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Author: Felix Simon Makolija	
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DECLARATION

I, the undersigned hereby declare that this thesis is my original work which has not been submitted to any other institution for similar purposes. Where other people's work has been used acknowledgments have been made.

FELIX SIMON MAKOLIJA

Full Legal Name

Signature

Date

DEDICATION

To my late parents: Simon Moses Makolija and Catherine Abelo who passed on while I was still doing my primary education. I am sure you would have loved seeing what your son has achieved. And to you my late grandfather Mr. Eliyas Lindeire your pieces of advice and encouragement bear fruits. May your soul rest in eternal peace.

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ABSTRACT

The purpose of this study was to explore the teaching of mental mathematics in Malawi's lower primary schools. The Malawi government has included mental mathematics in the National Numeracy Program (NNP) curriculum for lower primary school learners. The aim is to provide learners with mental mathematical knowledge and skills that would provide a solid foundation for future mathematics study in primary schools. However, while the introduction of mental mathematics in lower primary schools appears to be a solution to improve learners' performance in mathematics performance, more research is needed to determine how primary teachers teach mental mathematics. The purpose of this study was to explore how mathematics teachers plan, teach and view mental mathematics in Malawi primary schools. The sample was drawn from NNP pilot primary schools, particularly in lower primary schools (standards 1–4), where mental mathematics is introduced in the NNP curriculum. The study used the Mathematical Discourse in Instruction (MDI) framework and was directed by the key research question "How do teachers in primary schools piloting the NNP curriculum view mathematics?" This main research question was supported by the following three subquestions: (1). How do teachers plan mental mathematics?, (2). How do teachers teach mental mathematics?, and (3). what are the teachers' views on mental mathematics?

The study included twelve teachers from three primary schools in Malawi's rural Eastern region. The study is qualitative research that used interviews with teachers, lesson observations, and document analysis (lesson plans) to collect data.

The study findings show that including mental mathematics in the curriculum in lower primary schools is beneficial since it enhances learners' mathematics performance. It was established that teachers rely on teachers' guides and learners' workbooks for guidance on how to select the tasks and teach mental mathematics and that they have the autonomy to select and prepare their mental mathematics problems depending on the day's work. Based on the findings, the study indicates that mental mathematics may be a positive development because it helps learners build critical thinking abilities and number senses.

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List of Acronyms and abbreviations

MIE: Malawi Institute of Education

MoEST: Ministry of Education Science and Technology.

NNP: National Numeracy Programme.

OBE: Outcome-Based Education.

CHAPTER 1: **INTRODUCTION TO THE STUDY**

1.0 CHAPTER OVERVIEW

The study was aimed at exploring how primary[1] school teachers teach mental mathematics in Malawi schools piloting a National Numeracy Programme (NNP) curriculum. The study adopted the definition from Longman (2010) defining mental mathematics “as the practice of doing calculations in one’s head without the need for paper, pen, or calculator” (p. 973) and the concept will also be further discussed in chapter 2. The study is a case study of twelve teachers in the lower primary (standards[2] 1– 4). This chapter will present the background and context of the study, the statement of the problem, the purpose of the study, the research questions, and finally the significance of the study.

1.1 BACKGROUND

Education is one of the most significant areas in Malawi, generally coming in second behind agriculture. Indeed, education is regarded as one of the most important levers for improving the living conditions of Malawians. Malawi has two major educational systems in operation: formal and nonformal (United Nations Educational, Scientific, and Cultural Organization (UNESCO), 2014).

Malawi's formal education system is divided into three levels, according to the World Bank (2010):

> Primary Education, Secondary Education, and Higher Education. Basic Education, Secondary Education, Primary and Secondary Teacher Training, Technical and Vocational Training, and University Education comprise the formal education system. Non-formal education includes Early Child Development and Adult Education (under the Ministry of Gender, Children, Disability, and Social Welfare); Out of School Youth and Functional Literacy (under the Ministry of Youth and Sports); and Basic Education (under the Ministry of Education, Science, and Technology (MoEST). As a result, primary education is effectively identical to basic education.

According to the MoEST (2014), there are 8 years of primary education (standards 1–8). Primary education in Malawi is divided into two sections: lower primary (standards 1–4) and upper primary (standards 5–8). The lower primary is divided into two sections: the infant section (standards 1 and 2) and the junior section (standards 3 and 4), whereas the upper primary is described as senior

[1] Primary school education in Malawi is comprised of eight years and secondary school education has four years.
[2] Standard in Malawi is the same as grades

section (standards 5–8). Secondary education lasts four years (Forms 1–4), with the first two years being lower secondary and the last two years being upper secondary school. Malawi's school year is divided into three terms (term 1, term 2, and term 3) for primary and secondary education (MoEST, 2014).

According to Kadzamira and Rose (2001), the official entry age into primary school is six years old, though there are variations. Learners in standard eight write their last examinations in primary school to be admitted to secondary school. Primary education is thus the most significant component of Malawi's educational system because it serves as the foundation for knowledge acquisition in secondary and, eventually, university education.

Even though basic education has been provided for free since 1994, a compulsory education system has yet to be implemented (UNESCO, 2010). In Malawi, advancement to the following class (grade) is not automatic. Examinations are required at the end of each academic year for learners to move to the next level (Japan International Cooperation Agency (JICA), 2011). In addition, learners in Standard 8 of primary education and Forms 2 and 4 of secondary education must pass a national examination administered by the Malawi National Examinations Board (MANEB) to go to higher levels of education (JICA, 2011).

After passing the Primary School Leaving Certificate Examination in Standard 8, learners are granted admission to secondary schools of varying levels based on their performance. Only the top-scoring learners are allowed to attend Conventional Secondary Schools, while the rest can attend Community Day Secondary Schools (UNESCO, 2010). Furthermore, because secondary schools can only handle a limited number of learners, some learners are denied permission to continue their education despite passing the examinations (World Bank, 2010). These learners have the option of attending private secondary schools or foregoing higher education. Learners take the Junior Certificate Examination at the end of Form 2 and the Malawi School Certificate Examination at the end of Form 4. These examinations are used to test curricular ability as well as to advance learners to the next level. The research focused on primary education, specifically lower primary (standards 1–4).

"In Malawi and many other countries, mathematics is a core subject in the curriculum in both primary and secondary schools" (Longwe, 2016, p. 1). It is an important subject because mathematics is essential for meeting daily demands. Mathematical expertise has several economic benefits. Furthermore, many job fields require mathematical skills, as do those interested in self-employment (Longwe, 2016).

Longwe (2016) claimed that, while mathematics is vital, many learners do not consider it as something that may expand their understanding of the world or a source of inspiration; rather, they see it as a subject that must be endured. (p. 2). Some studies believe this is because many teachers teach mathematics instrumentally, using solely methods, which contributes to learners' low performance (Brombacher, 2019; Longwe, 2016; Sandram, 2016).

In Malawi, assessments and studies suggest that learners struggle with mathematics in terms of learning and comparison, to neighbouring nations (Brombacher, 2019; Eliya, 2016; MANEB, 2016; Njora, 2010). According to the reports, many primary school learners' mathematics achievements are low, and many learners fail to meet the minimum levels of proficiency stated in the Malawi Primary School National Curriculum (Brombacher, 2019; Eliya, 2016). An assessment exercise undertaken by the United States Agency for International Development (2010) revealed that learners in primary schools perform low in mathematics. Another source of evidence is the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) results from 2010 tests given to standard six learners, which revealed that 98% of the learners lacked mathematical skills beyond basic numeracy (Ministry of Education Science and Technology (MoEST), 2011). Malawi was placed second from the bottom in mathematics when compared to the other fourteen countries (SACMEQ, 2010). Furthermore, less than 8% of standard three learners obtained the desired level of numeracy in the Primary Achievement Sample Survey (PASS) performed by MoEST (2010) to examine achievement levels of learners in English and Mathematics in standards three, five, and seven. It was also discovered that no learner in standard five scored more than 50% in mathematics, while 99% of standard seven learners scored less than 50% in mathematics (Chimombo et al., 2014). The outcomes of PASS demonstrate that learners in primary schools are not performing well in mathematics, indicating that mathematics education in Malawi is ineffective.

According to Macken (2014), educators all over the world acknowledge the necessity to adapt long-standing numerical education to meet new advancements and numerical needs in today's society. Following MoEST (2003), the primary curriculum was reviewed and revised to make national education programmes more reflective of changing socioeconomic and political realities while also making it engaging to learners by allowing them to engage completely.

Malawi's national primary curriculum has been changing since 1961, according to the literature (Chilimanjira, 2011; Kabwila, 1995; Khomani, 2005; MoEST, 2006). Malawi had a Content-Based Curriculum that had been reviewed and revised in 2006. Malawi then replaced the Content-Based Curriculum with the Outcome Based Education (OBE) curriculum (MoEST, 2010). According to MoEST (2011), the OBE mathematics curriculum has six core elements which are:

(i) number operations and relationships,
(ii) patterns, functions, and algebra,
(iii) space and shape,
(iv) Measurement,
(v) data handling and
(vi) accounting and business studies.

Number operations and relationships take up more than 50% of the intended lessons planned for mathematics. The study focused on only the core elements of numbers, operations, and relationships.

The OBE curriculum is supported by Learner Centred Education (LCE) teaching methods which focused on learner involvement in the teaching and learning situation to enhance achievement. The OBE curriculum expects that learners should be able to count and perform basic mathematical operations at the end of standard 4 (MoEST, 2009).

Although Malawi implemented the OBE curriculum in 2006, learners' mathematics performance did not improve. Sandram (2016), on the other hand, noted several changes in the mathematics primary curriculum, such as extra content, activities, new algorithms, and LCE techniques, while other parts, such as mental mathematics, were not stressed in the OBE curriculum. Teachers ceased teaching learners' mental mathematics since it was not included in the OBE curriculum, which was overburdened with new elements (Sandram, 2016).

It is remarkable, however, that learners still struggle with basic mathematical operations such as addition, subtraction, multiplication, and division more than a decade after the OBE curriculum was implemented (Brombacher, 2019). Furthermore, learners fail to complete the mathematics curriculum's rationale and criterion-referenced measurement (assessment standards and success criteria of the OBE curriculum) in primary school leaving certificate Examinations (MANEB report 2014 -2018).

MoEST undertook a scoping study in 2019 to address Malawi's low mathematics performance (MoEST, 2020). The goal was to gain a better understanding of why learners' performance in mathematics in lower primary schools is low and to identify the most effective strategies for improving numeracy results in standards 1–4.

According to the scoping study, low performance in early-grade mathematics in Malawi has as much to do with perceptions of what it means to do mathematics as it does with practicing mathematics (Brombacher, 2019). Furthermore, the study revealed that the mathematics environment in Malawi had limited resources, resulting in limited learning opportunities for learners. In addition, the study discovered that the OBE curriculum is impervious to the interconnected way in which learners develop number concepts. The scoping study examined resources such as the mathematics curriculum for standards 1–4, mathematics teaching guides, and learners' textbooks published by the MIE (Brombacher, 2019).

The scoping study recommended that there should be a programme that will provide the opportunity of developing a modernized vision of what it means to do mathematics for Malawi by developing a vision of mathematics in which students experience mathematics as a meaningful, sense-making, problem-solving activity, and a vision of mathematics teaching and learning that expects learners not only to know mathematics but also to understand the mathematics they know, be able to apply the mathematics they know to solve unfamiliar problems and be able to argue with the mathematics that they know (Brombacher, 2019).

In response to the suggestions provided by the scoping study carried out in 2019, the Malawi government launched the National Numeracy Program as a project in 2020 through the Ministry of Education, Science, and Technology (MIE, 2021). The initiative aimed to improve learners' numeracy learning outcomes by establishing a strong numeracy foundation in the six core areas mentioned earlier. The project's success has resulted in the development of a new primary mathematics curriculum known as the National Numeracy Programme (NNP) curriculum, which is now being trailed in select schools.

1.2 NATIONAL NUMERACY PROGRAMME CURRICULUM IN MALAWI

According to MIE (2021), NNP is a four-year (2020-2023) government of Malawi programme led by MoEST and supported by the UK government through UK Aid. The curriculum promotes mathematical idea comprehension, reasoning, and application in an unknown setting. Among the various goals of the NNP, one was to reform the mathematics curriculum for lower primary (standards 1-4) and develop teaching and learning resources associated with the curriculum. It also includes the six essential aspects of the OBE curriculum (MIE, 2021).

The NNP curriculum expects learners to conduct calculations, recognize and create patterns, recognize shapes, measure length, mass, capacity, and volume, collect and organize data, handle real-world problems, and acquire buying and selling abilities (MIE, 2021). The technique of teaching develops learners' mathematical knowledge with understanding, confidently supports them, applies mathematical knowledge in an unknown context, and develops reasoning ability.

As previously said, many learners struggle and fail to master mathematics in lower primary schools. As a result, the NNP curriculum may help to improve the quality of teaching mathematics.

1.2.1 How is the NNP Curriculum piloted?

From 2022 to 2023, the NNP curriculum will be tested at 204 primary schools. Mathematics teachers at the pilot schools were taught the content of the NNP curriculum as part of the pilot, and newly produced teaching and learning materials, as well as new teaching methodologies, are being implemented in piloted schools from standards 1–4. Following the successful assessment and completion of the piloting phase, the curriculum will be implemented in all Malawian primary schools (MIE, 2021). All teaching and learning materials created will be distributed to all Malawian schools. Inservice training and continuing school and classroom-based assistance for all primary school learners and teachers in standards 1–4 (MIE, 2021).

The NNP curriculum's goal is to improve the quality of the teaching of mathematics in lower primary schools. The NNP curriculum is also intended to improve service delivery so that more girls and boys, particularly those from disadvantaged families, move through and complete primary school with measurable increases in learning outcomes (MIE, 2021). The NNP curriculum's fundamental concepts are organised around three important themes: counting, problem-solving, and manipulating numbers.

1.2.2 The Teaching of Mathematics in Malawi using the NNP Curriculum

Traditionally, the teaching of mathematics in Malawi has been dominated by the teacher delivering a lecture, followed by an example, and learners imitating the teacher's approach to practice solving new problems (Sandram, 2016). Critics argue that this method of teaching fosters rote memorization. Sandram (2016) stated that, while rote learning is good for helping learners remember specific concepts, teachers appear to perceive it as an effective method of teaching all concepts in mathematics. Sandram (2016), in agreement with Wolfram (2010), argued that this traditional method of teaching mathematics does not help learners acquire the desired mathematical skills because it only emphasises the application of procedures without understanding them, and thus does not promote critical thinking and problem-solving skills in learners.

The justification for learning mental mathematics in Malawian primary schools focuses on improving the learner's critical understanding of how mathematical relationships are applied in the social, environmental, cultural, and economic context (MoEST, 2008). By rote learning, learners in infant and junior primary school must be able to count and do mathematical operations by the end of standard 4. Learners in standards 5–8 must make conclusions from altered data and apply mathematics to solve practical problems (MoEST, 2008). However, it is documented that learners in these classes (standards 5–8) fail to achieve the rationale and criterion-referenced measurement (assessment standards and OBE success criteria) of the mathematics curriculum in primary school (Eliya, 2016). This is largely due to a lack of a solid mathematical foundation throughout their infant and junior primary school years (standards 1–4).

As a result, the primary focus of this study is to critically examine how mathematics primary school teachers plan and teach mental mathematics in the first four years of primary school, as these early years lay the groundwork for the children's subsequent years.

According to MIE (2021), with the introduction of the NNP curriculum in Malawi, mathematics is taught in three distinct routines and mathematics instruction has been separated into these routines. As a result, mathematics is taught using the three routines described below:

(i) the lesson routine,
(ii) the learner activity routine,
(iii) the reflection routine.

To begin, the lesson routine lasts 15 to 20 minutes and is led by the teacher. In teacher-led activities, the teacher helps learners through counting numbers, problem-solving, and mental mathematics based on their class. The activity's content is determined by the work that learners are required to accomplish in the following phase of the lesson. To ensure that the teacher and learners are always on the same page and progressing in the same direction, the matching page of the learners' workbook is indicated in the teacher's lesson plan.

Second, there is learner action. Learners are given 15–20 minutes to complete the provided activity in the learner workbook. Learners engage independently on a mental mathematic task assigned by the teacher that is related to the preceding routine's activities. Normally, learners are assigned to practice counting, problem-solving, and numerical manipulation. At this point, the teacher checks to see if learners can follow what was presented before. The teacher is also entrusted with assisting learners who are having difficulty with the assigned work.

Finally, both the teacher and learners reflect on their experiences. It lasts 5–10 minutes, and the teacher asks learners questions to highlight what they have noticed in the lesson, with a focus on detecting patterns or mathematical structures within the activity that was assigned to them. Based on the reactions of the learners, the teacher eventually consolidates the lesson by emphasising the key parts of the lesson and the tasks that were completed.

Therefore, this study has explored the notion of how mental mathematics is taught in piloting primary schools.

1.3 STATEMENT OF PROBLEM

As stated in the preceding section, the NNP curriculum in Malawi emphasises the teaching of mental mathematics (MIE, 2021). Longman (2010) defines mental mathematics as the practice of doing calculations in one's head without the use of paper, pen, or calculator, which raises questions about how well teachers succeed in teaching learners and achieving learners' understanding of mental mathematical concepts in primary schools. As a result, successful mental mathematics instruction should be prioritised to increase learners' numeracy skills. Munthali (2019) remarked that as part of the country's objective to improve primary school mathematics teaching and learning, learners should be assisted to have a deeper understanding and insight into how teachers effectively teach them. One of the new concepts in the basic element of numbers, operations, and relationships is the teaching of mental mathematics.

It is important to explore how Malawian teachers teach mental mathematics in the early years of primary school because this is where the foundation of learning is laid. There are no studies that show how mental mathematics is taught in piloted schools to improve mathematics teaching and learning. This backdrop inspired the researcher to explore how teachers teach mental mathematics in Malawian pilot schools. As a result, the purpose of this study is to fill that gap.

1.4 RESEARCH QUESTION

The research questions of this study were divided into two parts: the main research question and the specific research questions.

1.4.1 Main Research Question

How do teachers in primary schools piloting the National Numeracy Program curriculum in Malawi implement and view mental mathematics?

1.4.2 Specific Questions

The following specific questions will be used to answer the main research question:

1. How do teachers plan mental mathematics?
2. How do teachers teach mental mathematics?
3. What are the teachers' views on mental mathematics?

1.5 THE PURPOSE OF STUDY

The purpose of the study is to explore the teaching of mental mathematics in the early years of primary school (standards 1–4) in the piloted primary schools in Malawi. The study is designed to explore how mathematics primary school teachers plan their lessons, teach, and their views on mental mathematics in the lower primary.

1.6 THE SIGNIFICANCE OF STUDY

The study focused on how teachers taught mental mathematics in the early primary school years (standards 1–4) in three Malawian pilot schools by using the NNP curriculum. The study reveals how mental mathematics is taught and how learners are invited to the mental mathematics lesson that follows the NNP curriculum. As a result, the outcomes of this study give a picture of how teachers teach mental mathematics in lower classes in Malawi's piloted primary schools. The picture will thus inform future reviewers of an early revision of the curriculum and curriculum materials before scaling out to the entire Nation (MIE, 2021). The study also serves as a reminder to the researcher as a Mathematics teacher educator of the need to prioritising the teaching of mental mathematics so that student-teachers acquire the abilities while in college.

1.7 CHAPTER SUMMARY

Finally, the chapter has introduced the research study. It has concentrated on the aim of the research study, the background and setting of the study, the problem statement, the purpose of the study, the research questions, and the significance of this research study to various stakeholders.

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.0 CHAPTER OVERVIEW

This chapter discusses literature related to the teaching of mental mathematics in the lower primary in Malawi and looks at some studies done related to the teaching of mental mathematics. This chapter is divided into eight sections. The first section will give an overview of related studies on the teaching of mental mathematics from different parts of the world – including some other African countries.; the second section will describe how mental mathematics can be taught; the third section will look at the key principles of teaching mental mathematics, the fourth section will present the aspects of mental mathematics, the fifth section will look at types of mental mathematics questions, the sixth section will describe the importance of teaching mental mathematics, the seventh section will look at the theoretical framework and finally the eight section will present the chapter summary.

2.1 RELATED STUDIES ON THE TEACHING OF MENTAL MATHEMATICS

Studies in the UK have shown that mental mathematics has improved numeracy standards (Crown, 2010). The studies had an emphasis on mental mathematics to understand its complexity. This means recognizing what is involved in mental mathematics and, further, recognizing the developmental shift from additive to multiplicative reasoning which is necessary for a mature conceptualization of numbers. So mental mathematics has proved successful in the UK.

