A FRAMEWORK FOR THE DEVELOPMENT AND IMPLEMENTATION OF EFFECTIVE INSTRUCTIONAL TEACHING PRACTICES OF MATHEMATICS: A CASE OF A SCHOOL IN LIMPOPO PROVINCE

by

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KEY TERMS:

Mathematics achievement; academic performance; effective mathematics instructional practices, professional development, instruments; didactic method, change framework, constructivism, scaffolding.

DEDICATION

I dedicate this study to God the father, the son, and the Holy Spirit for keeping me on track though my spectacles could no longer focus; I have safely reached the end point of my titration experiment.

I also dedicate this work to the following: My Mother Malope for her encouragement; My wife Nomsa and my brother Noto for their constant questioning of my destiny; and smaller sons Phethego and Tshwanelo who missed their chances to be with me during my research.

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ABSTRACT

Through the study, the researcher developed and implemented a framework for effective mathematics instructional practices. The main purpose of the study was to analyse current mathematics instructional practices and then evaluate the process of the development and implementation of the framework of effective mathematics instructional practices in the classroom.

The study was carried out in a school in Malokela Circuit of Sekhukhune District in the Limpopo Province involving two mathematics teachers and their respective classes Grade 10 and Grade 11. A qualitative case study design was employed in the process of teaching and learning. Sampled participants were observed, video-recorded, audio-recorded and interviewed. In order to identify current mathematics teachers' practices, teachers were observed based on the lesson plans, teaching and reflective interviews before training on the framework took place. Further, the two teachers were trained on the framework for effective mathematics instructional practices and allowed to implement it for 12 days in their respective classes during normal teaching time.

The study revealed that before training, teachers' practices were ineffective, traditional and didactic. It emerged that both the teachers thought that effective teaching was when the teacher was telling, explaining and demonstrating. After training and implementation of the framework for effective mathematics instructional teaching practices, it emerged that both teachers made significant changes in their instructional practices towards effective mathematics instructional practices. Teachers were able to ask productive questions, and these questions led learners to discover solutions without being taught algorithms. The study also established that teachers changed their role of being the transmitter of information and took on the role of a facilitator. Further, the study provided evidence that working on professional development through the effective mathematics instructional practice (EMIP) framework led to learning gains amongst Grade 10 and 11 mathematics learners. Although the gains were small, the study revealed that teachers were able to plan lessons which were consistent with the framework. In addition, the purpose of the planned lessons was to guide teaching not for purposes of compliance to subject advisers. A remarkable observation was that the teachers were able to create a relationship in which both the teacher and the learners understood and respected each other in the classroom.

Learners were able to use relevant resources without being told besides the textbook.

The study further established that the use of professional development through this framework could be pursued by other teachers and curriculum advisers. The confidence is boosted by the changes that were seen on both teachers and learners. When given persistent assistance and monitoring which is not for fault-finding for consequences, teachers seemed to cooperate and move towards change. It is therefore encouraging to have found some changes within the short space of time (three weeks) after the teachers' participation. It is recommended that teachers should use this framework for their own development and improvement over a longer period. It is also recommended that further studies about this framework could be used for a longer duration.

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ACRONYMS

ANA	Annual National Assessment
BED SPF	Bachelor of Education Senior Phase and Further Education and Training
CAPS	Curriculum Assessment Policy Statement
CDE	Centre for Development and Enterprise
CK	Content Knowledge
COI	Classroom Observation Instrument
DBE	Department of Basic Education
EMIP	Effective Mathematics Instructional Practices
ESL	English Second Language
HOD	Head of Department
ICT	Information Communication Technology
ICOT	ISTE Classroom Observation Tool
ISTE	International Society for Technology in Education
LoLT	Language of Learning and Teaching
LPOI	Lesson Plan Observation Instrument
MANCOSA	Management College of South Africa
NCEE	National Center for Educational Evaluation and Regional Assistance
NCS	National Curriculum Statement
NCTM	National Council of Teachers of Mathematics
NETAC	National Evaluation and Technical Assistance Centre
NSC	National Senior Certificate
PCK	Pedagogical Content Knowledge
PD	Professional Development
PK	Pedagogical knowledge
RNCS	Revised National Curriculum Statement
RVAI	Researcher Video Analysis Instrument
SACMEQ	Southern and Eastern African Consortium for Monitoring Educational Quality
STAM	Secondary Teaching Analysis Matrix
TIMMS	Third International Mathematics and Science Study
UNISA	University of South Africa
WEF	World Economic Forum
WMCS	Wits Maths Connect Secondary
ZPD	Zone of Proximal Development

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CHAPTER 1

THE RESEARCH PROBLEM AND ITS CONTEXT

1.1 INTRODUCTION

This chapter introduces the study of a framework for the development and implementation of effective mathematics instructional teaching practices (EMIPs), captures my own observations of working with mathematics teachers, gives an overview and highlights the main purpose, research questions, objectives and the brief outline of the study.

Research indicates that there are problems that face practitioners involved in mathematics education around the world, namely, learners' lack of achievement in, and disengagement from the subject, conceptual understanding, procedural fluency and competence in word problems application (Alsharif & Atweh, 2010; Wu, 2008). South Africa is no exception: learners' achievement and conceptual understanding of mathematics seem to be very low compared to other countries (Ngoepe, 2014). In addition to the sentiments shared by Ngoepe (2014), Pournara, Hodgen, Adler and Pillay (2015) report that South African learners achieve extremely poorly in mathematics. The following table as adapted from Jojo, Dhlamini, Phoshoko, and Ngoepe (2014) indicates how South Africa performed against fellow countries in the Southern and East African Consortium for Monitoring Educational Quality [SACMEQ] in both 2000 and 2007.

Table 1.1:

Performance of South African learners on SACMEQ 2000 and 2007.

	Learners' Mathematics Scores	
	2000	2007
Eastern Cape	449	469
Free State	448	492
Gauteng	552	545
Kwazulu-Natal	510	485
Mpumalanga	433	476
Northern Cape	461	499
Limpopo	446	447

Learners' Mathematics Scores		
North West	420	503
Western Cape	591	566
South Africa	486	495
SACMEQ	500	510

Adapted from SACMEQ (2007)

Based on the results from the table, it is evident that South Africa has performed below the expected SACMEQ level. In 2000, South Africa scored 486 which is 14 below the SACMEQ score of 500 and, in 2007, South Africa scored 495 which is 15 below the SACMEQ value of 510. Both 500 (for 2000) and 510 (for 2007) are the minimum stipulated measurement score a country should achieve in order to conform to other SACMEQ countries.

In addition to the world performance measurement is that, South Africa on its own is in the 'maths crisis' (Pausigere, 2014) because the nature and extent of the South African maths crisis has been much more pronounced and in some ways multiplex. Spaull (2013), on the report for Centre for Development and Enterprise [CDE] (2015), indicates that South African education is in crisis. This is further supported by Sheperd (2011) in saying that the World Economic Forum [WEF] ranked South Africa 137th out of 139 countries in terms of mathematics and science which was the third from bottom. The Trend in the International Mathematics and Science Study [TIMMS] in 2011 showed that South African learners had the lowest performance of all 21 middle-income countries that participated. The CDE (2015) also reported that there was an increase in enrolments of learners in private extra mathematics classes because of poor teaching (mathematical instructional practices) in public schools.

The problem in the South African context has been identified. The Minister of Education and other stakeholders have come up with programmes that are trying to identify and remedy the situation like the introduction of Annual National Assessment [ANA]. In its determination to improve the mathematical skills of the learners, the Department of Basic Education [DBE] (2011) introduced the ANA for Grades 7 and 9. The ANA is a tool that assesses whether a learner needs extra help or not and the results are used to inform teacher's lesson plans and classroom instructional practices and target the improvement in numeracy by 90% by 2024 (DBE, 2011). The ANA continues to reveal a need to introduce mathematics intervention programmes in primary level classes to administer early treatment measures to minimise incidents of poor achievement in higher classes. The ANA brings out a factor that has been given little attention, namely, what actually goes on in the classroom instructional practices (Harwell, 2003). The following table indicates the ANA Grade 9 and the NSC Grade 12 mathematics results from the year 2012 to 2015 for both South Africa as a whole and Limpopo Province where the study was located.

Table1.2:

Grade 9 ANA and Grade 12 NSC Achievement for RSA and Limpopo

Year	**Grade 9**		**Grade 12**	
	RSA	**Limpopo**	**RSA**	**Limpopo**
2012	12.7%	8.5%	54.0%	34.0%
2013	13.9%	9.0%	59.1%	40.1%
2014	10.8%	5.9%	53.5%	39.6%
2015	------	-------	49.5%	40.8%

Source: (CDE, 2013; DBE, 2012, 2013, 2014, 2015).

The table indicates that there is a problem with mathematics in Grade 9. Learners' achievement is very poor for both the country and the Limpopo province in which the study is located. The average percentage is very low and fluctuates. Based on the performance in Grade 12 mathematics, it also shows that the learner achievement in this subject is problematic. This is because the results include learners who were awarded a satisfactory pass of 30%. The results indicate that there are low levels of competency in the subject.

