ltd.

The Namibian. 29:10 & 14. 10 April 2015. *Educational Reform and Teacher Readiness & The Secret of Singapore's Success.* Windhoek: Democratic Media Holdings (Pty) Ltd.

Thomas, G. (2009). *How to do your research project: A guide for students in education and applied social sciences*. London: SAGE Publications.

Tobey, C.R. & Minton, L. (2011). *Uncovering student thinking in mathematics Grades K-5*. London: SAGE Publications.

Törner, G. (1994). *Self-estimating Teachers' views on mathematics teaching: modifying Dionne's approach.* Duisburg: University of Duisburg (Germany). Retrieved October 2013 from http://www.cohn.math.uni-duisburg.de

Treffers, A. (1987). *Three Dimensions: A model of goal and theory description in mathematics instruction*. Dordrecht: Kluwer Academic Publishers.

Treffers, A. (1993). Realistic Mathematics Education. *Educational Studies in Mathematics*, 25, 89-108. Retrieved January 2013 from www.link.springer.com/article/10.1007%2FBF01274104.

Trends in International Mathematics and Science Study. (2011). *Kompetenzen von Schülerinnen und Schülern am Ende der vierten Jahrgangsstufe in den Fächern Deutsch und Mathematik. Ergebnisse des IQB-Ländervergleichs 2011*. Münster: Waxmann.

Uittenbogaard, W. (2007). *Hoe Juliette en Jonas Leren Rekenen: Appels en Peren: Naar Hans Freudenthal.* Panama-Post. Reken-wiskundeonderwijs: onderzoek, ontwikkeling, praktijk. Amsterdam: Korteweg-De Vries Instituut, Universiteit van Amsterdam.

University of Namibia. (2012a). *A decentralised model for Continuing Professional Development of educators in Namibia*. 8th draft. Windhoek: UNAM CPD Unit.

University of Namibia. (2012b). *Continuing Professional Development establishment.* Windhoek: CPD Unit, UNAM.

United Nations Educational, Scientific and Cultural Organization. (2011). *The EFA 2000 assessment country reports Namibia*. Retrieved March 2014 from http://www.unesco.org/education/wef/countryreports/namibia/rapport_1.html.

United States Agency International Development. (2011). *First principles: designing effective education programs for in-service teacher professional development.* Retrieved March 2014 from http://www.equip123.net.

Van de Craats, J. (2007). *Waarom Daan en Sanne niet kunnen rekenen.* NAW 5/8 Nr 2. Amsterdam: Korteweg-De Vries Instituut, Universiteit van Amsterdam.

Van den Brink, J. (1990). Realistisch rekenonderwijs aan jonge kinderen onderzocht: Kanttekeninge bij inhoud en metode. *Tijdschrift voor Didactiek der β-wetenschappen 8,* 1990, 2 (100 – 119).

Van den Broek, J. & Ros, B. (2012). *Van lastig naar leuk: Leren tekenen: Rekenbewust vakonderwijs in het VO, Utrecht*. Retrieved January 2014 from http://www.aps.nl/rekenbewust-vakonderwijs

Van den Heuvel-Panhuizen, M. (2000). *Mathematics education in the Netherlands: A Guided Tour.* Freudenthal Institute CD-Rom for ICME9. Utrecht: Utrecht University.

Van den Heuvel-Panhuizen, M. (Ed.). 2008. *Children learn mathematics. A learning-teaching trajectory with intermediate attainment targets for calculations with whole numbers in primary school.* Rotterdam: Sense Publishers.

Van den Heuvel-Panhuizen, M. (2010). *Reform under attack: Forty years of working on Better Mathematics Education Thrown on the Scrapheap? No Way!* Freudenthal Institute for Science and Mathematics Education: Utrecht

University. Retrieved July 2012 from http://www.principlesrme.org/discover/2010.0307.

Van den Heuvel-Panhuizen, M. (2013). *Excerpts from "Mathematics education in the Netherlands: A guided tour.* Retrieved June 2013 from http://www.principlesrme.org.

Van der Mee, G. (2008). De Metode van Opa Moet Weer Terug: De Gelukkige Rekenklas. *Het onderwijsblad*, 2008, 18 (33 - 37)

Webb, L. & Webb, P. (2004). *Eastern Cape Teachers' beliefs of the nature of mathematics: implications for the introduction of in-service mathematical literacy programmes for teachers.* Retrieved November 2013 from http://www.pythagoras.org.za

Webb, R. (Ed.). 2010. *Researching primary education: Methods and issues.* London: Routledge.

Whitehead, T.L. (2005). *Basic classical ethnographic research methods.* Retrieved June 2014 from http://www.anth.umd.edu.

Whittles, K. (2008). *Cryptology: A didactical transposition into a Grade 10 school mathematics classroom. (PhD-thesis).* Retrieved June 2012 from http://folk.uib.no/pprsk/GRASSMATE/Student_projects/Kalvin.htm.

Widjaja, Y.B. & Heck, A. (2003). How a Realistic Mathematics Education Approach and Microcomputer-Based Laboratory Worked in Lessons on Graphing at an Indonesian Junior High School. *Journal of Science and Mathematics Education in Southeast Asia*, 2003, 26(2), 1-51.Retrieved November 2013 from http://www.science.uva.nl.

Wittmann, E. C. (2004). *Developing Mathematics Education in a Systemic Process.* Kluwer Academic Publishers. Retrieved August 2013 from http://www.educ525.tex.

Wittmann, E. C. (2005). Freudenthal 100 Symposium: Realistic Mathematics Education, past and present. *Nieuw Archief voor Wiskunde Journal*, 5(294 - 296)

Wubbels, T., Korthagen, F. & Broekman, H. (1997). Preparing teachers for realistic mathematics education. *Educational Studies in Mathematics*, 32:1-28. Dordrecht: Kluwer Academic Publishers. Retrieved January 2013 from http://www.educ525.tex.

Woods, P. (1995). *Creative Teachers in Primary Schools.* Philadelphia: Open University Press.

Yin, R.K. (2009). *Case Study Research Design and Methods.* 4th ed. Applied Social Research Methods Series. London: SAGE Publications.

Zeichner, K. & Dahlstrom, L. (1999). *Democratic Teacher Education Reform in Africa.* Windhoek: Gamsberg Macmillan.

Zulkardi, A. (2014). *How to design mathematics lessons based on the realistic approach.* Retrieved January 2014 from http://eprints.unsri.ac.id/692/1/rme.html