In Romania, Beishuizen (2001) states that mental mathematics is taught in two ways: the first approach is by encouraging learners to invent and share with others their intuitive strategies for a given calculation problem. The second one is taught in a special lesson with few advanced strategies. Gurbuz and Erden (2016) argued that many teachers view mental mathematics as important for learners to learn but the focus should not be limited to helping learners develop mental computation strategies but also to developing higher-order thinking, reasoning, and critiquing, along with the ability to make sense of numbers and number operations which has helped learners to improve their performance.

Similarly, Baranyai et al. (2019) found that mental mathematics is categorised into two ways. The first way is seen as a basic skill where learners apply some learned procedures when calculating without any aids and the second way is seen as a high order thinking skill where learners need to generate their calculation strategies.

In Australia, Rodgers (2009) observed that mental mathematics enables learners to think and learn more in-depth about how numbers relate to each other, make decisions about procedures, and create strategies for calculating. This shows that mental mathematics has changed the thinking capacity of learners and they are free to create and choose their strategies. Mental mathematics has improved the performance of learners in Australia. For example, learners improved in accuracy on the additional items from 28.6% to 68.6% on the post-test that was given to them. This increase indicates that mental mathematics affected learners' performance (Heirdsfield, 2011).

Tabakamulamu (2010) in Zambia noted that the teaching of mental mathematics changed the teachers' beliefs and practices of supporting learners in a classroom. Tabakamulamu (2010) found that the "lack of the development of number sense was due to the absence of practicing mental mathematics and the use of mental mathematics with understanding" (p. 27). The absence of practicing mental mathematics can make learners not understand how number senses can be developed. It is good to understand the development of number sense. The performance of learners was improved in Zambia because of the introduction of mental mathematics as cited by Tabakamulamu (2010).

Studies in Namibia have revealed that the low performance of senior primary school learners in mathematics was based on the absence of mental mathematics (Mukutu, 2015; National Institute for Educational Development, 2010; Spaull, 2011). This has led the Ministry of Education to incorporate mental mathematics into its curriculum (Namibia Ministry of Education and Culture, 2016). In another hand, Peters (2016) found that it was necessary to determine the reactions and outcomes of an intervention model on mental mathematics. Learners are required to mentally compute exact answers and make approximations as pointed out by Morgan (1999). So, teachers in the senior primary schools were tasked with an emphasis on mental mathematics strategies to enhance numeracy and number sense among learners. The teachers' intervention in mental mathematics has improved the level of functional numeracy in learners (Tutak et al., 2011). For example, the results from the post-test indicated that the performance of learners improved with a significant level of standard deviation of 0.05 (Njora, 2010).

In South Africa, McCarthy and Oliphant (2013) observed that much of the reason that makes learners not develop necessary foundational skills is the way how mathematics is being taught. Graven et al. (2013) argued that many learners in the early grade performed low due to reliance on inefficient counting-based strategies calculating which hinders the development of foundational skills needed to progress to more complex concepts addressed in the later years. They suggested that the problem of low performance in mathematics can be achieved by the introduction of mental mathematics. For example, learners performed well in the post-test conducted in South African schools. The performance improved from 28% to 44%. This shows that mental mathematics plays a great role in developing reasoning-based calculating strategies (Department of Basic Education, 2011).

Hence the NNP curriculum in Malawi has adopted the teaching of mental mathematics as suggested by Educational Mathematics Researchers above to improve the performance of learners in mathematics. Therefore, this study aims to explore teachers teaching mental mathematics as required by the NNP curriculum in Malawi.

2.2 THE TEACHING OF MENTAL MATHEMATICS IN MALAWI

In Malawi, the OBE curriculum omitted mental mathematics from the instructional materials. Everett et al. (2014), on the other hand, observed that mental mathematics is the most commonly employed kind of computation in everyday life. As a result, they concluded that by excluding mental mathematics, learners may lack some mathematical skills that are essential in their daily lives. The MoEST is now interested in putting greater focus on mental mathematics in primary school through the NNP curriculum to improve mathematics education in Malawi (MIE, 2021). To strengthen learners' reasoning skills, the NNP curriculum incorporates mental mathematics into mathematics instruction. According to Hartnett (2007), mental mathematics requires more than recollection of numerous acquired techniques, but rather a deeper understanding of how numbers work.

The term mental mathematics' will be used in this study to refer to classroom activities in which a teacher asks a learner to perform calculations mentally and the learner answers verbally. It is adequate to explain that mental mathematics is the manipulation of numbers in the mind, which occurs daily. This is consistent with Crown (2010), who stated that everyday practice with mental mathematics is crucial to the development of various manipulation and calculation procedures required to build learners' number fact collection. We live in a society where mathematics is used to illustrate societal problems and to explain suggested remedies. In the opinion of Baranyai et al. (2019), mental mathematics is required to answer mathematical issues. As a result, each mathematical process problem is required for a constructive and creative process. In this situation, mathematics develops all of a learner's mental talents.

2.3 PRINCIPLES FOLLOWED WHEN TEACHING MENTAL MATHEMATICS

Crown (2010) observed that the teaching of mental mathematics needs some principles for the teaching to be effective. For instance, he observed that learners should be encouraged to choose different strategies and to use informal jottings to keep track of the information they need when calculating.

To begin with, teachers should introduce practical approaches and jottings with models and images learners can use to carry out calculations as they secure mental mathematics. This principle provides suitable equipment for learners to manipulate and explore how and why a calculation strategy works and that helps learners to describe and visualise the method working. For example,
5 + 2 = 7 and 2 + 5 = 7.

Furthermore, teachers should provide practice time with frequent opportunities for learners to use one or more facts that they already know to work out more facts. Learners need time to develop their mathematics. They need time to think, explore, discuss, and explain their reasoning.

Lastly, learners should ensure that they confidently add and subtract any pair of two numbers mentally using jottings to help them where necessary. Longman (2010) described jotting as an informal piece of written work that is done to help work out the answer to a calculation or a problem. Jottings can be worthwhile for mathematics learners, as especially in mental mathematics activities, it can be difficult for learners to process the technicalities of a sum without breaking it down visually. Learners should be encouraged to make jottings as they work and recognise how these can support their thinking. In mental mathematics, jottings can be done separately before giving the answers orally if the tasks demand more multi-step problems to keep track of answers as they work through in their heads. For example, The learner can read: 127 + 51 + 13 +5 +9 =

The learner can also think: 127 + 51 + 13 + 5 + 9 =

The learner can jot: 140 + 60 + 5 =

Finally, they can solve in their heads to come up with the answer.

Generally, it needs to be both non-competitive and non-judgmental so that learners can feel confident about taking risks in their exploration of mathematics. These principles will be used to analyse the views of primary school mathematics teachers on how they teach mental mathematics in Malawi.

2.4 ASPECTS OF MENTAL MATHEMATICS

Baroody (2006) pointed out that learners' progress through three stages to acquire the four basic mathematical operations of addition, subtraction, multiplication, and division. The stages are as follows:

The first stage is Counting Strategies where learners use object counting. For example, using counters or fingers or verbal counting to determine the answer. For instance, with 2 + 5 a learner will start by counting 2 real objects followed by counting 5 real objects. These two sets of objects will then be combined and counted again as one set of objects to determine how many are together.

The second stage is Reasoning Strategies where the learner uses known information to logically determine an unknown combination. For example, with 5 + 4 a learner knows that 10 - 1 is 9, and 5 + 5 is 10, so 5 + 4 is 10 less by 1 and therefore the answer must be 9.

The third stage is Mastery: where the learner becomes efficient (fast and accurate) in producing answers. For example, with 10 - 3, a learner quickly responds, 'It's 7; I just know it.'

According to Crown (2010), there are six aspects of mental mathematics which are as follows:

1. Re-calling facts. For example, what is 3 add 7? and what is 6 x 9?
2. Applying facts. For example, tell me two numbers that have a difference of 12. If 3 x 8 is 24 what is 6 x 0.8?
3. Hypothesizing or predicting the fact. For example, if the diagram below has 4 rectangles, how many rectangles are in the next diagram?

4. Interpret results. For example, what does the number that ends in 5 or 0 tell us?
5. Deciding and comparing procedures. For example, how could you subtract 10 from 15
6. Apply to the reason. For example, why is the sum of two odd numbers always even? For example,

$$5 + 3 = 8$$
$$7 + 9 = 16$$

2.5 TYPES OF MENTAL MATHEMATICS QUESTIONS

According to Crown (2010), there are two types of mental mathematics questions that are being taught in schools: closed and open questions.

Crown (2010) explained that closed questions generally have just one correct answer. Closed questions help to establish specific areas of knowledge, skills, and understanding. They also focus on children providing explanations as to how and why something works. Not only that, but Crown (2010) also emphasized that closed questions can be applied when identifying and developing approaches and strategies for a particular purpose. For example, what is 5 x 2? The learner is supposed to come up with one answer which is 10.

On the other hand, Crown (2010) state that open questions usually have a variety of alternative solutions and approaches that offer children a chance to respond in different ways; they often focus on children providing explanations and reasons for their choices and decisions and a comparison of which of the alternative answers are correct or which strategies are more efficient. For example, the learner is given a chance to explain how he or she has arrived at an answer. For example, 8 + 7 = 15. A learner can solve it as follows:

$$8+7 = 15$$
$$= (5+3) + (5+2)$$
$$= (5+5) + (3+2)$$

= 10+5

=15

Or

8+7 = 15

= 8+ (5+2)

= (8+2) +5

= 10+5

= 15

2.6 IMPORTANCE OF TEACHING MENTAL MATHEMATICS IN A CLASSROOM

The aim of introducing mental mathematics in the lower primary school classes is to make sure that learners are equipped with basic knowledge of number operations and relations that will give them a better background in mathematics as they prepare for upper primary school classes (MIE, 2021).

There has been quite tremendous research that supports the notion of the importance of mental mathematics in developing reasoning-based calculating strategies, and problem-solving skills that promote success in later written calculations (Brocard, 2014; Swan & Sparrow, 2001; Threlfall, 2002). Heirdsfield (2011) draws attention to the importance of mathematical patterns and relationships in developing proficiency with mental mathematics. Mental mathematics is, however, one of the basic skills for school-aged children.

With mental mathematics, learners can understand mathematical concepts instead of just reading and memorizing them. Mathematics is logic and it should be solved with logical steps. Mental mathematics is important for children to learn but the focus should not be limited to helping learners develop mental computation strategies but also to developing higher-order thinking, reasoning, and critiquing along with the ability to make sense of numbers and number operations (Crown, 2010; Cengiz et al., 2011).

Gürbüz and Erdem (2016) agreed that mental mathematics is an important thinking process because it enables learners to learn more in-depth about how numbers relate to each other, make decisions about procedures, and create strategies for calculating. Everett et al. (2014) admitted that mental mathematics is the most common form of computation used in everyday life. However, Gürbüz and Erdem (2016) argued that mental mathematics is a way of calculating with understanding and reasoning than processing with no representation.

2.7 THEORETICAL FRAMEWORK OF STUDY

The study was informed by Mathematical Discourse in Instruction (MDI) framework that was developed by Adler and Ronda in 2015. According to Adler and Ronda (2016), the MDI framework is a socio-cultural framework that rose from their research-linked professional development project. The study adopted the MDI framework because of the following reasons: firstly, to guide in analysing teachers' classroom practices specifically on how the teaching of mental mathematics makes the object of learning (Adler & Ronda, 2015) accessible to the learners. Secondly, to guide analysis of how teachers use words to name mathematical concepts, how explanations are built on what is supposed to be taught, and tasks are given during the teaching of mental mathematics.

Marton and Tsui (2004) observed that the MDI framework through exemplification and the accompanying explanatory talk, are two commonplace practices that work together with the opportunities provided for learners to participate in mathematics discourse. The MDI framework is well known for its four components which are shown in Figure 1 and each component has been explained in detail.

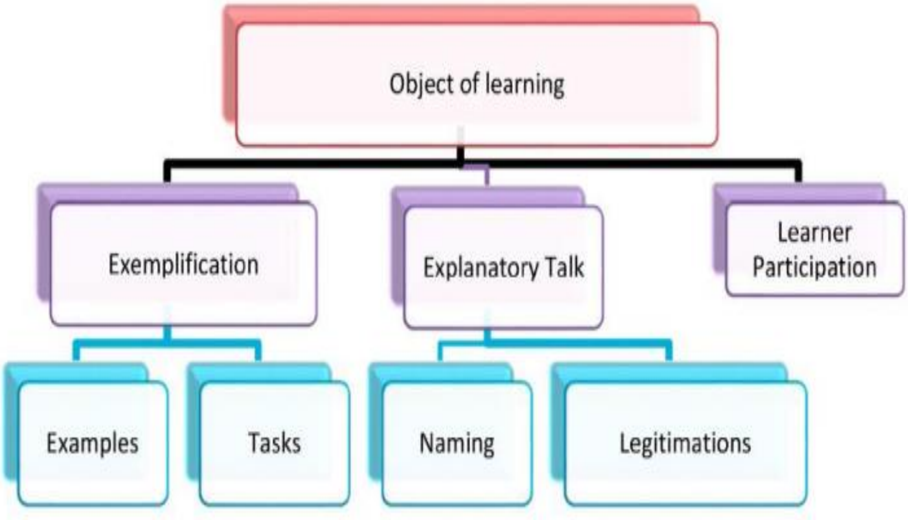


Figure 1: Constitutive elements of the MDI frame and their interrelations

Note: adopted from Adler and Ronda(2015)

2.7.1 Object of Learning

Learning is always about something and bringing to the learner what this is, the 'object' of learning, is central to the work of teaching (Adler & Ronda, 2015). Adler and Ronda (2016) describe the object of learning as the focus of the lesson which has both content and capability component. The content of a lesson goal can be a mathematical concept, relationship, or procedure.

2.7.2 Exemplification**.**

Exemplification includes examples, tasks, and representations. This study concentrated on tasks only because teachers do not give examples during the teaching of mental mathematics.

Tasks

Adler and Ronda (2016) define tasks as what learners are asked to do in a classroom. Tasks are needed to increase the understanding and mastery of mental mathematics. According to Ronda and Adler (2016), tasks must have the potential to engage the learners to make connections among features of mathematical content. Tasks are needed to engage learners in different experiences of the content which will enable learners to make connections among features of the mathematical content. There should be a variation of mental mathematical tasks. Furthermore, Stein et al. (2000), concluded that teachers must select rich mathematical tasks and pose mental mathematics problems that lend themselves solutions that involve various mathematical operations in which learners can demonstrate their mastery. Marton and Pang (2006) explain that the key to better learning involves bringing attention to patterns of variation amidst invariances.

2.7.3 Explanatory Talk

Explanatory talk in the MDI framework is the function of which is to name and legitimate what is focused on and talked about, that is, related to tasks (Adler & Ronda, 2015).

Naming

Adler and Ronda (2015) defined naming as the use of words to refer to other words, symbols, images, procedures, or relationships. Naming is considered the use of colloquial (non-mathematical) and mathematical words within and across episodes of a lesson. Naming or the use of words, therefore, constitutes teacher-learner interaction and learner-learner interaction to develop a shared understanding of mathematical terms.

Legitimate

Legitimating using mathematics is when a teacher refers to mathematics to explain something. Analysing how objects focused on are named, and what is legitimated in an episode is key to being able to describe the mathematics made available to learn through explanatory talk, as well as reach a summative judgment on naming and legitimating as these accumulate over time in a lesson (Adler & Ronda, 2015).

2.7.4 Learner Participation

Learner participation is an important aspect as it plays so many crucial roles in enhancing learners' understanding of a lesson. It is one area that is encouraged to be incorporated into the NNP curriculum in Malawi. This aspect of the MDI framework looks at how learners participate in the lesson. Adler and Ronda (2015) explain that their main concern or focus under learner participation is what learners are invited to say, specifically whether and how learners have the opportunity to speak mathematically and to verbally display mathematical reasoning. Learner participation is about doing mathematics and talking about mathematics.

2.8 CHAPTER SUMMARY

This chapter has discussed what the literature has said about the teaching of mental mathematics using the NNP Curriculum in the piloting schools in Malawi. It has also looked at how mental mathematics is taught in lower primary schools in Malawi and different parts of the world. It has discussed the principles and aspects followed when teaching mental mathematics. The chapter has also presented arguments by different researchers on the importance of mental mathematics in schools. The next chapter presents the methodology of the study.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.0 CHAPTER OVERVIEW

This chapter will describe the research design, data collection instruments, pilot study, study samples, data collection techniques, validation, and reliability of the study, data construction, data analysis, and the chapter summary.

3.1 RESEARCH DESIGN

Creswell (2012) described research designs as procedures used for collecting, analysing, interpreting, and reporting data in research studies. In summary, research designs are plans and actions for research that include detailed methods of data collection and analysis. The study has adopted a descriptive qualitative research design to answer the research questions; collect, analyse, and interpret data, and get an in-depth understanding of how mental mathematics is being taught. Similarly, Dawson (2008) claims that descriptive qualitative research design attempts to get an in-depth understanding from participants concerning their attitudes, beliefs, and experiences. Furthermore, descriptive qualitative research design allows the researcher to study the phenomenon (in this case, it is the teaching of mental mathematics) as it occurs in natural settings without any intervention or manipulation of variables (Nassaji, 2015). In addition, descriptive qualitative research enables researchers to study things in their natural settings, attempting to make sense of or interpret phenomena, in terms of the meanings people bring to them (Nassaji, 2015). This is in line with Amaratunga et al. (2009) who emphasized that one major feature of the qualitative design is putting the focus on naturally occurring, ordinary events in natural settings so that there is a view of what "real life" is like. They further contend that qualitative data provide rich descriptions that are vivid, nested in a real-life context, and have a ring of truth. Furthermore, Salmons (2016) suggested that the inherent flexibility of qualitative studies gives further confidence that what has been going on is understood. Hence, the researcher should be flexible and confident enough to understand what is going on in my study.

The goal of this research is to explore teachers' teaching of mental mathematics in lower primary schools (standards 1–4) in Malawi. The study used different data sources to collect information to answer the research question of this study.

Table 1: Summary of research methods, data collection, and instruments

QUESTIONS	METHODS	TOOL
Question 1 How do teachers plan the teaching of mental mathematics?	• Interviewing mathematics teachers • Observing the lessons • Analysing the documents (lesson plans)	• Lesson observation guide • Document analysis guide • Interview guide.
Question 2 How do mathematics teachers teach mental mathematics?	• Observing the lessons • Interviewing mathematics teachers	• Lesson observation guide • Interview guide.
Question 3 What are teachers' views on mental mathematics?	• Interviewing mathematics teachers	• Interview guide

3.2 DATA COLLECTION INSTRUMENTS

Data was collected through a lesson observation guide, interview guide, and document analysis guide.

3.2.1 Lesson Observation Guide

The lessons were observed using the lesson observation guide. The observation guide was developed to suit the aim of the study and it was designed based on the principles of the teaching of mental mathematics. The guide was used to write the required information from the lesson plans and also from the class activities as the lesson progressed. The study chose to use the lesson observation guide to generate qualitative data while checking how teachers teach and invite learners to the mathematics lesson (see Appendix 3). Lesson observation helped me to obtain some more information that could not have been obtained through interviews. In addition, the guide was used to establish teachers' ability to demonstrate mastery of the content and principles of the teaching of mental mathematics in the curriculum.

3.2.2 Interview Guide

The guide involved open-ended questions each of which was focusing on one aspect of the topic. The questions were developed based on the research on mental mathematics. The interview guide had three parts, each answering one of the three specific research questions (see Appendix 2). The respondents were asked if the audio recorder could be used, and the respondents had no problem they accepted the request. Furthermore, the interview guide also helped me to get a general overview of how teachers view the teaching of mental mathematics in the newly proposed primary mathematics curriculum. Additionally, the interview guide was used to guide the sequential flow of the interview questions and also to make sure that the information provided answered the research question. The questions were answered by the participants orally. Therefore, the interviews were conducted with twelve teachers to generate data on the questions: how do teachers plan their mathematical lessons, how do teachers teach mental mathematics, and what knowledge and views do primary school teachers have about mental Mathematics?

The audio recorder was used to capture information that was missed during the writing of responses as the interview was in progress. The voice records were transcribed. The files were listened to carefully to make sure that no important data was missed.