The district (Sekhukhune) and the circuit (Malokela) in Limpopo province at which I am working were also in the same situation. The majority of learners moving from Grade 9 are opting for Mathematical Literacy at the expense of mathematics based on their previous Grade 9 mathematics performance which is poor. Only a few who have passed Grade 9 mathematics with at least 40% and upwards, take mathematics, and those few have the previously mentioned problem of lack of conceptual understanding. The circuit is performing very poorly compared to their counterparts generally, and especially within the field of mathematics. The problem then cascades down to the schools. Even though my school has performed best in mathematics and other subjects in the circuit since 2008 based on Grade 12 results, the problem of mathematics conceptualisation and achievement is not ruled out especially in lower classes. In my school, Grade 10 mathematics seems to be more problematic than Grade 12. I taught Grade 11 and 12 mathematics from 2006 to 2016 with more than four different teachers teaching Grade 10 mathematics in different years. The achievement and understanding of mathematical concepts by the learners from Grade 10 were very poor in all those years (2006 to May 2016). Apart from the achievement, those learners that pass Grade 10 into Grade 11 are having trouble with mathematics as a subject. They cannot conceptualise the content. There seem to be an accumulated deficit (content gaps) from Grade 10. So, as a Grade 11 and 12 mathematics teacher, I was expected to make up for a large deficit.

The basics skills that are needed in Grade 12 mathematics from the previous Grades are missing. For example, when dealing with functions, when asking learners to find the x intercepts on a parabola or hyperbola which are Grade 11 topics, learners find it difficult to solve for x (make x the subject) when the value of y is zero. Time and again, I had to teach the Grade 10 mathematics topics in detail before getting to Grade 11 and 12 mathematics content. This clearly indicates that there is a problem with the mathematics instructional practices from the previous grades' teachers.

There are several factors that are found to contribute to the problem of poor performance in other parts of the world and South Africa like ineffective instructional practices, teacher pedagogy and teaching practice. Of these factors, ineffective instructional practices seem to make a profound contribution towards poor performance and lack of mathematics understanding (National Centre for Educational Evaluation and Regional Assistance [NCEE], 2013; Ngoepe, 2014). According to Johnson, Ellis and Rasmussen (2016), some of the specific problems that were identified in their study included courses that are oversaturated with material, pacing that hinders comprehension and reflection, the lack of application or conceptual discussions, and teaching practices that suggest instructors take little responsibility for learner's success. In the South African context, pacing is put up front in almost all mathematics content and curriculum. Pacing is regarded as demarcating the yearly mathematics content into days, weeks, quarters and dates on a pace setter. The curriculum advisers and the school management are actually looking at pace setter completion and the control tests are also based on those pace setters. Based on these practices and research arguments, there is a need to rectify or improve the situation;

by devising effective instructional practices in mathematics which will enable learners to conceptualise mathematics and achieve highly.

Research (Grouws, 2004; Marlowe, Mathur & Schoenfeld, 2010) indicates that effective instructional practices in mathematics could be beneficial to both the teacher and the learner if implemented. According to Marlowe, Mathur and Schoenfeld (2010), effective instructional practices are providing learners with consistent reinforcement for successful performance of academic tasks, helping the teachers to minimise time wasting and maximise learners' engagement in learning. In other words, the effective instructional practices lead to more learner engagement through active response, learner-to-learner interaction and increased opportunities to solve problems (Marlowe, Mathur & Schoenfeld, 2010). Furthermore, Grouws (2004) indicates that effective instructional practices encourage learners to solve problems in a way that is meaningful to them and to explain how they solved the problem, resulting in an increased awareness that there is more than one way to solve most problems. There are more benefits of using effective instructional practices.

1.2 BACKGROUND

This study explores a framework for the development and implementation of EMIPs. Terms such as instructional practices, classroom practices, teaching practices and instructional teaching practices are used interchangeably. The reason behind the interchangeable usage is because some studies tend to define what the meanings are whereas some studies opt not to define the terms. Munroe (2015) defines teaching practices as learning experiences that are facilitated by a human being while instructional practices are learning experiences in which instructional support is conveyed by teaching and other forms of mediation. Munroe further defines classroom practices as the teaching and learning that take place in classroom; that is, the day-to-day routines of both the teacher and the learner inside the classroom. Classroom (instructional teaching) practices can be described as a comprehensive range of presentations and discussions (Mok, 2012); and any studies and scientific experiments happening inside the classroom, including the investigation of the key agents (the teachers, resources and learners) (Munroe, 2015). Mok (2012), Munroe (2015) and Allen and Crowley (2013) indicate that classroom practices are a major component of classroom discourse and a vehicle for increasing mathematics learners' learning and understanding. In this study, the terms ‘instructional practices’ and ‘classroom practices’ will be used interchangeably since both involve teaching and what is happening inside the classroom. Classroom (instructional teaching) practices involve the teaching and learning of mathematics and assessment.

The teaching and learning of mathematics have always been a complex and challenging endeavour both in South Africa and elsewhere in the world (Ngoepe & Treagust, 2003; Steedly, Dragoo, Arafeh, & Luke, 2008). The complexity of the teaching and learning of mathematics has been researched and identified to cause lack of mathematical understanding and poor learners’ performance (National Center for Educational Evaluation [NCEE], 2013; Ngoepe & Treagust, 2003; Pretorius, 2000).

1.2.1 Poor Learners’ Performance in Mathematics

South African learners perform poorly in mathematics. Mativandlela (2009), Pournara et al. (2015) and Jojo et al. (2014) report that, in both 2006 and 2007, South African learners achieved extremely poorly in mathematics compared to other countries in the SACMEQ. The same sentiments are revealed by the DBE (2011) through the ANA report.

Further, to the SACMEQ measurement is that, South Africa on its own is in ‘maths crisis’ as reported by Pausigere (2014). Sheperd (2011) attests that the WEF had ranked South Africa 137th out of 139 countries in terms of mathematics and science learner achievement.

1.2.2 Lack of Effective Mathematical Teaching and Learning

The issue of teaching for understanding and or learning for understanding is another complexity concerned with teaching and learning of mathematics. Research indicates that instruction, especially at the high school level, remains overwhelmingly teacher-centred, with greater emphasis placed on teaching algorithms than on helping learners to think critically and apply their knowledge to real-world situations (Wachira, Pourdavood & Skitzki, 2009). In the South African context, the transformation of mathematics education since 1994, the launch of the National Curriculum Statement [NCS] in 2004, the review of the NCS to the Revised National Curriculum Statement Grade R to 12 [RNCS-12] and the Curriculum Assessment Policy Statement [CAPS] as from 2012 has led to a shift in philosophy that focuses mainly on the transmission of information to recent teaching reforms which are based on a constructivist approach to teaching and learning (DBE, 2011; Mosala, 2011). The introduction of the NCS replaced the traditional pedagogical style of rote learning where the teacher was seen as the main source of information, with more learner-centred pedagogical approaches that were intended to engender critical thought. The main focus for the NCS is for teaching for understanding and learning for understanding to be achieved.

There are numerous factors influencing learner achievement and learner understanding as mentioned previously. Those factors revolve around classroom practices, teacher pedagogy or teacher classroom practices. Although there are numerous factors influencing learner achievement in South Africa, the instructional practices that mathematics teachers use have a profound influence on learners' learning and achievement (National Center for Educational Evaluation and Regional Assistance [NCEE], 2013; Ngoepe, 2014).

The complexity of teaching and learning mathematics in the form of classroom practices is linked to the effective way of teaching and learning of the subject (Bruce, 2007; Birman, Desimone, Porter, & Garet, 2000; NCEE, 2013; Pretorius, 2013). From the three identified problems – lack of mathematics understanding, poor learner performance and lack of mathematics achievement – it is clear that the teachers use ineffective classroom practices that have a profound influence on mathematics learning. One of the major goals of EMIPs is the development and improvement of teaching and learning, ultimately improving mathematics learner achievement and improving mathematics understanding. Again, EMIPs are one of the basic ways by which learners' thinking and learning is stimulated (Ngoepe, 2013). In achieving these goals, EMIPs must strive towards teaching for understanding. Despite the benefits of EMIPs touted by researchers, ineffective instructional practices are still the overwhelmingly predominant instructional techniques in most classrooms.

Teaching for understanding has always been important in mathematics education, with recent publications on the subject by Goodell (2000), Ngoepe (2014) and Pournara, et al. (2015) indicating the importance of this matter. Teaching for understanding in mathematics requires actions on the part of the learner in the form of making connections to other things she or he already knows; that teachers have a critical role in promoting understanding through the ways in which they organise their classroom instruction and assessment; and that reflection is a vital part of learning (Goodell, 2000). As one part of effective instructional practices, teaching for understanding is also a major concern for mathematics in South African schools. According to DBE (2011), the following principles form the basis of the NCS R-12: Active and critical learning – encouraging an active and critical approach to learning, rather than rote and uncritical learning of given truths; and high knowledge and high skills – the minimum standards of knowledge and skills to be achieved in each grade are specified. To ensure that teaching for understanding is done effectively, there is a need to carefully consider what teaching for understanding entails (Newton, 2000). Then teachers need to identify the principles that will foster effective instructional practices.