3.2.3 Document Analysis Guide

A document analysis of the teachers' lesson guide was used to triangulate the information collected through lesson observation and interviews. In addition, document analysis provides first-hand information on the kind of written feedback from the teachers and the nature of the tasks they do (Cohen et al., 2007). Twenty lesson plans were photocopied (see Table 7), and mathematics workbooks and schemes of work were collected. In agreement with Merriam (2001) document analysis, as a data source is as good as lesson observation and interview. Merriam (2001) argued that document analysis has the potential to reveal information that the interviewee is not ready to share and also information that may not be available during observation and interviews (see Appendix 4).

3.3 PILOT STUDY

According to Teijlingen and Hundley (2001), a pilot study can provide a warning about where the main research project could fail, where research protocols may not be followed, or whether proposed methods or instruments are inappropriate or too complicated. The main objective of conducting this pilot study was to test the developed tools if they can help me in answering the research questions using responses from the participants. This was done at one school which was not in the sample, but it was one of the NNP-piloted schools in one of the districts of the Eastern region of Malawi. Three mathematics teachers were informed about the purpose of the study and volunteered to be observed during their teaching and later on interviewed as part of the pilot of the study. During the lesson observation, the observation guide proved to have included the required information that would provide answers to the research questions of the main research study.

After the pilot observations, a pilot interview with each teacher was conducted. The answers given in the interview with the teachers indicated that the interview guide provided useful information that could inform and help to answer the research questions of the study. Therefore, the study went on to collect data for the main research study using the same lesson observation and interview guides (refer to Appendix 3).

3.4 RESEARCH SAMPLE

Gill et al. (2010) defined a sample as a smaller set of data that a researcher selects from a larger population using a pre-defined selection method and sampling is the statistical process of selecting a subset of a population of interest for purposes of making observations and statistical inferences about that population.

A non-probability sampling, specifically purposive sampling was used in the selection of the schools, classes, and teachers. There are 204 primary schools on the pilot of the new curriculum. Out of 204 piloted schools only 3 schools, from one region out of the four regions in Malawi, where the study took place, and 12 teachers out of the many.

3.4.1 Selection of Participating Schools

Three schools in the Eastern region of Malawi were purposively selected. This is in line with Creswell's (2014) idea that the proximity of the research site provides easy access to participants and information. Participating schools were visited more than three times starting from the time consent was sought to the time data was collected. This is because in purposive sampling the researcher can select particular elements from the population that will be representative of the topic of interest based on the researcher's knowledge of the population. Similarly, Etikan et al. (2016) contend that judgment is made about which participants should be selected to provide the best information to address the purpose of the research. In concurrence, Cohen and Manion (1994) argued that in purposive sampling, the researcher handpicks the participants to be included in the sample based on their judgment of their typicality. This ensures that researchers build up a sample that is satisfactory to their needs. The study was based on the lower classes, standards 1 –4 because this is where the NNP curriculum is being piloted. Therefore, the selected schools were given codes as SX for school, SY for school, and SZ for school.

3.4.2 Selection of Participants

After the identification of schools was done, the head teachers at the schools were visited and briefed about the research. Thereafter, participating teachers were informed about the study, and consent forms to show that they willingly accepted to participate in the study were distributed and later collected. The study involved four teachers in each school (SX, SY, and SZ). A total of 12 qualified primary school mathematics teachers were involved as participants in the study. So, the virtual of being a Mathematics teacher in standards 1–4 and having undergone NNP training qualifies to be considered a participant in the study. The 12 primary school teachers who participated in the study were not forced to take part. The participating teachers were coded T1, T2, T3, … T12. Out of the 12 mathematics teachers, only 4 teachers from the three piloted schools had their lessons observed (standards 1 –4 teachers). These 4 teachers were purposively selected, one from each class (standards 1–4).

3.5 DATA COLLECTION TECHNIQUES

Fraenkel et al. (2012) observed that using a variety of strategies to collect data reduces biases and makes sure that there is no misinformation. Mukherji and Albon (2010) concluded that research which is usually concerned with describing experiences, emphasizing meaning, and exploring the nature of an issue in some detail uses qualitative techniques. Therefore, to answer the research questions for this study, data was collected through lesson observations, interviews with mathematics teachers, and document analysis as well as audio-recorded materials. These data collection techniques were chosen because they complement each other. Below is an explanation of each of the data collection techniques used.

3.5.1 Interviews

Mukherji and Albon (2010) described an interview as a method where one person asks questions to an individual or group of people with the expectation of getting answers to a particular question on a particular topic. They further added that interviews can be in three forms either structured, semi-structured, or unstructured. Interviews are classified according to the degree of flexibility that the interviewer has to probe and ask additional questions (Johnson & Christensen, 2008).

In agreement with Mukherji and Albon (2010), a structured interview follows a predetermined schedule without diverting from its sequence or question-wording in any way. Despite offering the potential for interviewing large numbers of participants whilst still generating manageable data sets, structured interviews may not capture sufficient detail or may fail to leave room for interviewees to provide important contextual information. This type of approach to interviewing may only generate a list of things people have said or be “simply a presentation of factors or realities about the world vocalized or reported upon by an informant without offering the opportunity to focus on influences and contextual structures that may be evident in peoples talk” (Sayer, 1992, p. 69). On the other hand, unstructured interviews, may not sufficiently cover all the details required to answer the research question. This type of interview involves collecting a wider spectrum of data as it is more flexible than the other two types.

For this study, a semi-structured interview was used as the main source of data collection. Semi-structured interviews were used because they allow one to be flexible and to diverge from the original. So, a semi-structured interview loosens participants to respond to interview questions without restrictions (Cohen et al., 2007). Additionally, semi-structured interviews gave me room for probing for clarifications where it was necessary. This is why the study chose to use this type of interview method to give flexibility to the interviewees and allow them to give as much information as necessary because semi-structured interviews remove all the restrictions. During the interviews, participating mathematics teachers explained their views on the teaching of mental mathematics and what is involved in their typical mathematics lesson. Responses to the probing and follow-up questions were also written down in the notebook. Interviews were conducted after all lesson observations were done on each teacher and they took about 10 to 15 minutes each.

3.5.2 Audio Recordings

Studies have shown that recorded interviews allow the interviewee and interviewer to develop and foster a better relationship and rapport during the proceedings, which led to the interviewee disclosing more detailed and in-depth information (Berazneva, 2013; Mary, 2008; Rita & Rohman, 2013; Sullivan, 2010). Sullivan (2010) observed that people avoided antagonising behaviours and built a better rapport with interviewees, which, in turn, produced less confrontation and more productive interviews.

According to Sullivan (2010), one of the primary benefits of recording an interview (audio or visual) is that it allows the interviewer to concentrate on the interview rather than writing notes, which can act as a distraction to both the interviewee and the person(s) asking the questions. This in turn often leads to a disjointed interview where key information can be overlooked, forgotten, or missed.

Concerning these benefits of audio recordings, the interviews were audio-recorded because audio recordings provide a more accurate record of what the teachers were saying as suggested by Sullivan (2010). For this reason, the audio recorder was used as a supplement instrument for preciseness and verification of the details that were noted during interviews.

3.5.3 Lesson Observation

Marshall and Rossman (2006) defined observation as the systematic noting and recording of behaviours and artifacts in the social setting chosen for a particular study. A total of 4 teachers out of the 12 coded T1, T8, T9, and T11, their lessons were observed. Teachers were observed teaching three times in each school. The lessons were observed three times to ensure that the lessons, were to answer the research question. It also assisted me to identify how the mathematics lessons were planned by actually observing them teaching. In support, Sandram (2016) states that the importance of observation is that the researcher generates information and behaviours that the participants are unwilling to disclose in an interview. Creswell (2009) also made a similar claim and added that observations are useful because the researcher can record information as it occurs. However, Creswell (2009) argued that during observation private and excess information may be observed. All the necessary ways of making sure that necessary information was strictly recorded, especially the information that will answer the questions under my study were made.

3.5.4 Document Analysis

Bowen (2009, p. 2) defined document analysis as “a systematic procedure for reviewing or evaluating documents both printed and electronic material”. In support, Corbin and Strauss (2008), explain that, like other analytical methods in qualitative research, document analysis requires that data be examined and interpreted to elicit meaning, gain understanding, and develop empirical knowledge. Similarly, Fraenkel and Wallen (2012) describe documents as written or printed materials that have been produced in some form. The following are some examples of documents that could be analyzed in schools: tests, registers, schemes of work, workbooks, lesson plans, and progress books. Research has shown that document analysis helps researchers to get hold of the initial language and words of the participants and it can reveal the information that the participant would not want to share during interviews (Corbin & Strauss, 2008; Creswell, 2009; Merriam, 2001). Therefore, the study used lesson plans, workbooks for the learners, and schemes of work as documents to be analyzed. Lesson plans were collected and photocopied for analysis. Going through the lesson plans, learners’ workbooks, and schemes of work were necessary for checking if teachers include mental mathematics in their mathematics lessons and if they use them according to their plans. Information obtained from the lesson plans helped answer the research question of the study.

3.6 DATA CONSTRUCTION

The study aimed at answering the main research question:

How do primary school teachers in three pilot schools view and teach mental mathematics in Malawi? The research question is guided by the three specific research questions that guided the collection of data.

1) How do teachers plan their mental mathematics questions?

The study was interested in finding out how teachers plan their mathematics lessons, and it was able to construct data based on how mathematics teachers prepare their lessons and how they select mental mathematics questions.

2) How do teachers teach mental mathematics?

The study was guided by this question to conduct lesson observation to find out how teachers provide learning opportunities for the learners to participate in the lesson. The data included opportunities in terms of structuring practices, learner-oriented practices, and enhanced activities. In the three categories, the study was able to look for the opportunities that teachers gave learners to explore and practice mental mathematics tasks.

3) What are teachers' views of mental mathematics?

The study was able to find out more about teachers' views and opinions regarding the introduction of mental mathematics in lower primary schools in Malawi. This question helped the study to find out if mental mathematics can have an impact on the teaching of mathematics.

3.7 DATA ANALYSIS

The main aim of data analysis was to make sense of the data that was collected. Cohen et al. (2007) described data analysis as a process of making sense of data in terms of participants' definitions of the situation, noting patterns, themes, categories, and regularities. They added that the data analysis process involves making sense of words, text, and image data and is more concerned with meaning. The data collected needs to be interpreted and conclude. Data analysis is the only means of drawing meaning to the collected data. Data collected in this study has been analysed using the MDI framework analysis. Adler and Ronda (2015), explain that the MDI system provides flexibility to use the data system to facilitate greater familiarity and immersion in the data, and eventually a better understanding of the insights and experience of the participants.

The audio recordings from the interviews that were captured as part of data collection were transcribed before the formal data analysis. As one way of getting familiar with the data, more time was spent with the research materials, reading and re-reading the transcripts and the field notes. The transcriptions were read and re-read and also listened to the audio recordings in trying to immerse into the data collected.

The MDI framework was developed to analyse the observed lessons in the classroom (Adler & Ronda, 2015). However, the MDI framework was used to analyse lesson plans and interviews because teachers mentioned tasks that could be used in classroom teaching. Tasks mentioned in the lesson plans and during the interviews were related to the teaching of the lesson with the known object of learning, hence it makes sense to evaluate the tasks mentioned in the lesson plans and during interviews using the MDI framework as if the tasks were used in the real classroom teaching. In addition, what the teachers wrote in the lesson plan reflected what they would do if it was the actual teaching in the classroom since they used the same lesson plan for their actual teaching.

Data from interviews were analysed using the framework because if teachers were to teach the way they responded during the interviews, their teaching would have been analysed using the MDI framework.

Data from the lesson plans and the interviews provided enrichment to the data from the classroom. After the transcription of the audio recordings, and being familiar with the whole set of data, coding proceeded using the MDI framework. Data analysis was done following the research questions based on the elements of the MDI framework which are: exemplification, explanatory talk, and learner participation (Adler & Ronda, 2015).

3.7.1 Exemplification

According to Ronda and Adler, (2016), tasks must have the potential to engage the learners to make connections among features of mathematical content. The first level of analysis was identifying and creating a list of tasks indicated in the documents narrated during the interviews and what was observed in the lessons. To conduct this, data derived from the document analysis, and some from lesson observations were analysed. Each teacher’s response to each question was carefully coded into categories depending on the questions on the instrument. The guiding question was based on the first research question:

How do teachers plan mental mathematics?

Following the MDI framework, the task level is limited to high and low cognitively demanding tasks with emphasis on three categories based on Watson and Mason's (2006) ideas on variance, similarity (S), and contrast (C). These three categories are based on the idea that cognitive demand increases as the connections between the concepts and procedures become more complex and intertwined. Therefore, tasks that require learners to carry out known (K) operations or procedures are classified as level 1, tasks that require K and some application (A), and these are classified as level 2, and tasks with K and/ or A and C/PS are classified as level 3 (Adler & Ronda, 2015).

3.7.2 Explanatory Talk

Teachers' classroom practices were explored using the second level of analysis through the categories of explanatory talk. The analysis was guided by the second research question of the study:

How do the teachers teach mental mathematics?

Teachers' explanations were unfolded through talk, and the levels and distinctions which were empirically derived through the examination of audio recordings and lesson observations were distinguished. It was distinguished as naming and legitimating in agreement with Adler and Ronda (2015).

Naming

Adler and Ronda (2015) defined naming "as the use of words to refer to other words, symbols, images, procedures or relationships" (p. 244). Naming is considered the use of colloquial, non-mathematical (NM), and mathematical words within and across episodes of a lesson either mathematical words used or reading strings of symbols (MS), or formal mathematical language used (MA). It is categorised into levels. In level 1, the talk is colloquial, and non-mathematical whereas in level 2, mathematical language is used appropriately, and there is movement between NM and MS, some MA, while in level 3 is where there is movement between NM and MA. As a researcher more attention was paid to the teachers' discourse shifts between colloquial and mathematical word use.

Legitimate

Legitimating is when a teacher refers to mathematics to explain something (Adler & Ronda, 2015). What is legitimated in an episode is key to being able to describe the mathematics made available to learn through explanatory talk, as well as reach a summative judgment on naming and legitimating as these accumulate over time in a lesson. The legitimating criteria are nonmathematical (NM) if there is everyday knowledge (E), visual cues (V), and assigning authority to the position (P) of the speaker of the statement, the teacher. NM in legitimation is classified as level 0. Criteria of what counts as mathematical that is particular or localised are (L) and level 1, another criterion is where there is partial generality (PG), and full generality (FG). Level 2 is where the legitimating criteria are beyond NM, and L and include PG. Level 3 is where the criteria are FG (Adler & Ronda, 2015).

Here the interest was to find out whether the criteria teachers transmit as an explanation for what counts is or is not mathematical, is particular or localised, or more general, and then if the explanation is grounded in patterns, procedures, and rules of the teaching of mental mathematics.

3.7.3 Learner Participation

Learner participation is about doing mathematics and talking about mathematics. When learners are given opportunities to answer yes/ no questions or offer single words to teachers unfinished sentences, it is (Y/N), where learners answer what/ how questions in phrases/ sentences are (P/S), and opportunities for learners to answer why questions, present ideas in discussion, teacher revoices, confirms, and asks questions is (D) (Adler & Ronda, 2015). Learner participation is specifically about whether learners have opportunities to speak or non-verbally display mathematical reasoning. Learner participation also seeks to find out if learner activity builds towards the learning goal. Table 2 is the summary of how the coding was done in a table form:

Table 2: List of codes for exemplification (Adler & Ronda, 2015)

Code for exemplification	
Examples	**Tasks**
Similarity: Experiencing one form of variation coded **S**, and level **1**	Across the lesson, learners are required to: Use of known operations and procedures coded **K**, and level **1** e.g., add, subtract, multiply, and divide.
Contrasting: Experiencing two forms of variation coded **C**, and level **2**	Application of known skills, or decide on an operation to use coded **A**, and level **2**
Fusion: Experiencing more than two forms of variation, coded **F**, and level **3**	Use of multiple concepts and making multiple connections, coded **C**/ **PS**, and level **3**
Level **0**: Experiencing no patterns observed hence no similarity nor contrast.	Level **3** or **2** is reduced to level **1** if it unfolds. **C/ PS→ K,** level **1** and to level 0 when no pattern is shown.

Table 3: List of codes for explanatory

Coding for Explanatory Talk	
Naming	**Legitimating**

Word use is colloquial, nonmathematical, coded **NM**, and level **1**	Criteria are non-mathematical, coded **NM**, and level **0**
Mathematics word used as names only coded **MS** and level **2** where there is **NM** and **MS**, and some **MA**	Criteria are localized, coded **L**, and level **1** Criteria counts as having partial generality, coded **PG**, and level **2** if criteria are beyond **NM**, **L**, and have **PG**
Mathematical language used appropriately coded **MA** and is level **3** when there is movement between **NM** and **MA**	Criteria are of full generality, mathematics legitimating is proved, coded **FG**, and level **3**
Level **0**: Experiencing no similarity and no contrast.	Level **3** or **2** is reduced to level **1** if it unfolds. **C/ PS→ K,** level **1** and to level 0 when no pattern is shown.

Table 4: List of codes used for learner participation

Coding of Opportunities for Learner Participation
To speak **yes/ no,** or single words to teachers' sentences, coded **Y/N**, and level **1** To speak some phrases and sentences in more than one episode, answering what/ how questions, coded **P/S**, and level **2** Some discussions in more than one episode, why questions, teacher revoices, coded **D,** and level **1**

3.8 VALIDATION AND RELIABILITY OF RESULTS

Researchers believe in having confidence in their data and also those who read their work have confidence in the researcher's findings. To ensure validation of the results from this study, triangulation was used. Creswell and Poth (2018) described triangulation as a method where researchers make use of multiple and different data sources, methods, investigators, and theories to provide corroborating evidence for validating the accuracy of the findings of the study. In this respect, the study used data collected from different sources to answer the research question to understand it better and make meaning of it. A variety of data sources were also used to ensure that the analysis, explanations, and findings were done through a variety of lenses. The data sources were cross-referenced as follows:

1. Teachers' contexts and realities. These were from direct quotes from the audio recordings of teachers' interviews which were used to frame how they plan their lessons and teach mental mathematics.

2. The teacher's view of mental mathematics through interviews (direct quotes from the audio recordings) which were mapped to exact moments in their lessons (verbatim of audio recordings).
3. Direct quotes from audio recordings of the lesson observation and the corresponding verbatim lesson observation.
4. The final analysis summary was supported by direct quotes from the teacher's audio recordings of the interviews.

Data triangulation was done to obtain rich data from different sources that would provide a deeper understanding of individual participants' actions and views. Noble and Heale (2019) stipulate that the triangulation of data sources helps to increase the reliability and validity of the research findings by ensuring that fundamental biases that arise from a single observer are overawed.

3.9 ETHICAL CONSIDERATIONS

When conducting a study, it is important to consider some ethical protocols and it is the responsibility of the researcher to be aware of the ethical issues that may arise while conducting the research (Cohen et al., 2007). The study involved four teachers whose lessons were observed, and 12 teachers were interviewed in three piloted primary schools. According to Huma-Vogel (2008), research is a moral and ethical enterprise and should aim at ensuring the privacy and interests of research participants to avoid inflicting harm on them for taking part in the study. Given this, ethical issues were considered in the study at two levels namely, informed consent and confidentiality and anonymity.

Authorizing from the Norwegian Centre for Research Data (NSD) to conduct the study was sought and permission to carry out the research project was given (refer to Appendix 1). Processing of personal data had been done following the principles under the General Data Protection Regulation of the NSD. Bearing in mind that all primary schools in a district are under the administration of the District Education Manager in Malawi, permission was also sought from the District Education Manager's office (see Appendix 5). The Primary Education Advisors for the piloted schools were visited and permission was granted to conduct the research in their area. Upon arriving at each school, a courtesy call to the head teacher's office was made where the researcher introduced himself, explain the study project and its purpose, and show copies of permission letters obtained from the University of Malawi and the University of Stavanger, District Education Managers, and Primary Education Advisors offices to conduct the study at any of the schools.

The teachers participated in the study of their own will without feeling threatened. As suggested by Schumacher and Macmillan (1993) that the investigator should inform the participants of all aspects of the research that might influence their willingness to participate and answer all inquiries of participants on features that may have adverse effects or consequences. The researcher explained the purpose of the study and the required time and commitment. Furthermore, Neuman (2003) explains that participants have rights and should therefore be given a chance to make informed decisions about whether to participate or not. Personal names and school names have been replaced by codes or pseudonyms. Each participant was assured of the confidentiality of their information and their anonymity. Teachers' data was treated with confidentiality and by data protection legislation. The anonymity of schools and participants was ensured by the use of codes on all research documents as well as in this thesis. The three schools that participated in the study were coded, and the twelve teachers from the schools were identified by codes.

After analysing the audio recordings of interviews, the audio recordings' files were deleted, and only anonymized text is kept after the research project. The participants were briefed in detail about their freedom to withdraw if they no longer wished to continue participating in the study.

3.10 CHAPTER SUMMARY

This chapter has given a description of the design that the research study has used, how the pilot study was conducted, the sample size and how the sample was generated, how data was constructed, the instruments which were used to collect data, how the instruments were administered, the validity and reliability of the methods for collecting data and data analysis. It has also looked at the ethical considerations and limitations of the study. 12 participants took part in the study. All 12 teachers were interviewed, and out of 12, only 4 teachers, their lessons were observed. Using the methods outlined in this chapter, data was collected and analysed, using the MDI framework, and the findings are presented in the next chapter.

CHAPTER 4: ANALYSIS OF DATA AND FINDINGS

4.0 CHAPTER OVERVIEW

This chapter provides details of the analysis and the findings of the study from the twelve mathematics teachers. Firstly, the study presents a summary of teachers' demographics, data from document analysis, and data from the interviews of the twelve teachers. Then data from the lesson observation for the four teachers from the three schools. Lastly, the study presents data from lesson plans. Within each section, data were analysed using the four components of the MDI framework guiding the study as described in the method chapter.

4.1 SUMMARY OF TEACHERS' DEMOGRAPHICS

4.1.1 Teachers' Age and Gender

The study included 12 teachers from the three selected schools. Teachers were of all ages and genders. The study included 4 teachers from each school. Table 5 shows the age and gender of teachers.

Table 5:Age and Gender

Gender	Age in years				
	20-30	31-40	41-50	More than 50	Total
Female	1	4	3	1	9
Male	0	1	2	0	3
Total	1	5	5	1	12

4.1.2 Teachers' Experience and Gender

Before the intervention of NNP, some teachers took advantage of their experience in teaching mental mathematics. The study included teachers of various ages and experiences. Table 6 displays the age and experience of the teachers.

Table 6:Experience and Gender

Gender	Experience in years					
	0-5	6-10	11-15	16-20	More than 20	Total
Female	1	2	3	0	3	9
Male	0	1	0	0	2	3
Total	1	3	3	0	5	12

4.2 Research question 1: How do teachers plan mental mathematics?

4.2.1 Results from Document Analysis

In this section, the study will present data from the analysed twenty lesson plans on mental mathematics. Data from documents such as schemes and records of work, learners' workbooks, and teacher guides were also analysed using a document analysis guide. In analysing the documents, the study was looking for the exemplifications, the explanations, and the learner participation. These are aspects of the MDI framework which is the theoretical framework informing the study. In addition, the study was looking for the lesson structure to answer research question number 2, which is about how mathematics teachers plan their mental mathematics lessons. This meant working through the selected documents to identify tasks and learners' participation activities that teachers used or planned to use in the teaching of mental mathematics. Finally, an interpretation of the data was made. Interpretation in this respect simply means making sense of the findings attaching meanings, offering explanations, and drawing conclusions on the same. The sections that follow present what the study found in these documents. Table 7 shows a summary of lesson preparation for the teaching of mental mathematics.

Table 7: Summary of planned lessons for the four teachers

Gender	No. of lessons planned	No. of lessons observed
Female	15	9
Male	5	3
Total	20	12

After reviewing the documents, the study revealed that some teachers do not teach mental mathematics to their learners daily. One of the NNP curricula aims is to encourage and improve mathematics performance through the introduction of mental mathematics in the early years of learning. Many of the lesson plans were discovered to have gaps in the mental mathematics plan page, indicating that teachers do not teach mental mathematics daily, in contrast to the NNP curriculum, which states that mental mathematics should be practiced daily as a routine. This was discovered in some lesson plans(see Figure 2). The study also revealed that not all teachers completed all 20 mental mathematics tasks. They skip some questions, and the questions are asked quickly. However, this is consistent with one of the concepts of teaching mental mathematics, the speed principle.

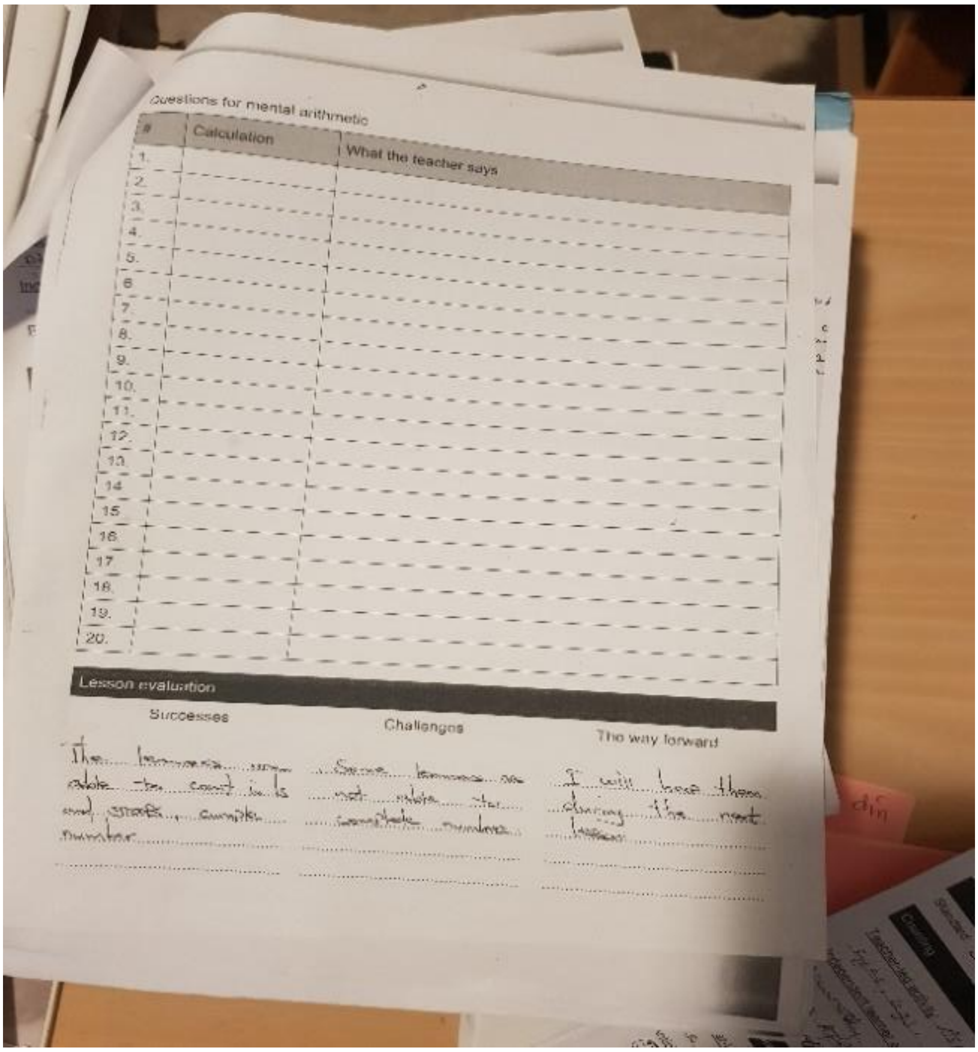
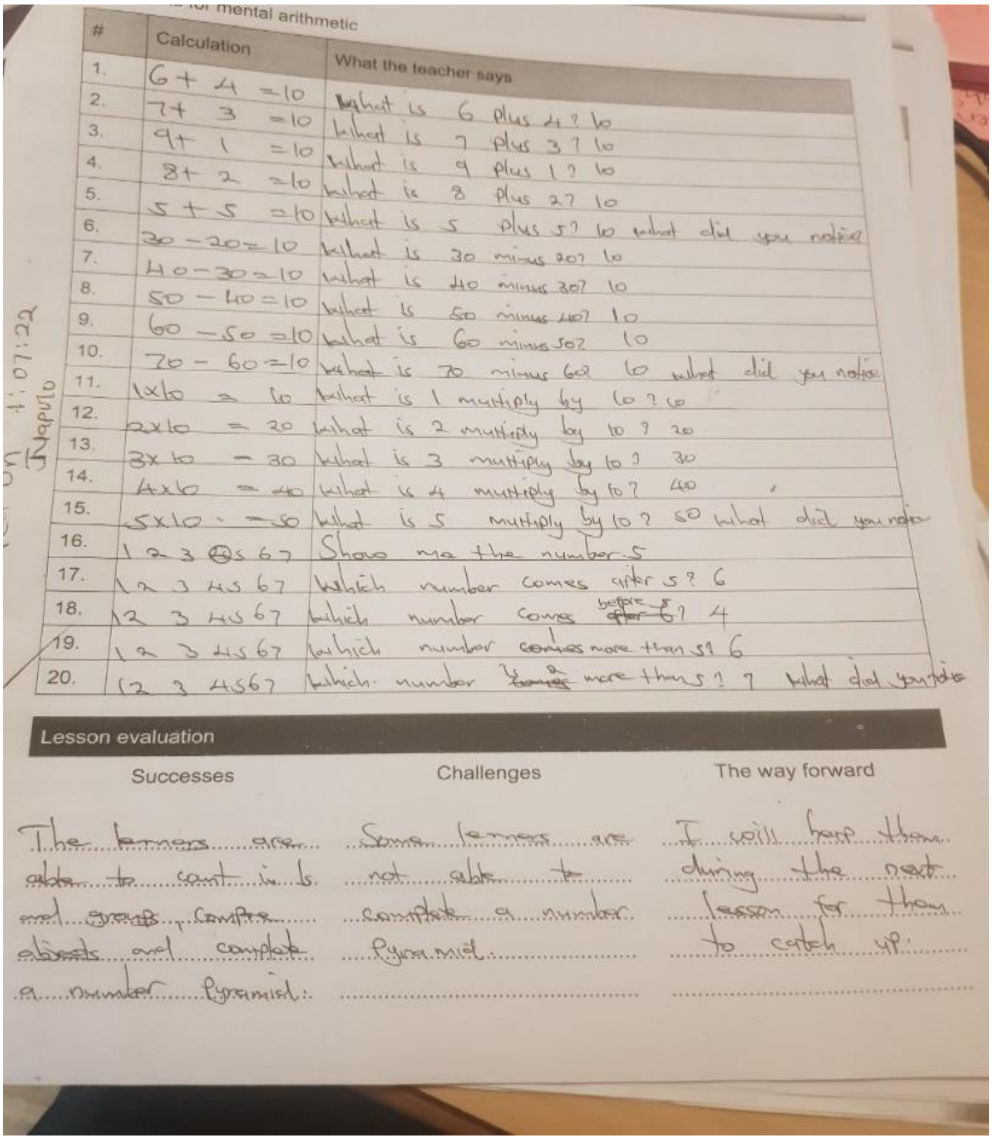


Figure 2: A blank plan for mental mathematics

4.2.2 Exemplification

It was found that all the mental mathematics plans were guided by the activities from the teachers' guides and learners' workbooks. This confirmed what teachers said during the interviews.

According to the study, 4 teachers that were observed planned all 20 questions in their lesson plan book. It was also revealed that the question format defines the mental mathematics skill that will be the emphasis of the activity. The ranges of numbers in which the class is operating. For example, as the class level advances, 2-digit numbers, 3-digit numbers, and 4-digit numbers are used. In the reflection on lesson plans, it was observed that after each set of 5 questions, teachers wrote the reflection question "What have you noticed?" before the next set of questions. This was done to support the development of learners' thinking and understanding of the number facts. (refer to Figure 3).



... for mental arithmetic

#	Calculation	What the teacher says
1.	6 + 4 = 10	What is 6 plus 4? 10
2.	7 + 3 = 10	What is 7 plus 3? 10
3.	9 + 1 = 10	What is 9 plus 1? 10
4.	8 + 2 = 10	What is 8 plus 2? 10
5.	5 + 5 = 10	What is 5 plus 5? 10 what did you notice
6.	30 − 20 = 10	What is 30 minus 20? 10
7.	40 − 30 = 10	What is 40 minus 30? 10
8.	50 − 40 = 10	What is 50 minus 40? 10
9.	60 − 50 = 10	What is 60 minus 50? 10
10.	70 − 60 = 10	What is 70 minus 60? 10 what did you notice
11.	1x10 = 10	What is 1 multiply by 10? 10
12.	2x10 = 20	What is 2 multiply by 10? 20
13.	3x10 = 30	What is 3 multiply by 10? 30
14.	4x10 = 40	What is 4 multiply by 10? 40
15.	5x10 = 50	What is 5 multiply by 10? 50 what did you notice
16.	1 2 3 4 5 6 7	Show me the number 5
17.	1 2 3 4 5 6 7	Which number comes after 5? 6
18.	1 2 3 4 5 6 7	Which number comes before ~~after~~ 5? 4
19.	1 2 3 4 5 6 7	Which number comes more than 5? 6
20.	1 2 3 4 5 6 7	Which number ~~comes~~ more than 5? 7 what did you notice

Lesson evaluation

Successes	Challenges	The way forward
The learners are able to count in 1s and group, compare objects and complete a number pyramid.	Some learners are not able to complete a number pyramid.	I will help them during the next lesson for them to catch up.

Figure 3: A sample part of the NNP lesson plan for standard 1

The study revealed that the questions in the lesson plans were typically posed in sets of 5 questions. The 5 questions in the set were deliberately designed to reveal a pattern. For example, the tables below (adapted from the NNP teachers' guide) shows the types of patterns that were used.

Table 8: Pattern 1 single-digit mental mathematics questions(adapted from NNP teachers guide)

Standard 1 and 2 questions	Standard 3 and 4 questions
• What is 5 plus 1? • What is 4 plus 2?	• what is 25 plus 1? • what is 34 plus 2?

• What is 3 plus 3? • What is 2 plus 4? • What is 1 plus 5? • What did you notice? So, what is 30 plus 30? Explain.	• what is 43 plus 3? • what is 52 plus 4? • what is 61 plus 5? What did you notice? So what is 430 plus 30? Explain.

Table 9: Pattern 3 Adding and subtracting to multiples of 10 (place value)

Standard 1 and 2 questions	Standard 3 and 4 questions
• What do we need to add to 10 to get 12? • What do we need to add to 20 to get 22? • What do we need to add to 30 to get 32? • What do we need to add to 50 to get 52? • What do we need to add to 60 to get 62? • What did you notice? So, what do we need to add to 60 to get 70?	• What do we need to add to 100 to get 152? • What do we need to add to 150 to get 152? • What do we need to add to 102 to get 152? • What do we need to add to 2 to get 152? • What do we need to add to 50 to get 152? • What did you notice? So, what do we need to add to 84 to get 684? Explain.

Table 10: Bridging 10s and multiples of 10

Standard 1 and 2	Standard 3 and 4
• 8 plus what is 10? • 2 plus what is 7? • What is 8 plus 7? • What is 8 plus 5? • What is 8 plus 9? • What did you notice? So, what is 6 plus 7? Explain. Standard 1 and 2 question • What is 23 minus 5? • What is 33 minus 5?	• 80 plus what is 100? • 20 plus what is 35? • What is 80 plus 35? • What is 80 plus 45? • What is 80 plus 59? • What did you notice? So, what is 60 plus 58? Explain. Standard 3 and 4 questions • What is 226 plus 8? • What is 236 plus 8?

• What is 43 minus 5? • What is 53 minus 5? • What is 83 minus 5? What did you notice? So, what is 83 minus 15? Explain.	• What is 246 plus 8 • What is 246 plus 18? • What is 246 plus 28? • What did you notice? So, what is 24plus 438? Explain.

4.2.3 Explanatory **Talk**

The lesson plans showed that teachers had planned to discuss with learners how they can identify the number patterns noticed in the sets of questions. The results show that if teachers were to reflect on how the sets of questions work with the learners in a real classroom situation, then, the explanatory talk would have been classified as level 3, and coded D according to the MDI framework (2015). (Refer to Table 3).

4.2.4 Learner Participation

From the analysis, the study found that all teachers planned to involve their learners through interaction in their lessons. All lesson plans were planned in the same way that the learners were given a chance to participate through a question-and-answer strategy.

4.2.5 The Structure of the NNP Curriculum Lesson Plan

The lesson structure was another aspect that the study was interested in. It was observed that all 12 teachers structured their lessons in the same way. All teachers started with the counting of numbers, followed by problem-solving, and finally the manipulation of numbers. This was the same as what was noted from the interviews with the teachers, they all reported a similar structure. This similarity in lesson structure could be because the teachers use a structure that is suggested in their mathematics teachers' guide and workbook.

The study's focus was on the last section manipulating numbers. This is where mental mathematics is based. In this section, it was found that manipulating numbers typically consists of 20 oral questions. Teachers pose the questions one by one with the learners responding as rapidly as possible. The actual questions to be posed were listed both in words and as the calculation presented by the question (refer to Figure 4).

4.3 Results from Interviews with Mathematics Teachers

The interviews were set to answer three research questions of this study, and an interview guide with questions guided by the research questions was used. Some of the questions asked to the interviewee were guided by the teaching as it was observed during the lesson observations. The interviews were semi-structured, as such, some questions asked were follow-up questions and modified questions depending on the responses given by teachers. For each teacher, the data was presented and analysed using the MDI framework but presented based on the research questions of the study. The following were the research questions that were addressed through interviews:

1. How do teachers plan mental mathematics?
2. How do teachers teach mental mathematics?
3. What are the teachers' views on mental mathematics?

In research question 1, the study wanted to find out how teachers plan their lessons. In research question 2, the main focus was on the teaching and learning process. Finally, research question 3 aimed to find out the teacher's views on the introduction of mental mathematics in the lower primary. Teachers were allowed to respond in the language they felt comfortable with, and they chose to respond to the questions in English and the local language. The raw data from the interviews with mathematics teachers and data from audio recordings were prepared for analysis by transcribing. Transcription was done by translating data from an oral language to a written language then listening to the audio while reading and comparing it with the written text.

4.3.1 Exemplification

During the interviews, teachers were asked how their lessons are planned. All teachers mentioned something about the planning and selection of mental mathematics tasks given to learners. This is in line with exemplification as one of the elements of the MDI framework. The study found that mental mathematics questions are planned to what is in the teacher's guide and learners' workbook. The following verbatim excerpts represent what T1 reported:

T1: Yes, I prepare the mental mathematics questions according to the topic given in the workbook.

Similar views were also given by all the other teachers. The following verbatim excerpts represented what some teachers reported:

T 10: Aaah, we prepare our work from the work page in their workbook. We look at the work on the work page.

T12: In mental mathematics, we ask learners oral mathematics questions so that they answer orally using their heads in one to two minutes. We ask questions in 5 sets. For example, we ask them how many groups of 10, groups of 5, or groups of 4 but they should be 5 in that set. We prepare 20 of them but in sets of 5.

It was found that all teachers listed the number of questions they expect to ask per day as specified in the NNP curriculum. They indicated that they plan up to 20 questions per day, with the planning influenced by the day's written manipulating number task in the learners' workbook and teachers' guide.

Teachers were also asked to explain how they select mental mathematics questions. It was discovered that all teachers reported the same methods for selecting and planning mental mathematics questions. They stated that they construct their mental mathematics questions based on the work plan for the day. The following is what other teachers commented:

T5: We prepare the questions with the teacher's guide's help so that they can practice them. So, I prepare up to 20 questions, which is the limit for standard 3 following the work plan.

T11: We prepare 20 questions, and we plan the questions in sets of five.

The study found that all teachers have to prepare their questions based on the day's work guided by the teacher's guide. The following verbatim excerpts represented what some teachers reported:

T8: Most of the time we create our questions from the teacher's guide depending on the day's activity.

T10: We create and plan the mental mathematics questions to fit the learners' level and age guided by the teacher's guide.

4.3.2 Explanatory Talk

Teachers were also asked to describe how they decide what explanations to give on a given mental mathematics question. Teachers participate in explanations by responding to questions such as "What do you notice?" to demonstrate to learners the pattern drawn from a set of questions. It was discovered from their descriptions that teachers have diverse approaches to explaining concepts. Teacher T4 said:

T4: Our explanations are more guided by the teacher's guides we are using now after a set of 5 questions there is a need to ask learners to explain what they notice and if they fail it is when we intervene to explain to them.

It was found that as the teachers are deciding the type of explanation to be given to the learners, teachers also think of the level of understanding of their learners. Teachers' responses about how they decide on what explanations to give to learners are given in the following verbatim excerpt:

T2: The way I start with my mental mathematics lesson determines how I will explain concepts during the questioning time. I may change my approach to asking questions depending on how the learners are responding.