1.3 RESEARCH PROBLEM

The ineffective teaching and learning which leads to lack of mathematical understanding is a major concern to the country. Research has indicated that the traditional approach is very common in teaching and dominates mathematics education (Khalid & Azeem, 2012; Wachira, Pourdavood & Skitzki, 2013). In a study which investigated the classroom practices of secondary mathematics teachers in townships schools in South Africa, Ngoepe (2003) revealed that the status of mathematics teaching in these schools was predominantly didactic. The practices were overwhelmingly teacher-centred instruction in terms of the teachers' content knowledge, the teachers' teaching, and teachers' assessment practices, the interaction between teachers and the learners and the resource availability. Wachira et al. (2013) had the same sentiments. The Secondary Teaching Analysis Matrix [STAM] framework of Gallagher and Parker (1995) was used to analyse the teaching of mathematics in the township schools. It is from this background that this current study is located in a rural area of South Africa. The study also revealed that there were many issues that hinder effective instructional practices in schools. From this study and others (Simmons & Kamlay, 1999), the STAM descriptors could be used to guide teaching and to help teachers to reflect on their classroom practices. Based on the classification, observations, analyses and recommendations of Ngoepe's (2003) study, in-service and pre-service training should be designed to help teachers to move from didactic teaching to more conceptual forms of teaching, that is, EMIPs. It is from these arguments that this study takes the STAM and other frameworks for the development and implementation of effective instructional practices in mathematics. It is envisaged that using this framework to guide effective instructional teaching practices could lead to more conceptual forms of teaching and boost learner achievement and mathematical understanding. The study aimed at exploring the issue of effective mathematics classroom practices by classroom-based research and professional development of teachers within the selected school in the circuit. Classroom (instructional) practices need to be improved through professional development hence the development and implementation of a framework that could develop teachers towards EMIPs.

1.4 PURPOSE OF THE STUDY

The purpose of the study was to identify current mathematics teachers' instructional practices, develop a framework for EMIPs and use the framework on mathematics teachers through classroom-based research and professional development which could lead to improved mathematics teaching and learning, mathematics understanding and mathematics achievement in Malokela Circuit of Limpopo Province. It could also lead to mathematics understanding and learners' mathematics achievement. Teachers' classroom practices are directly related to learner achievement and mathematics understanding (Major & Mangope, 2012).

To fulfil the above-mentioned purpose, the following objectives are purposed to guide the study.

1.5 OBJECTIVES OF THE STUDY

In order to achieve the above purpose, the following objectives are outlined:

- To identify current mathematics teachers' instructional practices;
- To identify effective mathematics instructional practices framework;
- To identify the changes that the development and implementation of effective mathematical instructional practices framework effects to teachers' instructional practices;
- To identify the impact of effective mathematical instructional practices on learners' questioning skills and the teacher's instructional practices;
- To use the model to help learners to improve on the choice and use (the relevant) resources.

In terms of the study objectives, the process cycle of the study is represented in Figure 1.1 below:

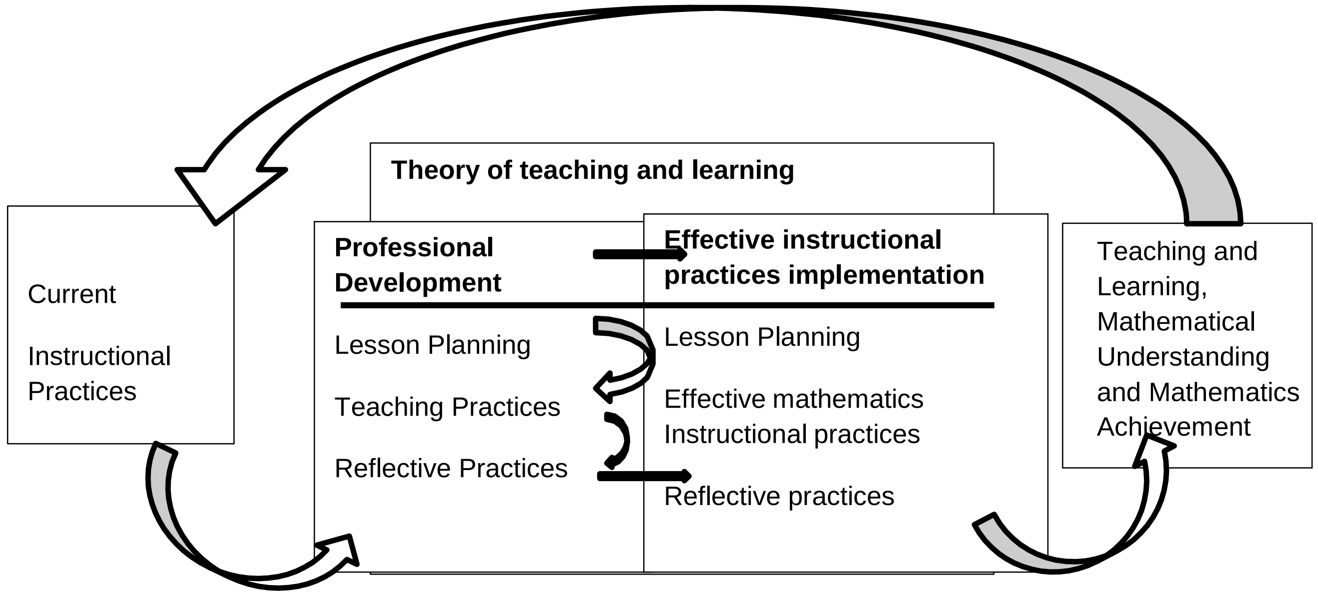


Figure 1.1*: A process cycle of the study*

The framework starts from the right-hand side (Teaching and Learning, mathematics understanding and mathematics achievement as a problem) to the left (current teachers' instructional practices) then to the right back to teaching and learning, mathematics understanding and mathematics achievement as a desired goal. The starting point is the problem area of the study: Ineffective teaching and learning, lack of mathematical understanding and poor mathematics achievement. Teaching and learning, lack of mathematical understanding and poor mathematics achievement in the framework are used for dual purposes: as a problem area and as a basis to achieve a desired outcome of the whole process. The external cyclic arrows indicate the way in which the proposed framework should be followed in order to continuously have EMIPs.

Starting as a problem of teaching and learning, poor mathematics achievement and lack of mathematics achievement, then, the big arrow points at current teachers' instructional practices. The instructional practices are seen as one of the main factors that affect teaching and learning, mathematical understanding and mathematics achievement (National Center for Educational Evaluation [NCEE], 2013; Ngoepe & Treagust, 2003; Pretorius, 2000). The framework indicates that once the problems are identified lack of mathematics understanding and poor mathematics achievement, we then look at the causal factors which are current instructional practices. Current instructional practices focuson the teaching and learning. The teaching and learning consisits of many factors to look in. But for the focus of the study, the questioning of both the teacher and the learners and the choice of resource by both the teacher and the learners. There is a need to move from the current instructional practices towards EMIPs. Based on the model, the movement could be done by focusing the whole process on the theory of learning: social constructivism. The theory as explained broadly in the section dealing with the theoretical framework of constructivism and its application to the study in Chapter 3 directs and give ways in which EMIPs could be implemented. From the underpinning theory, then come the EMIPs which start from lesson planning, interventions with recording teaching and reflections. Eventually the intervention is reviewed and the cycle is repeated until the desired outcomes are achieved.

1.6 RESEARCH QUESTIONS

To achieve the purpose and objectives of the study, the researcher endeavours to pursue the following research questions:

1.6.1 Research Questions:

The study seeks to answer the following research questions:

Research Question 1

What are the current mathematics teachers' instructional practices?

Research Question 2

What is the framework of effective mathematics instructional practices?

Research Question 3

How the development and implementation of effective mathematical instructional practices framework changes teachers' instructional practices?

Research Question 4

What is the impact of effective mathematical instructional practices on learners' questioning skills and the teacher's instructional practices?

Research Question 5

How do effective mathematics instructional practices affect learners' resources choice and usage?

1.7 SIGNIFICANCE OF THE STUDY

Since mathematics is the most crucial subject responsible for the growth and development of individuals and the socio-economic development of different countries, the significance of the study will be its meaningful contribution towards the attainment of the goals of DBE and solutions or part of the solution to the problem of the lack of mathematics conceptual understanding and poor performance as follows:

- to uncover the current mathematical instructions of teachers as a baseline for other to note.
- Further, help in finding the solutions to the problem of ineffective mathematics instructional practices encountered by mathematics teachers and practitioners.
- Eventually, help learners in mathematics understanding and mathematics achievement while conceptually capturing mathematics and hence have brighter future and understanding of the world.
- Lastly helps teachers to guide learners to identify which resources are relevant to be used.

1.8 DEFINITIONS OF TERMS

Didactic	A manner of instruction in which information is presented directly from the teacher to the pupil, in which the teacher selects the topic of instruction, controls instructional stimuli, obligates a response from the child, evaluates child responses, and provides reinforcement (Merriam Webster Dictionary, 2002)
Constructivism	A learning theory describing the process of knowledge construction (Major & Mangope, 2012).
Knowledge	An explanation and an assumption but not the final answer for all questions, it will be discarded along with the human process and new assumption will appear (Jia, 2010).
Content knowledge	The teacher's knowledge about the subject matter to be learned or taught (Koehler & Mishra, 2009).
Pedagogical Content Knowledge (PCK)	The teacher's deep knowledge about the process and practices or the methods of teaching and learning the subject Matter (Shulman, 1987).