T4: For me in standard 4, *ndimaona kakhonzedwe ka ana anga mkalasi* [I check how my learners are performing]. Sometimes they write in the teachers' guide the way to go with the explanation, but I consider the performance of my learners. For example, there are some learners that even if you teach and explain well, it is hard for them to grasp the concept, so I need to be mindful of that.

T7: It is not easy, sometimes it depends on how you plan and presents your questions. *Ana ako umawadziwa wekha* [You know your learners].

T8: We consider the age range of our learners, though the NNP curriculum is having a different insight. Most of them are very young so we don't ask them questions using hard English, learners don't understand what you are saying, so we use language that is easy for them to follow.

Teachers were also asked to describe how they involve learners in their lessons. Individual learners were involved by teachers asking them oral questions from mental mathematics tasks as given in the following verbatim excerpt:

T1: By asking them questions. Or else I walk around in the class and nominate a learner to stand to see if he/she can answer the question.

T10: Sometimes learners are asked to explain orally to the class how they have arrived at the answer.

It was also noticed that learners were asked to read and count numbers from the chart paper, as such, learners were invited to participate through speaking. The study also found that the questions the teacher asked during the mental mathematics lesson required learners to answer Yes/ No answers (choral responding), for example, the teacher would ask learners, “Are you following?”, “Are we together class?” and at other times what and how questions, for example, the teacher could ask learners, what number comes after 20, and learners individually would answer 21. Teachers used what and how questions where learners could say some phrases and sentences. Therefore, learner participation was Y/N, P/S and this is classified as level 2 based on the MDI framework (Adler & Ronda, 2015). Some responses that teachers gave about how they invite learners into the lesson are given in the verbatim excerpts:

T6: No, not all the questions are responded to by the learners. They just respond to maybe three to four questions. *Mmene zitengera kwa ana amene ali achangu pochita zinthu eti. Kwa ma ena ndi amene amayankha mwina umati ukafunsa funso upeza kuti amodzi modzi omwewo ndi a mene akumayankha mafunsow*o [most of the times the same learners are the one answering the questions]. *Ana ambiri sachita participate ndiye sindinganene kuti ndi positive response ayi, pokhapokha mwina ikakhala ya timanambala tochepa* [many learners do not participate in answering the questions, so I cannot say it is positive unless there are small numbers].

T9: *Si ana onse mkalasi amene amayankha mafunso amapezeka kuti ana amodzi modzi omwewo ndi amene akuyankha mafunso nthawi zonse* [Not all learners answer the questions in class, they are always the same learners answering the questions].

T11: For standard four *ana ambiri akumayankha mafunso ndithu ndipo akumatha kubweretsa njira zawo zimene afikira pa answer monga momwe mwaonera mkalasi muja* [in standard 4, many learners can answer mental mathematics questions correctly, and they also do bring their methods of approaching a problem].

T12: Some do respond well, and the majority do not.

4.4 Research question 2: How do teachers teach mental mathematics?

This section presents the results of lesson observations. Four teachers were selected from the study's 12 participants to participate in lesson observation. The teachers were selected on purpose for their roles as class teachers. Three times, each teacher was observed. A lesson observation guide was used to record and observe how they teach. More emphasis was placed on the activities that took place during the lesson, particularly how the teachers asked questions and invited learners to participate.

4.4.1 Results from Lesson Observation

Research question 2 was answered through lesson observation. Four mathematics teachers were observed while teaching. A total of 12 mathematics lessons were observed. Each teacher was observed three times to have a good picture of the classroom situation (teacher T1 from SZ, teacher T8 from SX, teacher T9 from SY, and teacher T11 from SY). Data analysis was guided by the MDI framework. Table 11 below shows the number of questions the four teachers planned and implemented during the lesson observations.

Table 9: Number of mental questions planned and implemented during observation

	No. of mental questions planned			No. of mental questions implemented		
Teacher	Lesson 1	Lesson 2	Lesson 3	Lesson 1	Lesson 2	Lesson 3
T9 standard 1	20	20	20	20	15	20
T1standard 2	20	20	20	14	16	11
T11 standard 3	20	20	20	15	20	20
T8 standard 4	20	20	20	14	20	14

4.4.2 Lesson Observation in Standard 1 at School SY

T9: (in standard 1 at school SY) conducted her lesson on mental mathematics and it was found that she provided learners with time to think and respond to the question posed. The teacher was able to explain some concepts and procedures. It was observed that only a few learners were raising their hands to respond to the questions. The teacher prepared 20 mental mathematics questions in the three lessons following the learner’s workbook. She managed to finish all 20 mental mathematics tasks in lessons 1 and 3 and managed to ask 15 questions in lesson 2 (see Table 9), though some questions were not answered by the learners. The learners were called by their names and asked to present the solution verbally. Learners were able to explain the procedures and what happens to every set of questions in a pattern.

The study observed that mental mathematics is there to act as a preparatory exercise for the main lesson because it was linked to the main task of the day. The study noticed that few learners volunteered in answering the questions. The non-volunteers were not given a chance to attempt in answering the questions. Learners were able to explore what they noticed in the sets of questions. The following verbatim excerpts represented what was observed as part of the standard1 lesson 1 observation:

T9: It's time for mathematics as usual we are going to start with mental mathematics. Show me the number 23 from the chart. Yes, stand up

L: This is 23 pointing at number 23 on the chart

T9: Good. Which number comes after 23? Yes

L: 24

T: Good. Which number comes before 23? Yes.

L: 22

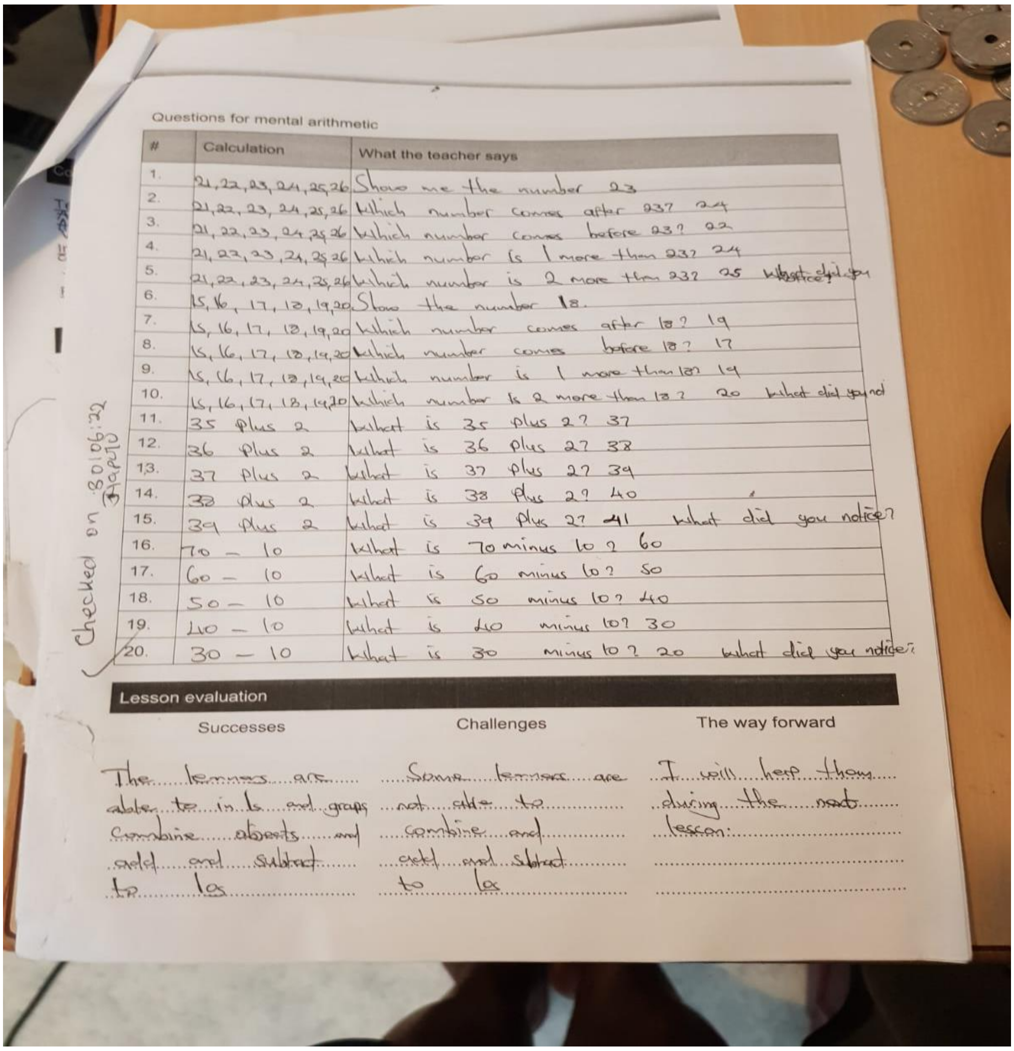
T9: Ok, which number is 1 more than 23? Yes

L: 24

T9: Yes good. Which number is 2 more than 23? Yes

L: 25

T9: Yes, excellent. Now, what have noticed? Who can explain? Yes, you



Questions for mental arithmetic

#	Calculation	What the teacher says
1.	21, 22, 23, 24, 25, 26	Show me the number 23
2.	21, 22, 23, 24, 25, 26	Which number comes after 23? 24
3.	21, 22, 23, 24, 25, 26	Which number comes before 23? 22
4.	21, 22, 23, 24, 25, 26	Which number is 1 more than 23? 24
5.	21, 22, 23, 24, 25, 26	Which number is 2 more than 23? 25 what did you
6.	15, 16, 17, 18, 19, 20	Show the number 18.
7.	15, 16, 17, 18, 19, 20	Which number comes after 18? 19
8.	15, 16, 17, 18, 19, 20	Which number comes before 18? 17
9.	15, 16, 17, 18, 19, 20	Which number is 1 more than 18? 19
10.	15, 16, 17, 18, 19, 20	Which number is 2 more than 18? 20 what did you notice
11.	35 plus 2	What is 35 plus 2? 37
12.	36 plus 2	What is 36 plus 2? 38
13.	37 plus 2	What is 37 plus 2? 39
14.	38 plus 2	What is 38 plus 2? 40
15.	39 plus 2	What is 39 plus 2? 41 what did you notice?
16.	70 – 10	What is 70 minus 10? 60
17.	60 – 10	What is 60 minus 10? 50
18.	50 – 10	What is 50 minus 10? 40
19.	40 – 10	What is 40 minus 10? 30
20.	30 – 10	What is 30 minus 10? 20 what did you notice?

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Lesson evaluation

Successes	Challenges	The way forward
The learners are able to in ls and groups combine objects and add and subtract to 10s	Some learners are not able to combine and add and subtract to 10s	I will help them during the next lesson.

Figure 4: List of NNP mental mathematics questions for standard 1

4.4.3 Lesson Observation in Standard 2 at School SZ

From the lesson observation of teacher T1 in standard 2, it was observed that the teacher planned all 20 questions in the three mental mathematics plan pages. However, the teacher did not finish all the questions she planned. She managed only 14 questions out of 20 in lesson 1, 16 questions in lesson 2, and 14 questions in lesson 3 (see Table 9). It was found that only a few learners participated by offering their answers whilst the rest were able to follow and understand the lesson. It was noted that only learners who raised their hands were the ones called by the teacher to answer the questions. The rest of the questions were answered by the teacher. The following verbatim excerpts represented what we observed in standard 2 during the part of lesson 1 observation (see figure 6):

T1: What are 2 groups of 5? yes

L: 10

T1: Ok, good. What are 3 groups of 5? Yes, you!

L: 20.

T1: No, the answer is 15. What is 4 groups of 5? You!

L: It is 20

T1: Yes, good. What have you noticed?

L: [silence]

T1: Class the numbers are increasing by 5

T1: What is 5 multiplied by 10? (After the waited time the teacher called one learner who raised his hand).

T1: Yes

L: 50

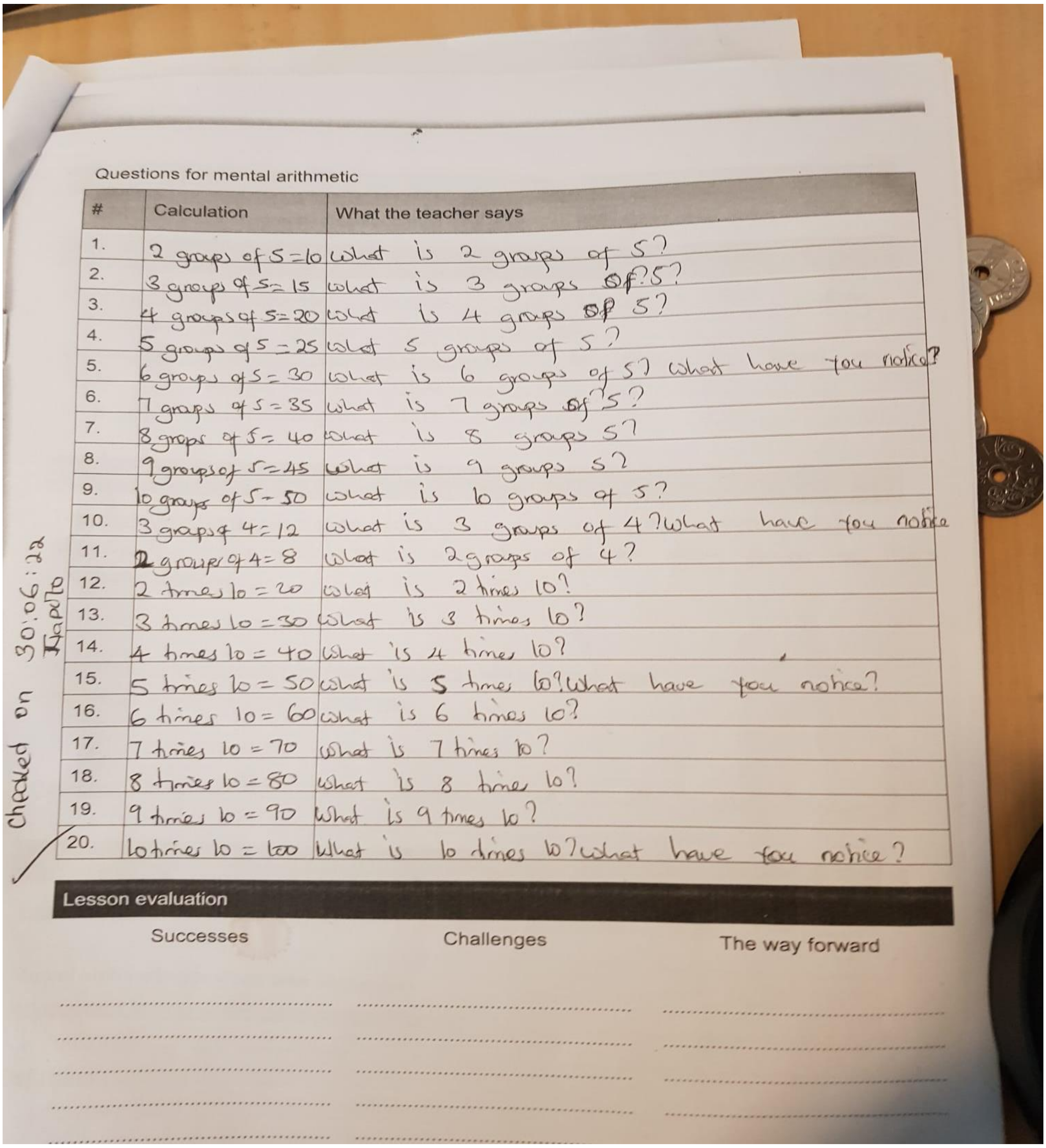
T1: Good. What is 6 multiplied by 10

L: 60

T1: Good. What have you noticed?

L: *Akumaonjezereka ndi 10*[they are increasing by 10].

T1: Good. Indeed, the numbers increased by 10 in each case.



Questions for mental arithmetic

#	Calculation	What the teacher says
1.	2 groups of 5 = 10	What is 2 groups of 5?
2.	3 groups of 5 = 15	what is 3 groups of 5?
3.	4 groups of 5 = 20	What is 4 groups of 5?
4.	5 groups of 5 = 25	What 5 groups of 5?
5.	6 groups of 5 = 30	What is 6 groups of 5? What have you notice?
6.	7 groups of 5 = 35	What is 7 groups of 5?
7.	8 groups of 5 = 40	What is 8 groups 5?
8.	9 groups of 5 = 45	What is 9 groups 5?
9.	10 groups of 5 = 50	What is 10 groups of 5?
10.	3 groups of 4 = 12	What is 3 groups of 4? What have you notice
11.	2 groups of 4 = 8	What is 2 groups of 4?
12.	2 times 10 = 20	What is 2 times 10?
13.	3 times 10 = 30	What is 3 times 10?
14.	4 times 10 = 40	What is 4 times 10?
15.	5 times 10 = 50	What is 5 times 10? What have you notice?
16.	6 times 10 = 60	What is 6 times 10?
17.	7 times 10 = 70	What is 7 times 10?
18.	8 times 10 = 80	What is 8 time 10?
19.	9 times 10 = 90	What is 9 times 10?
20.	10 times 10 = 100	What is 10 times 10? What have you notice?

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Lesson evaluation

Successes | Challenges | The way forward

Figure 5: List of mental mathematics questions for standard 2

4.4.4 Lesson Observation in Standard 3 at School SY

Teacher T11 was observed teaching in standard 3 at school SY where she prepared 20 mental mathematics questions for her class in all three lessons and managed to ask all 20 questions, she planned in lessons 2 and 3. However, she did not finish the planned questions in lesson 1. She managed to ask only 15 questions out of 20 (see Table 9). It was observed that the questions were prepared based on the four basic operations (see Figure 6). It was observed that the teacher linked mental mathematics tasks and the task in the activities in the workbook. It was also observed that some concepts and procedures were not well explained. The study noted that learners were asked to raise their hands if they know the answer. After raising their hands, learners were called by their names to respond to the questions and only a few learners were able to raise their hands and participate in the lesson. The following verbatim excerpts represented part of the lesson that was observed in standard 3 during lesson 2:

T11: Yes, class, it's time for mental mathematics. What is 11 plus 9? Yes, stand up

L: It is 20

T11: Good What is 21 plus 9? Yes

L: 30

T11: Good. What is 31 plus 9? Yes.

L3: 50

T11: Nnhnnh, No. yes, 31 plus 9? Yes

L: 40

T11: Yes good. What is 41 plus 9? Yes

L: 50

T11: Yes, excellent. Now, what have you noticed? Who can explain? Yes you

L: *Tikuphatikiza manambala poonjezera 9 paliponse* [we are adding numbers by increasing by 9 in each case].

T11: OK *wina* [another one] yes

L: *Manambala amene tikuophatikiza ndi 9 akumachuluka ndi 10 paliponse* [the numbers that we add 9 they are increasing by 10]

T11: Good, *tonse taona eti?* [have we all seen it, right?].

Ls: Yes (Answering in chorus)

T11: OK, *nanga awa?* [what about this?]. What is 13 plus 7? Yes

L: 20

T11: Good. What is 23 plus 7? Yes

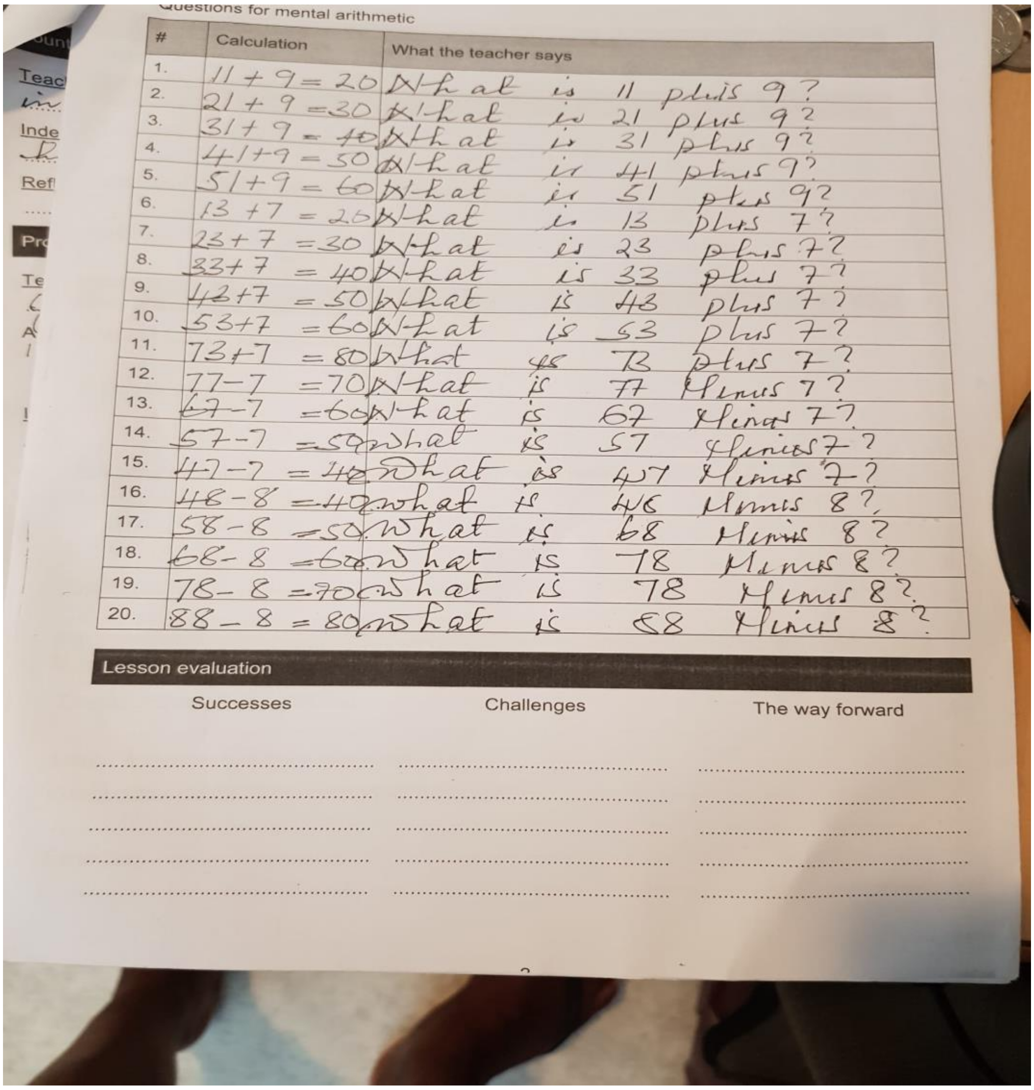
L: 30

T11: Good. What is 43 plus 7?

L: It is 50

T11: Yes good. Now, what have you noticed? Yes, at the back

L: The numbers are increasing by 10


Questions for mental arithmetic

#	Calculation	What the teacher says
1.	11 + 9 = 20	What is 11 plus 9?
2.	21 + 9 = 30	What is 21 plus 9?
3.	31 + 9 = 40	What is 31 plus 9?
4.	41 + 9 = 50	What is 41 plus 9?
5.	51 + 9 = 60	What is 51 plus 9?
6.	13 + 7 = 20	What is 13 plus 7?
7.	23 + 7 = 30	What is 23 plus 7?
8.	33 + 7 = 40	What is 33 plus 7?
9.	43 + 7 = 50	What is 43 plus 7?
10.	53 + 7 = 60	What is 53 plus 7?
11.	73 + 7 = 80	What is 73 plus 7?
12.	77 − 7 = 70	What is 77 minus 7?
13.	67 − 7 = 60	What is 67 minus 7?
14.	57 − 7 = 50	What is 57 minus 7?
15.	47 − 7 = 40	What is 47 minus 7?
16.	48 − 8 = 40	What is 46 minus 8?
17.	58 − 8 = 50	What is 68 minus 8?
18.	68 − 8 = 60	What is 78 minus 8?
19.	78 − 8 = 70	What is 78 minus 8?
20.	88 − 8 = 80	What is 88 minus 8?

Lesson evaluation

Successes	Challenges	The way forward

Figure 6: List of mental mathematics questions for standard 3

4.4.5 Lesson Observation in Standard 4 at School SX

Lastly, teacher T8 in standard 4 at school SX was observed. The teacher prepared 20 mental mathematics questions following the day's work (see Figure 8). It was observed that many learners were not raising their hands to respond to the questions, and this made the teacher not continue with the questions instead he asked the learners to turn to their workbooks and do the exercise for that day. The study noted that the teacher did not manage to finish all 20 mental mathematics questions only 14 questions were asked during lessons 1 and 3 observation (see Table 9), and many questions were not answered by the learners. Only 9 out of 20 questions were answered correctly by the learners. However, he managed to finish the planned questions in lesson 2. It was found that only those learners who raised their hands were nominated to answer the questions verbally. The study also noted that though many learners were not participating active learners were able to explain well what was happening with questions in the sets which indicates that mental mathematics plays a role in their understanding. The following verbatim excerpts represented part of lesson 1 observed in standard 4:

T8: What is 770 minus 700?

L: 70

T8: Good. What is 800 minus 750

L: 50

T8: Good. Explain?

L: We are completing 10s

T8: So, we are completing 10s. Number *zaukozo zikumachepa ndi* 10 [the numbers are decreasing by 10**]** we are completing 10s. What is 600 plus 250?

L: 850

T8: Correct. What is 700 minus 630? Yes.

Ls: [silence]

T8: The answer is 70. What is 800 minus 730?

Ls: [silence]

T8: The answer is 70. What is 900 minus 855?

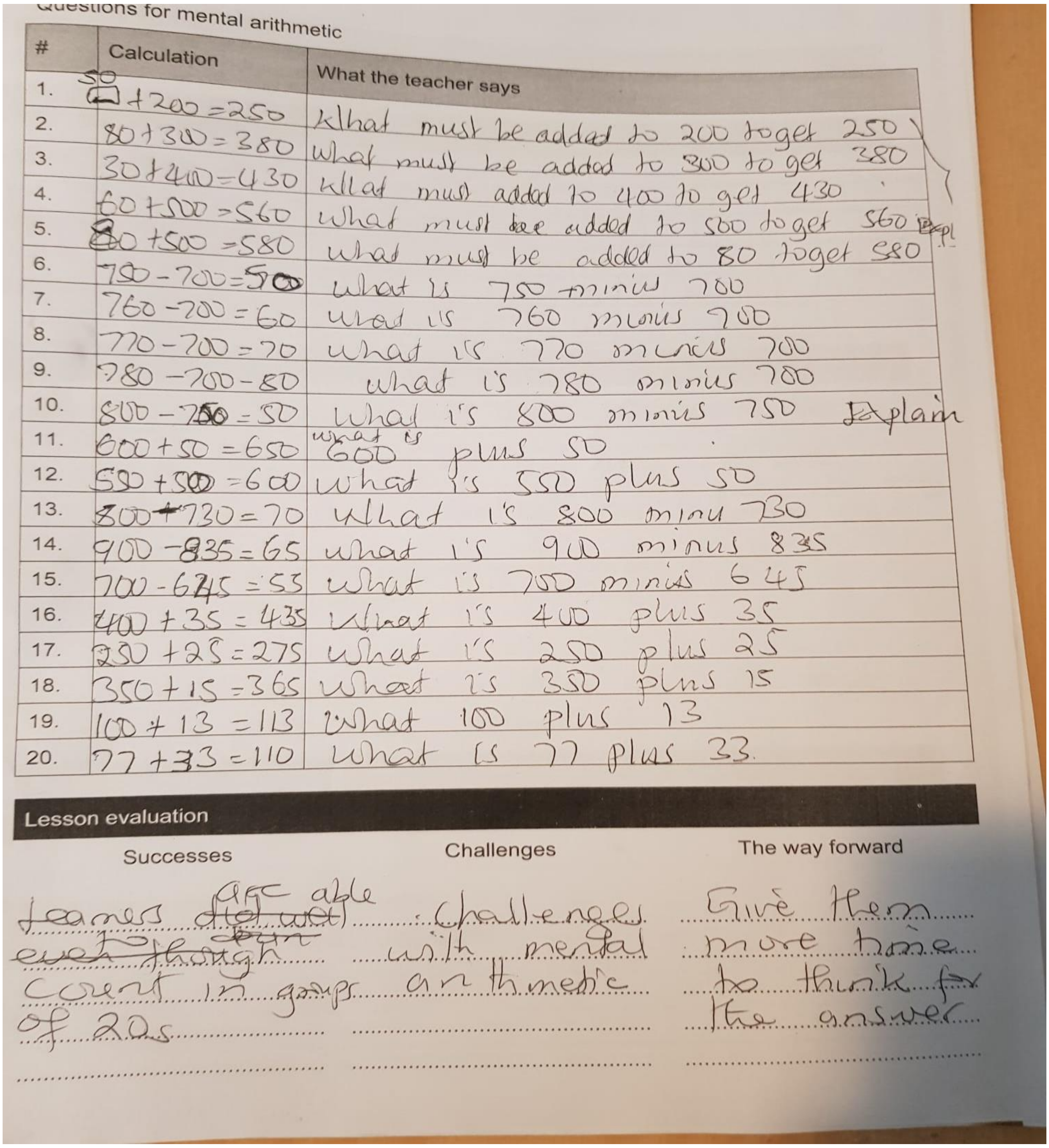
Ls: No response [silence]

T8: The answer is 45. What is 700 minus 665?

L: 45

T8: What do you notice? [no explanation was given]

The following is the mental mathematics plan that the teacher used.



Questions for mental arithmetic

#	Calculation	What the teacher says
1.	50 + 200 = 250	What must be added to 200 to get 250
2.	80 + 300 = 380	What must be added to 300 to get 380
3.	30 + 400 = 430	What must added to 400 to get 430
4.	60 + 500 = 560	What must be added to 500 to get 560
5.	80 + 500 = 580	What must be added to 80 to get 580
6.	750 − 700 = 50	What is 750 minus 700
7.	760 − 700 = 60	What is 760 minus 700
8.	770 − 700 = 70	What is 770 minus 700
9.	780 − 700 = 80	What is 780 minus 700
10.	800 − 750 = 50	What is 800 minus 750 Explain
11.	600 + 50 = 650	What is 600 plus 50
12.	550 + 50 = 600	What is 550 plus 50
13.	800 − 730 = 70	What is 800 minu 730
14.	900 − 835 = 65	What is 900 minus 835
15.	700 − 645 = 55	What is 700 minus 645
16.	400 + 35 = 435	What is 400 plus 35
17.	250 + 25 = 275	What is 250 plus 25
18.	350 + 15 = 365	What is 350 plus 15
19.	100 + 13 = 113	What 100 plus 13
20.	77 + 33 = 110	What is 77 plus 33

Lesson evaluation

Successes	Challenges	The way forward
Learners ~~did not~~ are able ~~even though~~ count in groups of 20s	Challenges with mental arithmetic	Give them more time to think for the answer

Figure 7: List of mental mathematics questions for standard 4

Below is an illustration of all the tasks that were planned and asked in all the lessons that were observed and how they were sequenced:

Table 10: Planned and implemented mental mathematics from teachers' lesson plans observed for standard 2 by T1

Teacher and Standard	Questions in the lesson plan	Questions used in class
T1 2	Lesson 1 1. what is double of 2? 2. What is double of 3? 3. what is double of 4? 4. What is double of 5? 5. What is double of 6? What did you notice? 6. What is double of 5? 7. What is double 10? 8. What is double 15? 9. What is double 20? 10. What is double 25? What have you noticed? 11. What is half of 10? 12. What is half of 20? 13. What is half of 30? 14. what is half of 40? 15. What is half of 50? What did you notice? 16. What is half of 4? 17. What is half of 6? 18. What is half of 8? 19. What is the half of 10? 20. What is the half of 12? What have you noticed?	**Lesson 1** 1. what is double of 2? 2. What is double of 3? 3. what is double of 4? 4. What is double of 5? What did you notice? 5. What is double of 5? 6. What is double 10? 7. What is double 15? 8. what is double 20? 9. What is double 25? What did you notice? 10. What is half of 10? 11. What is half of 20? 12. What is half of 30? 13. What is half of 40? 14. What is half of 50? What did you notice?
	Lesson 2 1. 2 groups of 5 = 10. What are 2 groups of 5? 2. 3 groups of 5 = 15. What are 3 groups of 5? 3. 4 groups of 5 = 20. What is 4 groups of 5? 4. 5 groups of 5 = 25. What are 5 groups of 5?	Lesson 2 1. What are 2 groups of 5? 2. What are 3 groups of 5? 3. What is 4 groups of 5? 4. What are 5 groups of 5? 5. What are 6 groups of 5? What did you notice? 6. What are 7 groups of 5?

	5. 6 groups of 5 = 30. What are 6 groups of 5? What did you notice? 6. 7 groups of 5 = 35. What are 7 groups of 5? 7. 8 groups of 5 = 40. What are 8 groups of 5? 8. 9 groups of 5 = 45. What are 9 groups of 5? 9. 10 groups of 5 = 50. What are 10 groups of 5? 10. 3 groups of 4 = 12. What are 3 groups of 4? What have you noticed? 11. 2 groups of 4 = 8. What are 2 groups of 4? 12. 2 times 10 =20. What is 2 times 10? 13. 3 times 10 = 30. What is 3 times 10? 14. 4 times 10 = 40. What is 4 times 10? 15. 5 times 10 = 50. What is 5 times 10? What have you noticed? 16. 6 times10 = 60. What is 6 times 10? 17. 7 times 10 =70. What is 7 times 10? 18. 8 times 10 = 80. What is 8 times 10? 19. 9 times 10 = 90. What is 9 times 10? 20. 10 times 10 = 100. What are 10 times 10? What have you noticed?	7. What are 8 groups of 5? 8. What are 9 groups of 5? What have you noticed? 9. What is 5 times 10? 10. What is 2 times 10? 11. What is 4 times 10? 12. What is 5 times 10? What have you noticed? 13. What is 7 times 10? 14. What is 8 times 10? 15. What is 9 times 10? 16. What are 10 times 10? What have you noticed?
	Lesson 3 1. What is double of 7? 2. What is the double of 8? 3. What is the double of 9? 4. What is the double of 10? 5. What is the double of 11? Explain 6. What is the double of 50? 7. What is the double of 60? 8. What is the double of 70? 9. What is the double of 80? 10. What is the double of 90? What did you	Lesson 3 1. What is double of 7? 2. What is double of 8? 3. What is double of 9? Explain 4. What is half of 40? 5. What is half of 90? 6. What is half of 100? 7. What is half of 80? Explain 8. What is double 60? 9. What is double 70? 10. What is double 80?

	notice? 11. What is half of 10? 12. What is half of 20? 13. What is half of 30? 14. What is half of 40? 15. What is half of 50? Explain 16. What is the double of 80? 17. What is the double of 90? 18. What is the double of 100? 19. What is the double of 200? 20. What is the double of 400? What did you notice?	11. What is double 90? What did you notice?

In lesson 1, standard 2 by T1: - There is similarity in all sets of questions, for example, doubling the numbers in sets 1 and 2, and getting halves of multiples of 10 in set 3. The number of questions asked was less than planned. The teacher managed to ask 14 questions out of 20 (see Table 10). There was no contrast because all the sets followed the same pattern. The level of exemplifying for this lesson is therefore categorised as level 1.

Lesson 2

The teacher prepared 20 questions but only asked 16 of them (see Table 10). The teacher posed three questions in set 2, 2 questions in set 3, and 2 questions in set 4 asked 4 questions. There is a similarity. They planned similarly and followed similar patterns. Find the groups of 5 in sets 1 and 2, for example, and she was able to ask all 5 questions from the sets. Set 1 has no contrast. In sets 3 and 4, the teacher hoped to find groupings and multiples of ten. There is a contrast between mixing two separate sums in one set, such as discovering groups of 5 and 4 at the same time. The level of exemplifying for this lesson is therefore categorised as level 2.

Lesson 3

The teacher asked fewer questions than planned, only 11 questions out of the 20 (see Table 10). There is a similarity in all the sets. There is a pattern of doubling the numbers in sets 1, 3, and 4, although the planned questions were not asked in set 2. The teacher asked 3 questions out of five in set 1, 4 questions in set 2, and four questions in set 4. Furthermore, the numbers were growing larger; for example, initially, they intended 20, 30, and 40, but soon 200, 300, and 400 appeared.

However, there is a contrast because the planned questions in set 3 differ from those delivered during a lesson observation, and some questions were skipped, resulting in the absence of the pattern. Therefore, the level of exemplifying for this lesson is categorised as level 2.

Table 11: Planned and implemented mental mathematics from teachers' lesson plans observed for standard 4 by T8

Teacher and standard	Questions in the lesson plan	Questions used in class
T8 4	Lesson 1 1. 2 x 15 = 30. What are 2 groups of 15? 2. 4 x 15 = 60. What are 4 groups of 15? 3. 6 x 15 = 90. What are 6 groups of 15? 4. 8 x 15 = 120. What are 8 groups of 15? 5. 10 x 15 = 150. What are 10 groups of 15? What have you noticed? 6. 100 ÷ 5 = 20. What is 100 divided by 5? 7. 100 ÷ 10 = 10. What is 100 divided by 10? 8. 100 ÷ 20 = 5. What is 100 divided by 20? 9. 100 ÷ 25 = 4. What is 100 divided by 25? 10. 100 ÷ 50 = 2. What is 100 divided by 50? What have you noticed? 11. 5 x 50 = 250. What is 5 times 50? 12. 6 x 50 = 300. What are 6 times 50? 13. 7 x 50 = 350. What are 7 times 50? 14. 8 x 50 = 400. What are 8 times 50? 15. 9 x 50 = 450. What are 9 times 50? 16. 10 x 50 = 500. What is 10 times 50? What have you noticed? 17. 500 ÷ 2 =250. What is 500 divided by 2? 18. 400 ÷ 2 = 200. What is 400 divided by 2? 19. 300 ÷ 2 = 150. What is 300 divided by 2? 20. 200 ÷ 2 = 100. What is 200 divided by 2? What have you noticed?	**Lesson 1** 1. What are 2 groups of 15? 2. What are 4 groups of 15? 3. What are 6 groups of 15? 4. What are 8 groups of 15? 5. What are 10 groups of 15? What have you noticed? 6. What is 100 divided by 5? 7. What is 100 divided by 10? 8. What is 100 divided by 20? 9. What is 100 divided by 25? 10. What is 100 divided by 50? What have you noticed? 11. What are 5 times 50? 12. What are 6 times 50? 13. What are 7 times 50? 14. What are 8 times 50?

	Lesson 2: 1. What is 100 plus 25? 2. What is 100 plus 34? 3. What is 100 plus 32? 4. What is 100 plus 43? 5. What is 100 plus 45? What do you notice? 6. What is 25 minus 5? 7. What is 35 minus 10? 8. What is 45 minus 20? 9. What is 45 minus 10? 10. What is 45 minus 15? What do you notice? 11. What is 15 plus 10? 12. What is 25 plus 10? 13. What is 35 plus 10? 14. What is 45 plus 10? 15. What is 55 plus 10? 16. What is 155 minus 25? 17. What is 145 minus 25? 18. What is 135 minus 25? 19. What is 125 minus 25? 20. What is 115 minus 25? What did you notice?	**Lesson 2:** 1. What is 100 plus 25? 2. What is 100 plus 34? 3. What is 100 plus 32? 4. What is 100 plus 43? 5. What is 100 plus 45? What do you notice? 6. What is 25 minus 5? 7. What is 35 minus 10? 8. What is 45 minus 20? 9. What is 45 minus 10? 10. What is 45 minus 15? What do you notice? 11. What is 15 plus 10? 12. What is 25 plus 10? 13. What is 35 plus 10? 14. What is 45 plus 10? 15. What is 55 plus 10? 16. What is 155 minus 25? 17. What is 145 minus 25? 18. What is 135 minus 25? 19. What is 125 minus 25? 20. What is 115 minus 25? What did you notice?
	Lesson 3: 1. What are 2 groups of 15? 2. What are 4 groups of 15? 3. What are 6 groups of 15? 4. What are 8 groups of 15? 5. What are 10 groups of 15? What have you noticed? 6. What is 100 divided by 5? 7. What is 100 divided by 10?	**Lesson 3:** 1. What are 2 groups of 15? 2. What are 4 groups of 15? 3. What are 6 groups of 15? 4. What are 10 groups of 15? What have you noticed? 5. What is 100 divided by 5? 6. What is 100 divided by 10? 7. What is 100 divided by 20?

	8. What is 100 divided by 20? 9. What is 100 divided by 25? 10. What is 100 divided by 10? What have you noticed? 11. What are 5 times 50? 12. What are 6 times 50? 13. What are 7 times 50? 14. What are 8 times 50? 15. What are 9 times 50? 16. What is 10 times 50? What have you noticed? 17. What is 500 divided by 2? 18. What is 400 divided by 2? 19. What is 300 divided by 2? 20. What is 200 divided by 2? What have you noticed?	8. What is 100 divided by 10? What have you noticed? 9. What are 5 times 50? 10. What are 8 times 50? What have you noticed? 11. What is 500 divided by 2? 12. What is 400 divided by 2? 13. What is 300 divided by 2? 14. What is 200 divided by 2? What have you noticed?