Non-probability sampling	The sample that targets a particular group, in the full knowledge that it does not represent the wider population rather simply represents itself (Cohen, Manion, & Morrison, 2011).
Research methodology	The practical "how" of any given piece of research. More specifically, it's about **how** a researcher **systematically designs a study** to ensure valid and reliable results that address the research aims and objectives (Jansen & Warren, 2020).
Secondary Teacher Analysis Matrix	An instrument used for observation of teachers and principals to alter practices for sciences and mathematics subjects (Gallagher & Parker, 1995).
Understanding	To assimilate something into an appropriate schema (cognitive structure) (Grossman, 1986).
Instructional practices	Learning experiences in which instructional support is carried by teaching and other forms of mediation as taken from Munroe (2015).
Professional development	A process of improving and increasing capabilities of staff through access to education and training opportunities in the workplace, through outside organisation, or through watching others perform the job (Abu-Tineh & Sadiq, 2018).

1.9 THESIS OVERVIEW

Chapter 1 introduces and provides the background of the study

Chapter 2 is divided into eight sections. The first section is an introduction of the Chapter 2, the second section discusses the definitions of instructional practices into perspective for the study. The third section states the characteristics of effective instructional practices. The fifth section presents the understanding of mathematical proficiency including mathematical content knowledge, and PCK. The sixth section gives details on what counts as professional development, theory of underpinning the study and its application on the study; the seventh section covers literature on studies on instructional practices including the STAM framework from an international perspective to the national (South African) perspective; and the last section discuss the development of the instruments in this study.

Chapter 3 includes a detailed account of the theoretical framework on which this study is guided.

Chapter 4 outlines the methodology used in the culminating exploration, including the sampling of schools and sampling of teachers, the research design, data collection, instrumentation and analysis techniques.

Chapter 5 presents the data analysis, results and the findings from the data.

Chapter 6 records the discussions, findings from the study, implications and recommendations and the conclusion to the study.

1.10 CHAPTER SUMMARY

This chapter provided organisation to the background, and the purpose of the study by highlighting issues about the research problem and its context. Further, the research questions were indicated. Lastly, the chapter closes by indicating the significance of the study, the definition of terms and the chapters outline.

In the following chapter literature review on historical perspectives on instructional practices, characteristics of EMIPs, creating a classroom environment for respect and rapport, conceptual understanding, inclusion of Information Communication Technology (ICT) in teaching and learning, importance of EMIPs, studies on instructional practices and current reforms of instructional practices are presented.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the literature review on the historical aspects and definition of instructional practices as they evolved for the study that was purposed to develop and implement a framework of effective mathematics instructional teaching practices is outlined. Also, the features that characterise EMIPs are listed and elaborated upon. The constructs of lesson planning, teaching practices and reflective practices are dwelt upon to bring out the complexity of teaching and learning of mathematics. The importance of EMIPs is described including the studies which investigated instructional practices on an international and national (South African) level. Further, current reforms on instructional practices and the reason for the focus on the development and implementation of the EMIPs are highlighted.

It was essential to review the literature because, in this process, the different views that the authors produced about the classroom practices are captured, critiqued and analysed. Neuman (1997) and Mudavanhu (2017) also supports the notion that the reviews provide information on the selected problem and enables the researcher to see the problem from various perspectives. On the same note, an evaluative report of studies found in the literature related to the selected area of the researcher is presented. Boote and Beile (2005) indicate that the review's purpose is to "describe, summarise, evaluate and clarify literature" (p.5).

2.2 HISTORICAL PERSPECTIVES OF INSTRUCTIONAL PRACTICES

The word 'instructional practices' comes from a combination of two words: instruction and practice. In order to describe the concept, the historical evolution of each word is explained and later the concept itself is defined.

Firstly, the origin of the word 'instruction' dates long back from c.1400 and originates from the Latin word *'instructionem'* which meant "an array, arrangement" and in later Latin which means "teaching", from the past participle stem of *instruere* "to arrange, prepare, set in order; inform, teach". *Instruction* has a connotation of the imparting of knowledge for its object, but emphasises, more than *teaching*, the employment of orderly arrangement in the things taught (Century Dictionary, 1889). The word instructional comes as an addition of the suffix –'al' to instruction *[< instruction + al*>] which then means "Of or pertaining to instruction; promoting education" (p. 3125).

Secondly, the word practice is known from as early as 15th century, as *practice*, which meant "practical application", originally especially of medicine but also alchemy and education. It originates from different countries: from Old French *pratiser meaning* "to practice"; from Medieval Latin *practicare* (see *practice* (v.) meaning "to do, perform, practice"; from Late Latin *practicus* meaning "practical"; and from Greek *praktikos meaning* "practical". From the early 15th century, the word was often assimilated in spelling to nouns in *-ice*. Also as *practic*, which survived in parallel with *practicus* and *practicare* into the 19th century. In c. 1400, the word, "to do, act" early "to follow or employ; to carry on a profession," especially in medicine (Century Dictionary, 1889, p. 3126).

The concept of instructional practices has been explored by several authors in education research (Allen & Crowley, 2013; Darch, Carnine, & Gersten, 1984, Kameeniu, Darch, Carnine, & Stein, 1986; Forrest-Pressley, MacKinnon, & Waller, 1985; Mok, 2012; Munroe, 2015; Baker, 2019). More often, the terms instructional practices, instructional teaching practices, classroom practices, teaching practices, and classroom instructions, are used interchangeably and there are no clear distinctions. Some of the researchers (Gersten, 1996; Forrest-Pressley et al., 1985; Darch et al., 1984) opted not to define instructional practices, classroom practices, teaching practices and instructional teaching practices but tend to use the terms as they appear. While some scholars (Allen & Crowley, 2013; Mok, 2012; Munroe, 2015) define instructional practices differently depending on their school paradigm, their meaning leans towards one common or similar idea which is used in the development and implementation of EMIPs.

Munroe (2015) defines teaching practices as learning experiences that are enabled by a human being while instructional practices are learning experiences in which instructional support is provided by teaching and other forms of mediation. From these two definitions, 'learning experiences' is key. It emerges that both practices (teaching practices and instructional practices) involve a process whereby learners gain a learning experience, whether facilitated by a human being or by a technological device. The common thread between instructional practices and teaching practices relates to the actions that teachers are doing in the classroom.

Munroe further defines classroom practices as the teaching and learning that takes place in classroom, that is, the day-to-day routines of both the teacher and the learner inside the classroom. Based on how Munroe (2015) defines classroom practices, it entails teachers teaching, learners learning, materials used in the process and the actions of both teachers to learner and learners to learners which also relates to learning experiences. This study was aimed at developing and implementing a framework for EMIPs. The practices entail what Munroe (2015) outlined in his definition: the actions of the teacher while teaching, the actions of learners during learning, the selection and use materials during the process of teaching and learning, and the communication interactions amongst the teacher and the learners, learners and learners and the environment in which the process is taking place. In the development and implementation process, the concept of reflective practices is also included.

On the other hand, Mok (2012) describes classroom practices interchangeably with instructional teaching practices as a comprehensive variety of presentations and discussions and any studies and scientific experiments happening inside the classroom. Munroe (2015) further adds that it includes the investigation of the key agents (the teachers, resources and learners) in the classroom. Mok (2012), Munroe (2015) and Allen and Crowley (2013) indicate that classroom practices are a major component of classroom discourse and a vehicle for improving mathematics learners' understanding. The main focus of the study is to develop and implement a framework for EMIPs, the constructs instructional practices and classroom practices are used interchangeably since both involves the teaching and what is happening inside the classroom. Classroom (instructional) practices involve the teaching and learning of mathematics and assessment. The definition that is used in the study, instructional practices is defined as learning experiences in which instructional support is carried by teaching and other forms of mediation as taken from Munroe (2015).

Mostly, instructional practices in mathematics education revolve around two methods: teacher-directed instruction (teacher-centred) or learner-centred instruction (Ahmed, 2013; Garret, 2008). The latter, in this study is used interchangeably with learner-centred instruction. Teacher-directed instruction is instruction in which the teacher is primarily communicating the mathematics to the learners directly and where the majority of interaction is from the teacher to the learner (Baker, Gersten, & Lee, 2002) while according to Gersten, Ferrini-Mundy, Benbow, Clements, Loveless, Williams, and Banfield (2012) learner-centred instruction is an instruction in which primarily learners are doing the teaching of the mathematics and the majority of interactions about the mathematics occur between and among the learners. In addition, Felder and Brent (2010) define learner-centred instruction as a broad teaching approach that includes substituting active learning for lectures, holding learners responsible for their learning, and using self-paced and or cooperative learning. There is no consensus as to which method is best between teacher-centred and learner-centred instruction. Some of the studies (Baker et al., 2002; Darch et al., 1984; Rittle-Johnson, 2006) found that teacher-directed instruction led to greater learner achievement in mathematics while other studies (Bransford, Brown, & Cocking, 2000; Fuchs, Fuchs, Finelli, Courey, Hamlett, Sones & Hope, 2006) found that learner-centred instruction was more effective. Based on the studies that investigated the instructional practices, it emerges that there is no method (either teacher-centred or learner-centred) that is superior to the other one. But there is a small line of distinction, with learner-centred instruction tending to be more effective. In this study, the focus is on practices that take place in the classroom which could yield higher learner achievement in mathematics and understanding; hence, the need for EMIPs.

The two practices are based on different theoretical perspectives. Firstly, the teacher-centred approach seems to be aligned mostly with the theory of teaching and learning called behaviourism. This is because, according to Garret (2008), the behaviourist model involves the use of techniques that bring learners' behaviour under the control of a stimulus and the behavioural approaches are consistent with a 'traditional' or transmission approach to instruction. Ahmed (2013) further indicates that the traditional teaching style specifically focusing on teacher-centred instruction makes learners simply the recipients of teachers' knowledge and wisdom.

Secondly, the learner-centred method is promoted by many theories in mathematics education like the sociocultural theory, the situated learning theory, the critical constructivism theory and the deconstructionist critical theory, to mention a few. For this study, the choice is on the alignment with the theory of learning called constructivism which will be discussed in detail in Chapter 3. This is because in learner-centred teaching, learners are assigned open-ended problems requiring critical or creative thinking, reflective writing exercises, and involving learners in simulations and role plays, meaning making, inquiry and authentic activity (Felder & Brent, 2010; Garret, 2008). Ahmed (2013) supports the idea that learner-centred instruction makes learners more autonomous and more self-directed in constructing their own learning experiences. Furthermore, Ahmed (2013), Felder and Brent (2010); and Garret (2008) support that the theory of social constructivism which is based on the principle that a learning environment should be created where knowledge is constructed by the learner and the teacher rather than simply by transmission by the teacher. Learner-centred instruction reflects and is rooted in the constructivist philosophy of teaching (Ahmed, 2013). Therefore, in the development and implementation of EMIPs, the teaching methods that are envisaged should be learner-centred methods. The TIMMS (2004) defines EMIP as a complex endeavour requiring knowledge about the subject matter of mathematics, the ways learners learn, and effective pedagogy in mathematics. In this study, the main focus is on the development and implementation of a framework for EMIPs in redressing the problems mentioned in Chapter 1 of ineffective instructional practices where teachers' practices are predominantly didactic. Literature on what constitutes characteristics of EMIPs was searched, analysed and documented. It was important to look at characteristics of effective instructional practices in order to position and ground the development and implementation of the framework around those effective characteristics.

The following section captures the characteristics of EMIP based on literature.

2.3 CHARACTERISTICS OF EFFECTIVE MATHEMATICS INSTRUCTIONAL PRACTICES

Researchers such as Wood and Sellers (1996), Larson (2002), Shellard and Moyer, (2002); Cooper (2006); Grouws (2004), TIMMS (2004) and the IOWA Department of Education [IOWA DoE] (2011) indicate that there are many characteristics of instructional practices and that these depend on the theoretical stance of the individual. Even though the characteristics are varied, not all of them are effective (TIMMS, 2004). Furthermore, it is important to note that while some researchers give a list of the characteristics of EMIP, some researchers do not list and one needs to identify and extract the characteristics from their arguments. On the same note, this study will list and identify the characteristics based on the arguments or list from the researchers.

Wood and Sellers (1996) indicate that effective mathematics teaching and learning is characterised by structuring the teaching of mathematical concepts and skills around problems to be solved. On the other hand, Shellard and Moyer (2002) posit that effective mathematics teaching and learning is based on three critical components, namely, teaching for conceptual understanding, developing learners' procedural literacy and promoting strategic competence through meaningful problem-solving investigations. Furthermore, Grouws (2004) indicates that in effective mathematics teaching and learning, teachers encourage learners to solve problems in a way that is meaningful to them and to explain how they solved the problem, resulting in an increased awareness that there is more than one way to solve most problems. From Grouws' argument, the main characteristic that become apparent is that learners should solve and explain how they solved the problem. From the above identified characteristics of effective mathematics teaching and learning, it is noted that there is a common thread amongst them which is teaching towards conceptual understanding, procedural literacy and promoting strategic competence. The conceptual understanding appears in Shellard and Moyer (2002) and Grouws (2004) when saying that teachers need to encourage learners to solve problem in a way that is meaningful to them and explain how they solved the problem. Apart from the conceptual understanding, EMIPs seek to solve a 'daily life' problem. This is contrary to what most teachers teach for – an algorithmic teaching which seeks to do routine exercises. The concept of conceptual understanding is explained in detail in Chapter 2.

Woods and Sellers (1997) posit that, in an effective instructional teaching there should be a "structured teaching of mathematical concepts" (p.167). The 'structured teaching' seems to mean that there is a concrete, fixed, single way of teaching that should be followed. This type of teaching is a problem in terms of the constructivism theory. Although, that is the case, structured teaching, the main important point thatemerges from Woods and Sellers (1997), is that the teaching should be based on a problem to be solved, and this aligns very well with the characteristic of EMIPs and the theory of social constructivism.

In the view of Cooper (2006), the characteristics of EMIPs for learners to achieve understanding are fourfold, namely, instruction that is organised around the solution of meaningful problems; instruction which provides scaffolding for achieving meaningful learning; instruction that affords opportunities for ongoing assessment, practice with feedback, revision and reflections; and the social arrangements of instruction to promote collaboration, distributed expertise and independent learning. These characteristics of Cooper (2006) clearly bring out factors/ characteristics (though Cooper calls them principles) that are directly related to the social constructivist theory. These factors/ characteristics are seen as a significant part of learning for conceptual understanding.

TIMMS (2004) does not necessarily give the characteristics, but defines EMIPs where the characteristics emerge from their definition. From TIMMS (2004), the definition of effective instructional practices as a complex endeavour requiring knowledge about the subject matter of mathematics, the ways learners learn, and effective pedagogy in mathematics brings out characteristics like the teaching which includes teacher's role, the learners' role and the knowledge of the learners. The definition indicates a characteristic – the complexity of instructional practices and what it requires to qualify for being effective (content-knowledge of the subject matter, the actions of learners in the classroom, and pedagogy – the effective way of teaching and learning the content). The model or framework of EMIP developed and explained in Chapter 3, focuses mainly on the complex instructional practices of learner engagement, environment, resources and pedagogy. These complexities are mainly what characterise EMIPs and the framework (TIMMS, 2004).

Larson (2002) states that there are five essential characteristics of effective mathematics 'lessons' namely, introduction, development of concept or skill, guided practice, summary and independent practice. One needs to indicate that looking at the essence of these characteristics, they lead to instructional practices because they contain the introduction, the development of concepts or skill, guided practice and independent practice which could be honed through teaching. Besides this, a lesson plan is one of the characteristics of EMIPs. IOWA DoE (2011) identified the following as the characteristics of effective instructional practices: teaching for understanding; teaching for learner difference; rigorous and relevant curriculum; learner-centred instruction; and assessment for learning (formative).

On the other hand, the National Evaluation and Technical Assistance Center (NETAC, 2010) define effective instruction as explicit instruction which is an effective teaching practices that could be characterised by supporting learners in acquiring new mathematics facts. From this definition, a characteristic of EMIPs emerges: supporting a learner in acquiring new mathematics facts. There are further characteristics that are included in the explicit instruction according to NETAC (2010): teacher-directed instruction of prerequisite skills; modelling of target skills; guided practice; independence practice; and corrective feedback.

Anthony and Walshaw (2007) view the characteristics of effective teaching in mathematics as critical aspects of pedagogical practice, namely, creating community, discourse, instructional tasks and tools and representation of mathematical ideas.

In their framework for organising concrete effective teaching practices, MacSuga-Gage, Simonsen and Briere (2012) indicate that effective mathematics teachers have a foundation characterised by practices that engage learners consistently and promote academic achievement, appropriate behaviour and relationship-building with learners. What comes out from their framework is that effective mathematics instruction should have the following characteristics: it should be explicit and engaging; the organisation should support all learners in the classroom; and the implementation should empirically support the classroom management practices (MacSuga-Gage et al., 2012).

Based on the literature discussed above, in the context of my study, I define EMIPs as the practices that are envisaged to help learners achieve in mathematics and have mathematical understanding with the use of resources relevant to the problem being solved and that support and create a conducive-learning environment. The main focus for this study is on the development and the implementation (how teachers should teach effectively) of the framework with the intended outcomes being to improve the teachers' instructional practices based on the EMIPs and to improve learners mathematical understanding and mathematics achievement. The teachers' instructional practices considered are questioning techniques, classroom interactions, creation of usage of resources and the environment which could lead to mathematics achievement and mathematical understanding which are the sub-problems of the study as mentioned in Chapter 1. The characteristics that have been identified fit well within the South African curriculum, CAPS and the theory of social constructivism.

National Council of Teachers of Mathematics (NCTM) (2014) lists the following effective mathematics teaching practices. Effective mathematics teaching practices:

- establish mathematics goals to focus learning;
- implement tasks that promote reasoning and problem-solving;
- use and connect mathematical representations;
- facilitate meaningful mathematical discourse;
- pose purposeful questions;
- build procedural fluency from conceptual understanding;
- support productive struggle in learning mathematics; and
- elicit and use evidence of learners' thinking. (NCTM, 2014).