T8 standard 4

Lesson 1

In comparison to what he had planned, the teacher asked fewer questions (see Table 11). He only asked 14 out of 20 questions. There is a similarity in the way all of the sets planned by the teacher in Lesson 1 are similar. For example, the discovery of groups of 15, splitting numbers with a difference, of 5, and dividing the numbers by 2. However, there is no contrast because all of the questions had the same number pattern. As a result, the level of exemplification for this lesson is classified as level 1.

Lesson 2

The teacher managed to ask all 20 possible questions(see Table 11). Sets 1 and 2 have no similarity since the numbers were not constant and were subtracted from three separate numbers, however, sets 3 and 4 have similarity because the numbers were added to 10 and subtracted by the number 25 in each case. In set 2, the numbers were deducted from three different numbers, which creates a contrast. This lesson's exemplification level is classified as level 2.

Lesson 3

There is a similarity between all of the sets planned by the teacher in Lesson 3. For instance, the discovery of groups of 15, numbers divided by the same number, the number divided by 2, and the numbers multiplied by 50. However, the teacher asked fewer questions than he had anticipated (see Table 11). He only asked 14 of the 20 possible questions. Furthermore, because all of the questions had the same number pattern, there is no contrast. As a result, the exemplification level for this lesson is set at level 1.

Table 12: Planned and implemented mental mathematics from teachers' lesson plans observed for standard 1 by T9

Teacher and standard	Questions in the lesson plan	Questions used in class
T9 1	1. 5 + 6 = 11. What is 5 plus 6? 2. 6 + 6 = 12. What is 6 plus 6? 3. 7 + 6 = 13. What is 7 plus 6? 4. 8 + 6 = 14. What is 8 plus 6? 5. 9 + 6 = 15. What is 9 plus 6? What did you notice? 6. 6 + 7 = 13. What is 6 plus 7? 7. 7 + 7 = 14. What is 7 plus 7? 8. 8 + 7 = 15. What is 8 plus 7? 9. 9 + 7 = 16. What is 9 plus 7? 10. 10 + 7 = 17. What is 10 plus 7? What did you notice? 11. 1, 2, 3, 4, 5, 6. Show me the number 3 12. 1, 2, 3, 4, 5, 6. Which number comes after 3? 4. 13. 1, 2, 3, 4, 5, 6. Which number comes before 3? 2. 14. 1, 2, 3, 4, 5, 6. Which number is 1 more than 3? 4 15. 1, 2, 3, 4, 5, 6. Which number is 2 more than 3? 5. What did you notice?	1. What is 5 plus 6? 2. What is 6 plus 6? 3. What is 7 plus 6? 4. What is 8 plus 6? 5. What is 9 plus 6? What did you notice? 6. What is 6 plus 7? 7. What is 7 plus 7? 8. What is 8 plus 7? 9. What is 9 plus 7? 10. What is 10 plus 7? What did you notice? 11. Show me the number 3 12. Which number comes after 3? 4. 13. Which number comes before 3? 2. 14. Which number is 1 more than 3? 4 15. Which number is 2 more than 3? 5. What did you notice? 16. Show me the number 22. 17. Which number comes after 22? 23.

	16. 20, 21, 22, 23, 24. Show me the number 22. 17. 20, 21, 22, 23, 24. Which number comes after 22? 23. 18. 20, 21, 22, 23, 24. Which number comes before 22? 21 19. 20, 21, 22, 23, 24. Which number is 1 more than 22? 23. 20. 20, 21, 22, 23, 24. Which number is 2 more than 22? 24. What did you notice?	18. Which number comes before 22? 21 19. Which number is 1 more than 22? 23. 20. Which number is 2 more than 22? What did you notice?
	Lesson 2 1. What are 2 groups of 2? 2. What are 2 groups of 20? 3. What is 4 groups of 2? 4. What are 4 groups of 20? 5. What 3 groups of 2? What did you notice? 6. What are 3 groups of 20? 7. What is double 2? 8. What is double 3? 9. What is double 4? 10. What is double 5? 11. What is double 10? 12. What is double 20? What did you notice? 13. What is 2 plus 2? 14. What is 7 plus 7? 15. What is 10 plus 14? 16. What is 20 plus 14? What did you notice? 17. What number is doubled 30? 18. What number is doubled to 100? 19. What is double 6? 20. What is double 16? What did you	**Lesson 2** 1. What are 2 groups of 2? 2. What are 2 groups of 20? 3. What is 4 groups of 2? 4. What are 4 groups of 20? 5. What 3 groups of 2? What did you notice? 6. What are 3 groups of 20? 7. What is double 2? 8. What is double 3? 9. What is double 4? 10. What is double 5? 11. What is double 10? 12. What is double 20? What did you notice? 13. What is 2 plus 2? 14. What is 7 plus 7? 15. What is 10 plus 14? What did you notice?

	notice?	
	Lesson 3 1. Show me the number 23 from the chart. 2. Which number comes after 23? 3. Which number comes before 23? 4. Which number is 1 more than 23? 5. Which number is 2 more than 23? What have you noticed? 6. Show me the number 18 from the chart. 7. Which number is 1 more than 19? 8. Which number comes before 18? 9. Which number comes after 18? What have you noticed? 10. What is 70 minus 10? 11. What is 60 minus 10? 12. What is 60 minus 10? What have you noticed? 13. What is 6 plus 4? 14. What is 7 plus 3? 15. What is 9 plus 1? What have you noticed? 16. What is 30 minus 20? 17. What is 40 minus 30? What have you noticed? 18. What is 1 multiplied by 10? 19. What is 2 multiplied by 10? 20. What is 3 multiplied by 10? What have you noticed?	**Lesson 3** 1. Show me the number 23 from the chart. 2. Which number comes after 23? 3. Which number comes before 23? 4. Which number is 1 more than 23? 5. Which number is 2 more than 23? What have you noticed? 6. Show me the number 18 from the chart. 7. Which number is 1 more than 19? 8. Which number comes before 18? 9. Which number comes after 18? What have you noticed? 10. What is 70 minus 10? 11. What is 60 minus 10? 12. What is 60 minus 10? What have you noticed? 13. What is 6 plus 4? 14. What is 7 plus 3? 15. What is 9 plus 1? What have you noticed? 16. What is 30 minus 20? 17. What is 40 minus 30? What have you noticed? 18. What is 1 multiplied by 10? 19. What is 2 multiplied by 10? 20. What is 3 multiplied by 10? What have you noticed?

T9 standard 1

Lesson 1

There is a similarity in all the sets in lesson 1. All of the sets are similar in the way the numbers were added by the same number. For instance, add 6 and 7. The teacher asked all 20 prepared questions (see Table 12). Because the questions have the same number pattern, there is no contrast. As a result, the level of exemplification for this lesson is classified as level 1.

Lesson 2

Sets 1 and 2 have certain similarities. The numbers are accumulating to one another and growing in size. In sets 3 and 4, there is no number similarity because two different groupings of numbers are employed. The teacher asked fewer questions. She managed to ask 15 questions out of 20 and skipped set 4 (see Table 12). The questions were asked at random, and some were skipped. Sets 1 and 4 have contrast since two separate patterns were presented in the set, however, sets 2 and 3 do not have contrast because the numbers have the same pattern. As a result, the level of exemplification in this lesson is classified as level 2.

Lesson 3

There is a similarity in all the sets in lesson 3. All of the sets are similar in the way the numbers were subtracted by the difference of 10 and multiplied by the same number 10. The teacher asked all the planned 20 questions (see Table 12). Because the questions have the same number pattern, there is no contrast. As a result, the level of exemplification for this lesson is classified as level 1.

Table 13: Planned and implemented mental mathematics from teachers' lesson plans observed for standard 3 by T11

Teacher and standard	Questions in the lesson plan	Questions used in class
T11 3	Lesson 1 1. What is 5 times 2? 2. What is 10 times 2? 3. What is 20 times 2? 4. What are 30 times 2? 5. What is 15 times 2? What have you noticed?	**Lesson 1** 1. What is 5 times 2? 2. What is 10 times 2? 3. What is 20 times 2? 4. What is 30 times 2? 5. What is 15 times 2? What have you noticed?

	6. What is 35 times 2? 7. What are 40 times 2? 8. What are 50 times 2? 9. What are 60 times 2? 10. What is 70 times 2? What have you noticed? 11. What are 10 times 10? 12. What is 20 times 10? 13. What is 30 times 10? 14. What is 40 times 10? 15. What is 50 times 10? What have you noticed? 16. What are 60 times 10? 17. What are 70 times 10? 18. What are 80 times 10? 19. What is 90 times 10? 20. What is 100 times 10? what did you notice?	6. What is 35 times 2? 7. What is 40 times 2? 8. What is 50 times 2? 9. What is 60 times 2? 10. What is 70 times 2? What have you noticed? 11. What is 10 times 10? 12. What is 20 times 10? 13. What is 30 times 10? 14. What is 40 times 10? 15. What is 50 times 10? What have you noticed?
	Lesson 2 1. 137 + 23 = 160. What must be added to 137 to get 160? 2. 147 + 23 = 170. What must be added to 147 to get 170? 3. 157 + 23 = 180. What must be added to 157 to get 180? 4. 167 + 23 = 190. What must be added to 167 to get 190? 5. 177 + 23 = 200. What must be added to 177 to get 200? What did you notice? 6. 20 + 5 = 25. What is 20 plus 5? 7. 30 + 5 = 35. What is 30 plus 5? 8. 40 + 5 = 45. What is 40 plus	Lesson 2 1. What must be added to 137 to get 160? 2. What must be added to 147 to get 170? 3. What must be added to 157 to get 180? 4. What must be added to 167 to get 190? 5. What must be added to 177 to get 200? What did you notice? 6. What is 20 plus 5? 7. What is 30 plus 5? 8. What is 40 plus 5? 9. What is 50 plus 5? 10. What is 60 plus 5? What did you notice? 11. What is 96 minus 20? 12. What is 96 minus 30? 13. What is 96 minus 40? 14. What is 96 minus 50? 15. What is 96 minus 60? What did you

	5? 9. 50 + 5 = 55. What is 50 plus 5? 10. 60 + 5 = 65. What is 60 plus 5? What did you notice? 11. 96 – 20 = 76. What is 96 minus 20? 12. 96 – 30 = 66. What is 96 minus 30? 13. 96 – 40 = 56. What is 96 minus 40? 14. 96 – 50 = 46. What is 96 minus 50? 15. 96 – 60 = 36. What is 96 minus 60? What did you notice? 16. 336 + 76 = 412. What is 336 plus 76? 17. 336 + 66 = 402. What is 336 plus 66? 18. 336 + 56 = 392. What is 336 plus 56? 19. 336 + 46 = 382. What is 336 plus 46? 20. 336 + 36 = 372. What is 336 plus 36? What did you notice?	notice? 16. What is 336 plus 76? 17. What is 336 plus 66? 18. What is 336 plus 56? 19. What is 336 plus 46? 20. What is 336 plus 36? What did you notice?
	Lesson 3 1. What is 11 plus 9? 2. What is 21 plus 9? 3. What is 31 plus 9? 4. What is 41 plus 9? 5. What is 51 plus 9? What did you notice? 6. What is 13 plus 7?	**Lesson 3** 1. What is 11 plus 9? 2. What is 21 plus 9? 3. What is 31 plus 9? 4. What is 41 plus 9? 5. What is 51 plus 9? What did you notice? 6. What is 13 plus 7? 7. What is 23 plus 7?

	7. What is 23 plus 7? 8. What is 33 plus 7? 9. What is 43 plus 7? 10. What is 53 plus 7? What did you notice? 11. What is 77 minus 7? 12. What is 67 minus 7? 13. What is 57 minus 7? 14. What is 47 minus 7? 15. What is 37 minus 7? What did you notice? 16. What is 48 minus 8? 17. What is 58 minus 8? 18. What is 68 minus 8? 19. What is 78 minus 8? 20. What is 88 minus 8? What did you notice?	8. What is 33 plus 7? 9. What is 43 plus 7? 10. What is 53 plus 7? What did you notice? 11. What is 77 minus 7? 12. What is 67 minus 7? 13. What is 57 minus 7? 14. What is 47 minus 7? 15. What is 37 minus 7? What did you notice? 16. What is 48 minus 8? 17. What is 58 minus 8? 18. What is 68 minus 8? 19. What is 78 minus 8? 20. What is 88 minus 8? What did you notice?

T11 standard 3

Lesson 1

Sets 1 and 3 there is similarity. The numbers are subtracted from a factor of ten. Set 2 has no similarity because adding two separate numbers is used, whereas set 4 does not. The teacher planned 20 questions and managed to ask 15 of them. Set 4 was left out (see Table 13). Sets 1, 2, and 3 have no contrast because the numbers all share the same pattern; as a result, the level of exemplification in this lesson is rated as level 2.

Lesson 2

There is a similarity in that all the sets in Lesson 2. The numbers in all of the sets were subtracted by the difference of 10 and added by the difference of 10. The teacher asked all the 20 questions she had prepared (see Table 13). There is no contrast because the questions in all of the sets have the same number pattern. As a result, the exemplification level for this lesson is set at level 1.

Lesson 3

There is a similarity in that all the sets in Lesson 3. The numbers in all of the sets 1 and 2 were added to 9 and 7 in each case and subtracted 7 and 8 from the numbers. The teacher asked all the

20 questions she had prepared (see Table 13). There is no contrast because the questions in all of the sets have the same number pattern. As a result, the exemplification level for this lesson is set at level 1.

During the analysis of the lessons, the study was coding the different sets in the lessons using four levels according to the MDI framework (Adler and Ronda, 2016). These are level 1, level 2, and level 0. Level 1 is when only one pattern of variation is used: similarity or contrast. Level 2 is when two different patterns of variation are used. For example, only similarity or only contrast.

Based on the observations of the lessons, the activities assigned to learners were graded based on whether they required learners to perform a known (K) operation or apply (A) what they already knew about the object of learning (Adler & Ronda, 2015). According to the MDI framework, the class observation schedule addressed specific areas, which are detailed in the subsections that follow.

4.4.6 Exemplification

Exemplification, for the MDI framework, was one of the aspects examined in the study. The study was particularly interested in the teacher's selection of mental mathematics tasks and how they relate to the main activity in the workbook. It was discovered that all the teachers used mental mathematics in their classes across all twelve lessons. The teacher would ask learners questions orally and have them solve them in their minds before responding orally.

4.4.7 Explanatory Talk

In lesson observations, the study observed that the explanations that teachers gave were a combination of explaining procedures and concepts. In some lessons teachers were explaining more on procedure than concepts, however, in most of the lessons there was a balance of the teacher's explanations of procedure and explanations of concepts. The following verbatim excerpt illustrates more on how teachers were explaining concepts:

Part of the lesson transcript for teacher T1

T1: *Ndiye, uyang'ane kuno. Ndinambala yanji imene imabwera kutsogolo kwa 34?* [So, look here. What number comes after 34?]

Ls: 35 (in chorus)

T1: Ok, good. *Ndinambala yanji imene imabwera pambuyo pa 59?* [What number comes before 59?]

Ls: Eeeh [Yes] 60(in chorus)

T1: No, *ndanena kuti nambala imene imabwera tisanafike 59 ndichani* [I have said which number comes before 59]

L: *Ine sala* [me, sir] 58.

T1: Yes, the number is 5.

Part of lesson 2 for Teacher T8

T8: *Amene akudziwa ansala akweze dzanja*. [anyone who knows the answer should raise his or her hand.]

T8: What is 100 plus 25?

L: 125

T8: What is 100 plus 34?

L: 134

T8: What is 100 plus 32?

L: 132

T8: Good. what do you notice?

L: *Pamene tikuphatikiza manambala tikumaonjezera 2 kapena 1 panambala iliyonse* [as we are adding numbers, we are adding 2 or 1 to each number].

T8: *Ndizoona pasiteji iliyonse pakusintha ndithu* [this is true, at every stage there is a change]. *Ndiye mukalemba muziona kuti kodi manambalawa akuyenda bwanji chifukwa masamu athu akhuzananso ndi zimenezi kuti tipeze ma ansala okhonza* [when you are writing the numbers, check the way the numbers are set]. *Ndipo tizitha kuona mmene manambala akuyendera* [when you are answering the questions you first check the pattern of numbers].

Observation from the two lesson extracts for T1 and T8 above show that the teachers were able to explain the mathematical procedure to the learners on the pattern followed. In both lessons, I observed that the teachers tried to explain some procedures in the local language for learners to understand and follow. Looking at the lesson extracts for the two teachers, for the most part, it shows that they used an explanation of the procedure to get to the answer. This was also the same, as the other ten lessons. The 20 lessons gave me a picture that the type of explanation that mostly took place during the lessons were explanations of procedures. Using the MDI framework (Adler &

Ronda, 2015), the tasks that the teacher gave learners could only provide learners with an opportunity to practice known procedures and operations (K), therefore, classified as level 1 tasks.

4.4.8 Learner Participation

In this subsection, the study presents data on how the teacher engaged learners in the lesson. There were several observations made on the classroom activity. For example, even though teachers encouraged all learners to participate in and contribute to the mental mathematics exercise, in some classes only a few participated. However, in other classes, the participations were good, especially in standard 1 and 2. The learners were able to add one-digit numbers for example, what is 7 plus 4 to come up with two-digit numbers. Though they had some challenges with the subtraction of one-digit numbers from two-digit numbers. For example, what is 62 minus 9?

4.5 Research question 3: What are teachers' views on the introduction of mental mathematics?

4.5.1 Results from Interviews with Mathematics Teachers.

The interviews were conducted using an interview guide, and the participants were all of the 12 selected teachers. The interviews took place following the third lesson observations. Respondents were free to answer the questions in any language they felt comfortable with, as long as the researcher could understand them. They all responded in both English and their native tongues. Individual interviews with teachers were conducted to examine how primary teachers understand mental mathematics concepts and their views on its inclusion in the lower primary school curriculum. They all talked about the relevance of mental mathematics to learners as a good method for improving learners' performance in mathematics. In general, the responses to these interviews suggested that teachers are enthusiastic about introducing mental mathematics into primary schools. Teacher T1 said:

T1: Aaaaah mental mathematics sometimes helps but sometimes it is not helpful in terms of learners *kwaifeyo zili bwinobwino* [to us teachers it is okay]. Komano [but] in terms of learners when it comes to mental mathematics there is a lot of work for learners to catch up. *Penanso ikumakhala kuti ntchito yomwe ili yokonzedwa ya ana ndi level yawo sizimagwirizana mogwirizana ndi msinkhu wawo manambala akumakhala kuti akuwakulira* [sometimes the work given to the learners is not equivalent with their age and level the numbers are so big to them]**.** For example, four groups of five. *Chifukwa ndiye kuti pali samu imene ikukhudzana ndizimenezo* [then it means there are sums which will involve that procedure]. *Ndiye poti mwana akafike pokuyankha kuti* four groups of 5 *ndi 20, iiih simasewera* [for a learner to come up with an answer four groups of five to be 20, it is not easy**]** for a standard 1 learner it is difficult**.**

Furthermore, T1 had more to say about mental mathematics:

T1: I see that mental mathematics would develop our learners' mathematical skills and if we as mathematics teachers can start now developing this in learners, their mental mathematics skills, am sure that it will yield better results in numeracy and improve their performance.

The study shows that teachers here expressed their views openly and similar views were also given by the rest of the teachers that the introduction of mental mathematics with more emphasis is a good move because it develops the foundation of mathematics in learners in their early stages as they prepare for the upper primary. This move will improve learners' performance in mathematics. The following verbatim excerpts represent what some teachers reported during the interviews:

T3: Wow, mental mathematics is good, and I like it, because it helps learners in terms of thinking. Only that for some reason it seems to be tough due to their thinking capabilities, yeah.

T6: Mental mathematics is useful in the way that they improve learners' mathematical skills.

T9: Mental mathematics is good for learners because they promote critical thinking and also it reduces pressure on learners.

T12: To me mental mathematics is good, and it should be done across the curriculum that is with the upper and lower primary mathematics curriculum to develop learners.

T8: Mental mathematics *ndiyabwino ndithu koma ikumadya nthawi ya maphunziro ena* [it is good to have mental mathematics, but it consumes a lot of time]. *Mwachitsanzo mafunso 20 kuti timalize sizochezatu* [for example to finish the 20 sums it is not a joke]**.** *Ife tomwe tiphunzitsenso maphunziro ena sizoona. Achepetseko nthawi komanso mafunso* [time and the workload on the number of mental mathematics questions should be reduced]. The time they are using mental mathematics they could have covered a lot. Some subjects suffer because most of the time is taken in mathematics. *Komano ataipanga* [but also] according to the age of learners you know wa standard wani ndi [the standard one learner is] 6 to 11 years. *Ndiye akaipanga aiziika poganizira kuti mwanayi ndi wa* standard 1[they should think of this standard one learner]. They should consider them 20 sums is too much for them. Maganizo anga atakhala 10 [my suggestion is that 10 questions should be enough for them].

From the interview guide (see Appendix 2) teachers were asked if they were teaching mental mathematics before the NNP, and they had different responses. The study found that some teachers were teaching mental mathematics even before the NNP curriculum, and others were not teaching it. The following verbatim excerpts represented what teachers reported:

T3: Yeah, *komano popeza mu standard 1 amayamba manambala 0 to 9. Range yake inali imeneyi* [yes, but in standard one, we were teaching them numbers from 0 to 9 that was the range]. *Akamapita standard 2 kukayamba 11 to 20 kaya 30* [when they go up to standard 2 they continue to 20 or 30]. *Komano* with NNP *akutilimbikitsa kuti mwana tisamupatse limiti ndichifukwa chake tikumafika* 1 to 100 [with NNP we are encouraged to teach them numbers up to 100]. *Nthawi imeneyo ndi manamba ochepawa zimatheka koma tsopano ndimanambala awawa ndizovuta* [at that time with smaller numbers it was possible]. *Pena ana akumasewera chifukwa chakuchuluka kwa manambala* [sometimes learners get bored and start playing due to many questions].

T5: No, no, no. Mental mathematics was not taught because of the opening of free primary education. *Timaphunzitsa nthawi ya a Kamuzu* [we were teaching during the Kamuzu era]. Before the introduction of free primary, we were used to teaching mental mathematics, but it was in the upper classes not in standards 1 and 2. But with the introduction of free primary education, everything changed. We were just following what was in the curriculum. *kuphunzitsa mental tinasiya chifukwa ntchito imachuluka ananso anachuluka* [we stopped teaching mental because there was too much work and many learners].

On the differences, the study found that those teachers who were teaching mental mathematics before the intervention of NNP were well-experienced. They seem to be applying what was happening during their time and those who were not teaching had no experience in mental mathematics. This is because many of the teachers who said they were teaching, had teaching experience of more than 10 years while the others had teaching experience of fewer than 10 years. (see Table 6). The following verbatim excerpts represent what some teachers reported:

T3: I have been teaching for 25 years now, and mental mathematics during our time was part and parcel of mathematics lessons though it was not in the curriculum.

T9: This is my sixth year in teaching, and I haven't heard about it. This is my first time teaching mental mathematics, all in all, mental mathematics is good.

T10: For me, since I have just joined the system [teaching] so mental mathematics is new to this NNP curriculum. It is my first time to be introduced to this.

T11: I have been teaching for 18 years, but when I was teaching in standard 3, I was teaching mental mathematics but not like today and it was part of the introduction. This is not new to me.

4.6 CHAPTER SUMMARY

The chapter offered the study's findings, which demonstrated how teachers plan, teach, and view mental mathematics. According to the findings, all teachers planned 20 mental mathematics questions for each of the lessons observed. These are planned with what is in the teacher's guide and learners' workbook. During implementation, some teachers did not complete their planned questions. In terms of the MDI framework, which guided this study, it was found that teachers planned questions that had variations of similarity and sometimes contrast. The teachers were able to clarify mental mathematics concepts to learners during the explanation, and they involved learners through verbal question and answer. It has been discovered that not all learners completely participate in and contribute to mental mathematics activities. Finally, it was found that teachers have positive views about mental mathematics but find it time-consuming. The next and final chapter presents the discussion, conclusion, recommendations, and limitations of the study.

CHAPTER 5: DISCUSSION AND CONCLUSION

5.0 CHAPTER OVERVIEW

This study explored the teaching of mental mathematics in lower primary school classes in Malawi. The study aimed at exploring how mathematics primary school teachers plan, teach, and their views on the inclusion of mental mathematics in the NNP curriculum. This chapter will discuss and give a summary of the findings, conclusions, implications, and limitations of the study.

5.1 DISCUSSION

The study was guided by the following main research question: How do teachers in primary schools piloting the National Numeracy Programme curriculum view and teach mental mathematics in Malawi? To answer this question, three specific research questions were used:

(1) How do mathematics teachers plan their mental mathematics lessons?

(2) How do mathematics teachers teach mental mathematics?

(3) What are the teachers' views on mental mathematics?

The findings are discussed in the order in which the research questions appear.

5.1.1 Research Question 1: How do mathematics teachers, plan their mental mathematics lessons?

According to the study's findings, teachers plan the lessons in the same way. The NNP curricular work plan is followed by all 12 teachers while planning their mental mathematics lessons. Teachers, for example, plan 20 mental mathematics questions every day, and the questions were prepared in four sets of five each. The questions follow a precise number pattern, which the reflection question clarifies. It was also discovered that mental mathematics questions were incorporated into the plan's manipulating numbers component. The section on manipulating numbers provides the mental mathematics questions that teachers will use in the class. Although exemplification is commonly connected with explanatory talk, it was revealed that addressing learners' questions and reflecting are also examples of explanatory talk. Given that the questions are distributed throughout the class, learner interaction can be seen in almost every aspect of the lesson. As a result of the teacher's comments, the MDI framework is reflected in all parts of the lesson. According to Watson and Mason (2006), paying attention to a plan allows for the implementation of mathematical improvements. As a result, the findings of this study back up this claim.

According to the findings of teacher interviews, teachers' choice of questions is impacted by both the teacher's guide and the learners' workbook. Teachers develop their questions based on the day's work plan. Mental mathematics assists learners in developing higher-order thinking and reasoning skills. This could be because they were told to do so throughout their NNP training, and it is also recommended in the NNP curriculum. This was stated during the interviews by teachers. According to the study, when selecting mental mathematics questions, they take into account the complexity of the questions, the class of the learners, and the level of understanding of the learners. Furthermore, the findings show that some teachers demonstrated creativity in terms of using prior experiences in preparing mental mathematics questions.

Furthermore, the study discovered that some teachers do not complete their planned questions and instead ask fewer questions during implementation. They reasoned that the questions were too many, thus they proposed reducing the number of questions during implementation so that learners grasp well and do not forget when given fewer questions, especially Standard 1 learners.

5.1.2 Research Question 2 How do Teachers teach mental mathematics?

The responses to the interviews revealed that the age of the learners in standards 1 and 2, determines how teachers teach mental mathematics by influencing their choice of questions. These findings indicate that questions should be appropriate for the learner's level. Teachers said that when using the NNP curriculum, they explore and design questions based on the performance of learners' capabilities. Learners are given the freedom to work on their own without being restricted. According to the NNP curriculum, learners should not be limited and should discover more on their own.

Furthermore, findings from the teacher interviews show that some of the issues that were mentioned by all the teachers in the interviews:

> Not all learners participate in their mental mathematics lessons. Only a few learners actively participate and can raise their hands to answer questions. Teachers said that to keep learners alert, they are randomly assigned to answer questions. Learners participate in their lessons by asking and answering questions.

It was also discovered that the majority of the explanations were in Chichewa and were primarily non-formal mathematical discourse. For example, in a non-formal mathematical discussion, the teacher could provide instructions to the learners by stating things like, "What have you noticed?", "Are you following?" and "Do what we were doing." Adler and Ronda (2015) underline the importance of formal mathematical language and explain that how teachers describe mathematical concepts, procedures, and activities performed during mathematics lessons directs learners' attention in a specific direction.

In addition, it was discovered in this study that explanations for mental mathematics were primarily procedural explanations in which learners were encouraged to identify the patterns of the basic operations in the set of questions. Furthermore, learners were given the freedom to use any approach they wanted when answering the oral mental mathematics questions. Finally, learners were allowed to share their observations about the question patterns used in class. This is consistent with the concept of teaching mental mathematics, which states that teach mental mathematics explicitly but also invite learners to suggest an approach and explain their ways of solution to the rest of the class (Crown, 2010).

According to the findings, not all learners took part in answering the questions. Only a few learners participated in answering the questions. Teachers said that to keep learners alert, they are randomly assigned to answer questions. Learners should be encouraged to participate in answering questions in front of other learners because mental mathematics improves learners' social skills by encouraging them to appreciate one another's responses and explanations. Learners were actively listening to each other's solutions, which helped them move from passive to active participants, as recommended by the NNP curriculum.

The research also demonstrated that teachers recognise the value of learner participation in creating a learning environment. Learner participation improves learners' knowledge and hence provides possibilities for learning. By increasing engagement, learners' learning opportunities could be expanded. Question and answer sessions help to engage learners. These mental mathematics questions provide chances for learning by assisting learners in keeping and remembering information.

5.1.3 Research Question 3: What are teachers' views on mental mathematics?

According to the findings of the study's interviews, all twelve teachers believe that learner participation is the most important factor in the success of mental mathematics. It was discovered that all twelve teachers agreed on the introduction of mental mathematics in the lower primary school and saw learner participation as the most important sign of successful mathematics education. The findings add to Adler and Ronda's (2015) MDI framework, which guided the research, in which learner participation is one of the most important aspects of a mathematics lesson. Teachers' views suggest that an emphasis on teaching mental mathematics improves learners' performance in mathematics not only in lower primary schools but also in upper primary schools in general, as stipulated by Heirdsfield (2011) that mathematical patterns and relationships will develop proficiency with mental mathematics.

5.2 CONCLUSION

The purpose of this study was to explore the teaching of mental mathematics in pilot primary schools in Malawi using the NNP curriculum. The study employed the following key research question to explore this: How do Malawian primary school teachers view and teach mental mathematics in the National Numeracy Programme curriculum? Three distinct research questions supplemented the primary research question. According to the specific research questions, summaries of the study's findings are provided. The first research question was, "How do teachers plan mental mathematics?" The second was, "How do teachers teach mental mathematics?" The third was, "How do teachers view the teaching of mental mathematics?" Below follows the conclusion for each research question

5.2.1 Planning of Mental Mathematics Lessons

According to the study, the NNP curriculum materials (learner workbooks and teachers' guides) in lower primary schools are well documented and give sufficient mathematical activities. These tools help teachers prepare and plan mental mathematics questions based on the day's work. Examples of mental mathematics questions that engage learners in reasoning are suggested in the teachers' guides. Every day, teachers are expected to plan 20 mental mathematics questions. The findings support the assumption that mental mathematics is advantageous because it improves learners' mathematical learning while also developing critical thinking and reasoning skills. Teachers rely not only on teacher guides and learner workbooks but also on their creativity. As a result, this study can conclude that teachers develop the skill of creativity by suggesting the type of mental mathematics questions to meet the level of performance of their learners.

5.2.2 The Teaching of Mental Mathematics

According to research findings on the teaching of mental mathematics, the planned 20 mental mathematics questions can be taught either before or after the day's main task. Findings from lesson observations suggested that the teachers' explanations were either conceptual or procedural. As a result of the data, the study may conclude that teachers' explanation is a procedural and can assist learners in developing a high level of thinking.

According to the study's findings, some teachers do not finish all of the planned 20 mental mathematics questions during a lesson. It has been discovered that some questions are missed or even asked at random without regard for their planned order. As a result, the study might conclude that some teachers do not complete all 20 planned questions.

According to the findings, teachers with long teaching experience were the ones who were teaching mental mathematics before the inclusion of mental mathematics in the curriculum.

5.2.3 Teachers' Views on the Teaching of Mental Mathematics

The study found that the number of mental mathematics questions per class is the same (20 questions) regardless of the level or age of the learners. Some teachers believe that the number of questions should be reduced depending on the class level of learners.

The findings on teachers' views on the inclusion of mental mathematics in the NNP curriculum suggest that it is a good concept. Almost all of the 12 teachers believed that mental mathematics can help and increase learner progress in mathematics. As a result, teachers regarded mental mathematics as advantageous. Therefore, the findings of this study have led to the conclusion that teaching mental mathematics in lower primary classes has a positive effect on increasing learners' mathematical ability.

5.3 IMPLICATIONS OF THE STUDY

When evaluating the results, it is important to note that the lessons contained all of the components of the MDI framework that led this study: exemplification, explanatory talk, and learner participation. Based on the findings, the study provided several recommendations about the study's implications.

According to the study, mental mathematics tasks presented in lower primary classes should be implemented in all Malawian primary schools because they will help learners' critical thinking at an early stage, thereby improving learners' mathematics performance.

Continuous professional development for mathematics teachers to improve their mental mathematical skills. The study revealed the necessity for frequent meetings with mathematics teachers to improve their skills in teaching mental mathematics.

According to what teachers indicated about the number of mental mathematics questions per class, the number of questions should be reduced based on the class level. For example, mental mathematics questions in standards 1 and 2 should be reduced from 20 to 15, but questions in standards 3 and 4 should remain at 20.

5.4 AREAS FOR FURTHER RESEARCH

Mental mathematics research in Malawi is new, and there is a need for exploring the influence of mental mathematics in primary schools. Future research could also look into the effects of teaching mental mathematics on learners learning. Furthermore, because teachers relied on both their creativity and teachers' guides in selecting mental mathematics questions, it is necessary to determine the effectiveness of these curriculum materials on teachers’ teaching.

5.5 LIMITATIONS

This study had some limitations. For example, because the participants were not a representative sample of the population, the results may not accurately reflect what is going on in Malawi as a whole. Only one district, three schools, and twelve teachers were involved in the study, out of the 204 piloted schools and many teachers in Malawi. Although the findings of this study are not intended to be generalisable to a larger population, working with more schools and teachers could be very beneficial in learning more about what this study was looking for. This is, nevertheless, phenomenological inquiry, which aims to generate meaning from experiences. Another limitation is that my role as a teacher educator may have had an impact on the study since participating teachers may have believed they were being monitored and thus changed the way they normally taught though they were oriented before the exercise.

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APPENDIX

Appendix 1: NSD Assessment Form

Assessment of processing of personal data

Reference number	Assessment type	Date
993468	Standard	26.09.2022

Project title

Exploring teachers, the teaching of mental mathematics through the National Numeracy Programme in primary schools in Malawi.

Data controller (institution responsible for the project)

Universitetet i Stavanger / Fakultet for utdanningsvitenskap og humaniora / Institutt for grunnskolelærerutdanning, idrett og spesialpedagogikk

Project leader Arne Jakobsen

Student Felix Simon Makolija

Project period 15.09.2022 - 01.08.2023

Categories of personal data General

Legal basis

Consent (General Data Protection Regulation art. 6 nr. 1 a)

The processing of personal data is lawful, so long as it is carried out as stated in the notification form. The legal basis is valid until 01.08.2023.

Comment

ABOUT OUR ASSESSMENT

Data Protection Services has an agreement with the institution where you are carrying out research or study. As part of this agreement, we guide so that the processing of personal data in your project is lawful and complies with data protection legislation.

We have now assessed the planned processing of personal data in this project. Our assessment is that the processing is lawful, so long as it is carried out as described in the Notification Form with dialogue and attachments.

IMPORTANT INFORMATION

You must store, send, and secure the collected data in accordance with your institution's guidelines. This means that you must use online survey, cloud storage, and video conferencing providers (and the like) that your institution has an agreement with. We provide general advice on this, but it is your institution's own guidelines for information security that apply.

TYPE OF DATA AND DURATION

The project will process general categories of personal data until 01.08.2023

LEGAL BASIS

The project will gain consent from data subjects to process their personal data. We find that consent will meet the necessary
requirements under art. 4 (11) and 7, in that it will be a freely given, specific, informed, and unambiguous statement or action, which will be documented and can be withdrawn.

The legal basis for processing general categories of personal data is, therefore, consent given by the data subject, cf. the General Data Protection Regulation art. 6.1 a).

PRINCIPLES RELATING TO PROCESSING PERSONAL DATA

We find that the planned processing of personal data will be in accordance with the principles under the General Data Protection

Regulation regarding:

- lawfulness, fairness, and transparency (art. 5.1 a), in that data subjects will receive sufficient information about the processing and will give their consent
- purpose limitation (art. 5.1 b), in that personal data will be collected for specified, explicit, and legitimate purposes, and will not be processed for new, incompatible purposes
- data minimization (art. 5.1 c), in that only personal data which are adequate, relevant, and necessary for the purpose of the project will be processed
- storage limitation (art. 5.1 e), in that personal data will not be stored for longer than is necessary to fulfill the project's purpose.

THE RIGHTS OF DATA SUBJECTS

We find that the information provided to data subjects about the processing of their personal data will meet legal requirements for form and content, cf. art. 12.1 and art. 13.

So long as data subjects can be identified in the collected data, they will have the following rights: access (art. 15), rectification (art. 16), erasure (art. 17), restriction of processing (art. 18), and data portability (art. 20).

We remind you that if a data subject contacts you about their rights, the data controller has a duty to reply within a month.

FOLLOW YOUR INSTITUTION'S GUIDELINES

Our assessment presupposes that the project will meet the requirements of accuracy (art. 5.1 d), integrity and confidentiality (art. 5.1 f), and security (art. 32) when processing personal data.

To ensure that these requirements are met you must follow your institution's internal guidelines and/or consult with your institution (i.e. the institution responsible for the project).

NOTIFY CHANGES

If you intend to make changes to the processing of personal data in this project it may be necessary to notify us. This is done by updating the information registered in the Notification Form. On our website, we explain which changes must be notified. Wait until you receive an answer from us before you carry out the changes.

FOLLOW-UP OF THE PROJECT

We will follow up on the progress of the project at the planned end date in order to determine whether the processing of personal data has been concluded.

Good luck with the project! Contact person: Henriette S. Munthe-Kaas

Appendix 2: Interview Guide for Teachers

Interview guide

The purpose of this interview guide is to collect information on how teachers teach mental mathematics in Malawi using the National Numeracy Programme curriculum

1. What do you think about mental mathematics?

 ____
 ____
 ____

2. Before National Numeracy Programme, were you able to use mental mathematics? Explain

 ____
 ____
 ____
 ____

3. How do you select the mental mathematics questions for your lesson?

 ____
 ____
 ____
 ____

4. How do you select the explanation for your learners when teaching mental mathematics?

 ____
 ____
 ____
 ____
 ____

5. Do you think mental mathematics is useful? Explain

 ____

6. How do you structure your mental mathematics lesson?

7. How do your learners participate in your mental mathematics lesson?

8. What challenges do you encounter in Implementing mental mathematics?

9. What could be some of the solutions to mitigate the challenges?

10. Is there anything else concerning the NNP curriculum that you would like to share?

Appendix 3: Lesson Observation Guide

Lesson Observation Guide

The purpose of this Observation guide is to collect information on how teachers teach mental mathematics in a classroom in Malawi using the National Numeracy Programme curriculum.

1. Does the teacher include mental mathematics in his/ her lesson?

2. How many mental sums does the teacher use?

3. How do learners respond to the questions?

4. How are the questions structured?

5. How are learners involved in the lesson?

6. Does the teacher show the tie between the topic and the mental mathematics questions?

Appendix 4: Document Analysis Guide

Document Analysis Guide

1. How are the mathematics lessons structured in the lesson plan?

2. When is mental mathematics applied in a mathematics lesson?

3. How many mental mathematics questions are set per mathematics lesson?

4. Are mental mathematics related to the concepts of the lesson?

Appendix 5: Letter of Introduction

UNIVERSITY OF MALAWI

Vice Chancellor:
Professor Samson Sajidu, BSc Mlw, MPhil Cantab, PhD Mlw

P. O. Box 280, Zomba, MALAWI
Tel: (265) 01 524 222
Fax: (265) 01 524 046
Email: vcl@unima.ac.mw

MATHEMATICS AND SCIENCE EDUCATION SECTION

24 June 2022

TO WHOM IT MAY CONCERN

LETTER OF INTRODUCTION: MR FELIX MAKOLIJA

This is to certify that Mr Felix Makolija is a mathematics teacher educator at Machinga TTC, and is studying towards a Master of Education (Mathematics Education) at the University of Malawi. Mr Makolija is in his second year of the masters programme and is researching on the National Numeracy Programme (NNP). Please allow him to observe lessons and interview teachers of mathematics in standards 1-4 where NNP is being implemented.

Your cooperation will be greatly appreciated. Please feel free to contact me if you have any queries or questions.

Mchengawedi, Sambainsa & Makungulu Head teacher

Approval granted

19/07/22

DISTRICT EDUCATION MANAGER
(RURAL)
1? JUL 2022
DEM

Sincerely

Mercy Kazima Kishindo
Professor of Mathematics Education
Email: mkazima@unima.ac.mw