Looking at these teaching practices as listed by NCTM, they are well linked to what is envisaged by the theory of social constructivism that underpins the study. They are also related to the principles and the aims of the NCS CAPS (DBE, 2011). The following aims (identify and solve problems, and make decisions using critical and creative thinking) are rooted within the NCTM (2014) characteristics which state that EMIPs implement tasks that promote reasoning and problem-solving.

Furthermore, from the CAPS, the following principles (active and critical learning, and high skills and high knowledge) are directly related to the NCTM characteristics such as building procedural fluency and conceptual understanding and use and connect mathematical representations (DBE, 2011). It is for this reasons that the NCTM characteristics are seen as a solid foundation for the development and implementation of the framework.

Alternatively, the Education Alliance (2006) lists the following as best effective practices: learner's engagement at high level; tasks built on learner's prior knowledge; scaffolding; making connections; procedures and understanding; modeling of high-level performance; learners explaining their thinking and meaning; self-monitoring of progress and appropriate time spent on tasks. The characteristics from the Education Alliance (2006); and NCTM (2014) capture all of the above-mentioned characteristics and are rooted in the social constructivist theory which underpins this study.

Through sifting, analysis and comparison, this study compared and analysed the characteristics as identified by the researchers and came to the conclusion that the list of characteristics that could guide the study are as listed by the NCTM (2014) and Education Alliance (2006) since they capture the characteristics mentioned in other literature. When summarising the EMIPs, the NCTM (2014) provides the list that includes or comprehensively covers the arguments that were indicated by the other researchers (Anthony & Walshaw, 2007; Cooper, 2006; Grouws, 2004; IOWA DoE, 2011; Larson, 2002; MacSuga-Gage et al., 2012; NETAC, 2010; Shellard & Moyer, 2002; TIMMS, 2004; Abu-Tineh & Sadiq, 2017).

In summary, the characteristics of EMIP consist mainly of the following features: the lesson planning followed by teaching practice which includes assessment, classroom environment, conceptual understanding, use of ICT and lastly, reflective practices. The next section explains the features of the characteristics of EMIPs: lesson planning, effective instructional practices (teaching practices), classroom environment, conceptual understanding and reflective practices as the framework that is developed and implemented in this study.

2.3.1 Lesson Planning

The lesson plan impacts positively on the development and implementation of EMIPs. Once teachers plan lessons, they are empowered and could have a clear understanding of the learning expectations for their learners and identify how and where these expectations fit into the larger instructional unit. The teacher could select and anticipate the set of questions and consider the required explanations that support the problem, task, conjecture and/ or the activities to be used. Henderson (2015) posits that in lesson planning, the teacher is able to sequence the lesson by firstly building on the previous lesson, and that the lesson components, pacing and momentum, and clarity on content and instructions is provided to allow all learners to work productively. In lesson planning, the teacher displays elements of lesson preparation: knowledge of the content and the structure, knowledge of the prerequisite relationships, and knowledge of content-related pedagogy (Danielson, 2013).

The following is a template on how a lesson should be planned and the items that need to be taken into consideration as adapted from National Aeronautics and Space Administration [NASA] (2013).

Lesson Planning Template

Grade_____________ Start Date:__________ End Date:____________

Duration:________________________________

Topic:_______________________________________Number of Activities :_____

Lesson Objectives:

Aim of the lesson: Problem-solving/ conjecturing/ investigating/Activity task. (circle and state):

____

____

Core Concepts:

____

____

Resources:

____

____

Formative Assessment :

Prior Knowledge :

Lesson Notes (Including key learners' misconceptions):

____

____

Activities	Teacher' s role	Learner's role	Resources	Method	Time

Reflection:____

____

The lesson planning should be structured around the following as captured from the literature (Cooper, 2006; DBE, 2011; Education Alliance, 2006; Felder & Brent, 2010; Grouws, 2004; IOWA DoE, 2011; NCTM, 2014; Shellard & Moyer, 2002; TIMMS, 2004):

- establishes clear goals for the mathematics that learners are learning; situates goals within learning progressions; and uses the goals to guide instructional decisions;
- sets out an investigation/problem solved/ conjecture;
- considers the learners' input either by current or prior knowledge and or be constructed by learners;
- makes sure that the investigation problem-solving/ conjecturing dominates the lesson;
- being a facilitator who guides investigation/ problem-solving/ conjecturing; question dependent; assesses throughout the lesson;
- allows learners the freedom to communicate their solutions and processes;
- caters for cooperative and collaborative learning; individual working alone; and with others;
- caters for conceptual activities applied to investigation/ problem-solving/ conjecturing;

- makes sure that resources cater for cooperative learning;
- allows multiple resources integrated into the investigation/ problem solved / conjecture;
- includes ICT and applied to investigations/ problem-solving/ conjecturing;
- creates an environment derived from investigation/ problem-solving/ conjecturing; and
- is teacher-guided and controlled.

The above-mentioned points could be entered on the lesson plan template. The lesson plan template provides space for the following items as indicated by literature: lesson objectives (clear goals), prior knowledge (what learners knows or were taught previously), resources, and inclusion of ICT, cooperative learning, problem-solving/investigation/conjecturing, teacher's role, learner input, communication and reflections. The items fit well within the theory of social constructivism because social constructivism espouses that learners should socially interact, communicate and engage in problem-solving/ conjecturing and investigating. A completed lesson plan was used for training purposes of the teachers involved in this study.

The same points that are envisioned on the lesson planning are actually those that underpin what an EMIP (teaching practice) should look like in the real classroom, that is, the real teaching practices (Danielson, 2013). The following section outlines the EMIPs which guide the teaching practice/instructional practices.

2.3.2. Teaching Practices

Ordinarily, teaching practices are defined by universities and colleges as a period that a trainee teacher spends teaching at a school as part of his or her training under the supervision of a trained teacher or person. In this study, teaching practices are defined as the actions that teachers are doing in their classroom during instruction. For the context of the development and implementation of a framework of EMIPs, the word teaching practice is as defined and is similar to reflective teaching. Reflective teaching is a process where teachers think over their teaching practices, analysing how something was taught and how the practice might be improved or changed for better learning outcome (Serra & Marco, 2015). Serra and Marco (2015) indicates that the process of teaching is not only aimed at teaching the learners but also improving the process of teaching itself in order to identify good instructional practices and improve poor instructional practices.

As defined above, EMIPs are the responses and practices envisaged to help learners achieve in mathematics and have mathematical understanding with the use of resources relevant to the problem being solved and that support a conducive learning environment. The following are the generic benchmark teaching practices for the development and implementation of the framework of EMIPs that could be used to observe the teacher in the classroom. Though each item of teaching practice is not directly listed on the classroom observation protocol, the items of the classroom observation protocol are embedded within these generic teaching practices. Since the framework of EMIP includes lesson planning, teaching and reflective practices. It is important to look at each individual item even though they are a series of processes.

Table 2.1:

The teaching practice (effective mathematics instructional practices)

Establish mathematics goals to focus learning. Effective teaching of mathematics establishes clear goals for the mathematics that learners are learning, situates goals within learning progressions, and uses the goals to guide instructional decisions.
Implement tasks that promote reasoning and problem-solving. Effective teaching of mathematics engages learners in solving and discussing tasks that promote mathematical reasoning and problem-solving and allow multiple entry points and varied solution strategies.
Use and connect mathematical representations. Effective teaching of mathematics engages learners in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem-solving.
Facilitate meaningful mathematical discourse. Effective teaching of mathematics facilitates discourse among learners to build shared understanding of mathematical ideas by analysing and comparing learner approaches and arguments.
Pose purposeful questions. Effective teaching of mathematics uses purposeful questions to assess and advance learners' reasoning and sense making about important mathematical ideas and relationships.
Build procedural fluency from conceptual understanding. Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so that learners, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems.

Support productive struggle in learning mathematics. Effective teaching of mathematics consistently provides learners, individually and collectively, with opportunities and support to engage in productive struggle as they grapple with mathematical ideas and relationships.
Elicit and use evidence of learner thinking. Effective teaching of mathematics uses evidence of learner thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning.

Source: (NCTM, 2014:01)

The table gives a summary of EMIPs as adopted from NCTM (2014). These are the practices that are used as the benchmark for the teacher development on what is expected of them during the teaching observations in this study. In order to achieve these benchmark practices, there is a need for reflection. The following sections give a brief explanation of what reflective practices are.

2.3.3 Reflective Practices

According to Lee and Barnett (1994), the use of reflection and reflective practices is important as a strategy for developing more thoughtful and effective teaching. They argue that the form of powerful reflection for development is for teachers to engage in professional dialogue by using reflective questioning.

Lee and Barnett (1994) indicate that participants are observed and interviewed. The participants engage in inquiry, reflection and analysis about their own work. They learn to observe, review, collect and analyse information about their practices. The action can be linked to action research and coaching but it is called shadowing and reflective interviewing. In the development and implementation of the framework, shadowing and reflective interviewing will be used. Based on these arguments, in this study, reflective practice will be used for two purposes: for teacher development process and for data collection for this study. This means the information gathered during reflective interviews are based on the lessons which are video-recorded and help the teacher in reflecting on the previous lesson and then making modifications for the next lesson based on the observations. The data from the reflective interviews will be analysed and interpreted in the findings of this study.

Based on the literature discussed earlier, EMIPs (lesson planning, teaching and reflective practices) could improve the teacher’s instructional practices and hence, learners’ understanding of mathematical proficiency. The following section explains what the creation of a classroom environment for respect and rapport entails as envisaged by the study's long-term outcomes.

2.3.4 Creating a Classroom Environment for Respect and Rapport

According to Miller and Pedro (2006), rapport refers to a relationship in which people like, understand, and respect each other. In terms of classroom, rapport could refer to a relationship between the teacher and the learners, and among learners themselves, that are based on understanding and respecting each other in the classroom throughout all the interactions. Stepanek (2000) posits that the classroom environment is more than just the physical space because it is the entire setting for learning which encompasses the relationship amongst and between learners and teacher. The classroom environment includes the expectations and norms of learning and behaviour. According to Danielson (2011), an essential skill of teaching is that of managing relationships with learners and among learners and ensuring that those among learners are positive and supportive. The way in which teachers interact with their learners, creates an environment of respect and rapport in their interactions. Through the interactions, they encourage and cultivate a culture of respect and communication among the learners (Danielson, 2011). An important aspect of respect and rapport relates to how the teacher responds to learners and how learners are permitted to treat one another. Patterns of interactions are critical to the overall tone of the class.

Stepanek (2000) indicates that there are no direct causal links between classroom environment and mathematics achievement. However, research has clearly demonstrated that the learning environment has a significant impact on learner achievement, as well as emotional and social outcomes at all grade levels (Danielson, 2011; Fraser, 1998; Hannah, 2013; Stepanek, 2000). Furthermore, Stepanek asserts that a positive classroom environment improves achievement of low-performing learners. He argues that learner achievement is higher when the actual classroom environment is consistent with learners' preferred classroom environment. Another benefit of the classroom environment for learners is motivation. According to Stepanek (2000), a widely accepted theory about the relationship between classroom environment and academic achievement is that it is mediated through learner motivation. Therefore, this means that motivation is related to subject attitude and mathematics achievement. From the characteristics of effective mathematics instructions, there is a suggestion that there is a need for changes to take place in both science and mathematics classroom environments. It is the reason why, in the development and implementation of effective mathematics instruction, more effort is put on the concept of classroom environment for creating a respect and rapport.

It could be said that traditional ideas of the teachers and learners' role and tightly controlled classroom management as well as insufficient attention to emotions and relationships hinder meaningful learning (Stepanek, 2000). For meaningful learning to take place, there is a need for a change to be made on how we teach our learners. The following are the key areas for improving the classroom environment in mathematics and science classrooms:

- Supportive relationships among teachers and learners;
- Learner participation in creating classroom norms, making decisions and setting goals;
- Clear expectations and responsibilities;
- Opportunities for collaboration/ cooperative learning;
- Adequate time for completing tasks and for discussions;
- Opportunities to work on open-ended tasks; and
- Interesting and meaningful activities (McRobbie & Fraser, 1993; Stepanek, 2000).

These key areas influence learners' positive attitudes and have strong relationship with their classmates and follow the classroom expectations, rules and norms. Again, the classroom environment should be designed in such a way that it helps learners construct their own knowledge. The theory which underpins this study is based on the premise that learning is most effective when the learner is actively engaged in creating his or her own knowledge and understanding by connecting what is being learned with the prior knowledge (Stepanek, 2000). In the development and the implementation of the framework for EMIPs, teachers are encouraged to carefully take into account the issue of prior knowledge. Teachers should use and understand the theory that constructing knowledge and understanding is a social, interactive process in which learners learn from each other by sharing ideas and points of view, asking questions, and building on their shared methods and ideas. According to Marlowe and Page (1998), a constructivist teacher asks rather than tells, models rather than explains, and works as hard as possible to get out of the limelight so that their learners may shine. The classroom environment is an important component in guiding learners toward an interactive and constructivist approach to learning. That is why the dimension of classroom environment is on the observation instrument (COI) in the methodology.

2.3.5 Conceptual Understanding

There are several definitions and descriptions of what conceptual understanding is (Malatjie, 2012). In the development and implementation of the framework for EMIPs only three definitions are considered. This is because the term comes a long way in research and theories of learning. Kharatmal (2009) referred to conceptual understanding as an integrated and functional grasp of mathematical ideas. This seems to imply that a learner has conceptual understanding when she/he is able to explain, describe and apply the same concept in different ways and in different situations. This further refers to the level at which a learner can draw on his or her preceding knowing and can use that knowledge in new ways. This definition fits well within the EMIP framework in terms of creating a classroom for rapport and respect. Kilpatrick and Swafford (2002) state that conceptual understanding refers to being able to comprehend mathematics concepts, to perform operations and relate concepts to one another. From Kilpatrick and Swafford (2002), there are three components of conceptual understanding: comprehension, operations and relations. These three components form a framework for discussing the knowledge, skills, abilities and beliefs which constitute conceptual understanding of mathematics content that the teacher would be busy with. The framework also guides learning with understanding. It says learning with understanding improves retention, promotes fluency and facilitates learning (Kilpatrick & Swafford, 2002).

On the other hand, Pirrie and Kieren (1994) see conceptual understanding as having seven layers, namely: primitive thinking, image making, image having, property noticing, formalising, observing, structure and investigating. This is called the Pirrie-Kieren Theory. The theory further explains the layers as follows: Primitive knowing refers to the knowledge that an individual brings to a setting. For this study, this is related to prior knowledge as the theory posits. The process of growth of understanding begins at this level and it contains what a teacher assumes a learner can do at the beginning of instruction. Image making refers to the level wherein a learner can make distinctions in his or her previous knowledge and can use that knowledge in new ways that involve actions and activities with that knowledge (Malatjie & Machaba, 2019). At the image-having layer, the learner is not tied to an activity any longer. The learner is able to carry out a mental plan for the activities with them and use it accordingly. Property noticing is a level of understanding that occurs when one can manipulate or combine aspects of his/her images to construct context specific, relevant properties. At the formalising layer, the learner is able to think consciously about the generalised properties and work with the concept as a formal object, without specific reference to a particular action or image. Pirie and Kieren (1994) used the constructivist idea of an individual understanding as the continual process of organising and reorganising knowledge structures. This correlates well with the theoretical framework.

The definitions of conceptual understanding by Kilpatrick and Swafford (2002) and Pirrie and Kieren (1994) were used/ adopted in this study to identify the elements of conceptual understanding. Both Kilpatrick and Swafford (2002) and Pirrie-Kierren (1994) give details of the stages of conceptual understanding. Kilpatrick and Swafford (2002) give components that one could look at when concluding that there is a conceptual understanding while Pirrie-Kierren (1994) gives the levels that could be used to identify if there is conceptual understanding during the classroom observations.

Looking on Khartmal (2009) and Pirrie-Kierren (1994), there is a consensus in explaining what conceptual understanding is. The consensus fits well with the current study on how to identify when learners are learning for conceptual understanding. Khartmal (2009) refers to conceptual understanding as the level at which a learner can make distinctions in his or her preceding knowing and can use that knowledge in new ways that engage actions and deeds with that knowledge, whereas in Pirrie-Kieren (1994), at the level of mage making, a learner can make distinctions in his or her previous knowing and can use that knowledge in new ways that involve actions and activities with that knowledge.

Kilpatrick and Swafford (2002) and Pirrie- Kierren (1994) are followed because their descriptions are similar though written differently and they provide for components that could be considered when identifying that a learner has conceptual understanding. Kilpatrick and Swafford (2002) further point out that for an evidence of conceptual understanding, learners will be able to verbalise connections among concepts and representations which are the cornerstones of EMIP framework. For the development and implementation of the framework of EMIPs, there was a need to combine the frameworks of Pirrie-Kierren (1994) and Kilpatrick and Swafford (2002). They posit that a learner conceptually understands mathematics, firstly, when the learner could be able to draw a representation of the concepts. Secondly, instead of emphasising misleading instructional language, short cuts, and the memorisation of algorithms in the mathematics class, teachers need to help learners develop a deep understanding of mathematical concepts and identify connections between these concepts (Molina, 2012). The teacher and learners in classroom need to use the language of instruction with care. This is because there are common terms that become embedded in mathematics instruction which have a different meaning in standard English than mathematics. For example, a teacher might write the fraction $\frac{9}{12}$ and tell the learners to reduce the fraction. The learners would follow the computation process and arrive at the solution of $\frac{3}{4}$ (Molina, 2012). The term reduce is carelessly used as 'make smaller' like in English. The learners tend to think that $\frac{9}{12}$ is smaller than $\frac{3}{4}$. But should the teacher communicate properly by sayins 'simplify', the learner could understand the relationship between the fractions. Further, teachers need to emphasise concepts instead of algorithms and shortcuts. Mathematics instruction should first ensure that learners' conceptual understanding is deeply embedded (Malino, 2012). Once the learners have mastered a concept, they should be able to show all the detailed steps in a process, explain those steps and connect the process related to those steps. In the development and implementation of the EMIPs, the issue of the correct use and explanation of mathematics concepts are included. And, in the observation instrument in the methodology, there is an item for training the teachers and identifying whether they use and teach mathematical concepts correctly.

2.3.6 Inclusion of Information Communication Technology in Learning

ICT is a term that describes types of technology that are used specifically for communications (Young, 2012; Mudavanhu, 2017). ICT is a technology that deals with communication, like cell phones, the internet and the wireless networks, among other things. There are many components of ICT that can aid teaching such as a calculator in mathematics (Mudavanhu, 2017).This is an ICT used for calculations involving several digits, including decimals, to solve number problems, know how to enter and interpret money calculations and fractions, and know how to select correct key sequences for calculation with more than one operation.

There are advantages of using ICT in teaching and learning mathematics. According to British Educational Communications and Technology Agency [BECTA] (2003) and Clements (2000), the ICT could help the teaching and learning in providing instant feedback from computer programs when trying out ideas, and encourages learners to use conjecture and to keep exploring. The ICT gives the teacher the tools to allow learners to perform complex tasks similar to those in the adult world. For example, graphic calculators and computerised graphing speed up the graphing process, freeing learners to analyse and reflect on the relationship between data (BECTA, 2003) instead of making mistakes in drawing and missing the desired outcome of analysing and interpretation.

2.4 THE IMPORTANCE OF EFFECTIVE MATHEMATICS INSTRUCTIONAL PRACTICES

EMIPs could be beneficial to both the teachers and learners if followed. According to Wachira et al. (2009), EMIPs transform learners' experiences, give learners an opportunity to reason and construct their understanding if the two concepts of collaboration and learner-centred teaching are fostered. This is supported by Sepeng (2013) when saying effective instructional practices improve the quality of discussions amongst the groups of learners. Kropiewincki (2006) adds that EMIPs give rise to another opportunity that is neglected: teacher development. The effective instructional practices provide a higher-level understanding of the strategies to the teacher. Since the development and implementation of the EMIPs is aimed at improving teachers' practices; a high level of understanding of the strategies to deal with PCK fosters meaningful learning which deem to solve the problem of ineffective instructional practices. Further, Tan and Ang (2016) indicate that professional development positively influences teachers' knowledge and resource choices, goals and orientations in planning. It is worth noting that EMIPs could enhance meaningful learning. The only questions that remain a mystery are why many teachers still use ineffective instructional practices, and whether there are studies on instructional practices to indicate the current trends among teachers to improve their practices. The following section explains the studies that were carried out to investigate the instructional practices and providing professional development to teachers.

2.5 STUDIES ON INSTRUCTIONAL PRACTICES

The following researchers: Adams and Krockover (1999), Cai, Perry, Wong, and Wang (2009), Haas (2002), Ngoepe (2003) and Simmons and Kamlay (1999) investigated instructional practices, and that indicated the concept have taken centre stage in research recently. Most involved in investigating instructional practices in order to investigate and or classify the teachers' instructional practices, to determine the factors contributing to poor mathematics performance. Researchers have long tried to understand the nature of classroom instruction to maximise learners' learning opportunities (Cai et al., 2009).

2.5.1 International Studies on Instructional Practices

On an international level, studies of instructional practices were undertaken though few used the STAM framework (Brown, 2002; Clements, Agodini & Harris, 2013; Haas, 2002; Pang, 2012; Wachira et al., 2009). Wachira et al. (2009) investigated and illustrated how one high school mathematics teacher engaged his learners in classroom discourse and promoted the use of appropriate mathematics language to communicate their thinking and make sense of mathematics concepts. Although the study did not use STAM, it emerged that one of the descriptors on the STAM model was investigated. The study found that learners' experiences can be transformed overtime by teacher's pedagogical practices which led to the proposition of the current study.

Wachira et al. (2009) further indicate that a collaborative and learner-centred environment gives learners an opportunity to reason and construct their understanding. The indication clearly relates to social constructivism on which this current study is based. For instructional practices to be effective, a collaborative and learner-centred environment should be fostered. Based on Wachira et al.'s (2009) study, other descriptors on the STAM model emerge: learner versus learner interactions about subject matter and environment which give learners an opportunity to reason and construct their understanding. Although the study was mainly focused on how the mathematics teacher engaged learners in classroom discourse, it has emerged that when other factors are taken into considerations, they amount to effective instructional practices.

In another study, Clements et al. (2013) investigated the correlation between instructional practices and learners' mathematics achievement. One finding which was inconsistent with some earlier researchers is that high achievement results do not necessarily support the contention that instruction should either be entirely 'learner-directed' or 'teacher-centred'. The inconsistency shown by this study is at odds with the theory of constructivism which gives learners a leading role. There is a need for further investigation to check whether instructional practices should be either learner-directed or not. Further, the study of Clements et al. (2013) did not investigate the correlation between effective instructional practices and mathematics achievement rather just instructional practices. As a result, there is a gap that needs to be closed – investigating the effective instructional practices and later the correlation between effective instructional practices and mathematics achievement.

In another study on improving teaching practices through action research, Brown (2002) investigated teachers' perceptions of the influence of action research on their thinking about instructional practices and the impact of this on teaching practices. The main focus areas of the investigation were the overall teacher's role, teacher's knowledge about teaching, teaching practices and reflective practices. The data were collected by interviewing teachers, informal classroom observations, and reviewing teacher and learner work and related artefacts (Brown, 2002).

Brown (2002) found that teachers perceived changes in the four areas of focus. Further, engaging in the stages of action research provided teachers with a method of implementing and analysing the teaching and learning process. The study recommended future studies to investigate the long-term changes in teachers' knowledge and practices while engaging in action research which are similar to this study's intentions as explained earlier.

Based on Brown's (2002) findings and recommendations, it become clear that for teachers to be effective in mathematics instructional practices, there is a need for professional development through reflective practices and research. In this study, reflective practice is one of the pillars of professional development. Teachers were engaged in teaching and after every lesson viewed their videos and reflected on them, based on the instruments that were used.

Kropiewnicki (2006) investigated effective instructional methods to train elementary pre-service teachers to apply reading comprehension strategies as readers and teachers. The study employed a qualitative inquiry where 12 learners participated. The data were gathered through observation of learners in strategy practice and performance and through document analysis of lessons plans and course assessments. It was found that the lesson plans proved to be the true measure of the understanding the strategies at the higher level of the teacher. The lesson plan is another part of effective instructional practices that is neglected by teachers. Based on the findings from Kropiewnicki (2006), teachers do not understand strategies for effective teaching at a higher level. Therefore, this study regards lesson planning as the first phase of the development process due to its importance which is seemly ignored.

In tracing the process of changing traditional teacher-centred instruction toward a learner-centred instruction in the Korean context, Pang (2012) looked closely at the teacher's success and struggles in the process of implementing new ideals into the actual classroom context. Pang (2012) investigated what changed and what did not change in the teaching practice in order to reveal culturally specific values and expectations. The project was an exploratory, qualitative, comparative case study. As a kind of purposeful sampling, the study used 15 teachers who were eager to improve their mathematics instructional practices which were first observed and analysed. It was found that the teacher demonstrated considerable changes in implementing new teaching approaches. The teachers also established an appropriate classroom atmosphere for discussion. These changes happened quickly and easily. The study recommends that the reformed teaching practices which incorporate learner-centredness needs to be examined further in order to see whether such changes arise from the simple adoption of Western theories or from culturally differentiated selection.

In a school-based professional development programme for teachers in Singapore, Tan and Ang (2016) aimed their programme at developing secondary school mathematics teachers' competencies to teach mathematical modelling. The study was aimed at determining what aspects of teachers' competencies, if any, were developed through participation in the programme. It was a qualitative case study in which data from four teachers were collected in the form of lesson artefacts, lesson videos, teachers' commentaries and interviews to examine teachers' decisions in their lesson planning, designing and teaching. The finding suggests that the school-based professional development programme positively influenced teachers' knowledge and resources, goals and orientations in planning, designing and enacting modelling learning experiences. Tan and Ang's (2016) study therefore suggests that it is very important and advisable to do school-based, professional development programmes; hence, the development and implementation of the framework for EMIPs was aimed at a school based in Malokela circuit with its own specific context.

2.5.2 South African Studies on Instructional Practices

There are few studies (Ngoepe, 2003; Ngoepe 2014) in South Africa that investigated mathematics classroom practices and used STAM framework in South African context. Even, from the few, the purpose of was simply to investigate and describe the teachers' practices and not devise an intervention. In his examination of some instructional practices in selected rural secondary schools, Ngoepe (2014) investigated the state of instruction in order to propose alternative ways of teaching. Teaching practices were examined in three disadvantaged secondary schools in 12 lessons of eight Grade 10 to 12 mathematics teachers. The study used an interpretive qualitative research design. This was because interpretive studies can provide detailed information about very small samples and the research was concerned about the details of teachers' practices in mathematics classrooms. The research strategy or method used was a case study which entailed descriptions of the individual teacher's instructional practices. The study used observations and video-recordings. The purpose of the video recordings was to validate the observations. The analyses were focused on the instructional practices the teachers used in terms of themes.

It was found that the themes emerged from the findings included homework, unproductive questioning, chorus responses, group work discussions, textbook use, teacher talk, copying and writing down answers. Homework was seen as one of the teaching strategies used most by the teachers, but it was subsequently found that the teacher would take over and work out the problems for almost all the learners who were called to work out problems on the chalkboard. The study also indicated that unproductive questioning was predominantly used in the classroom. It emerged from the study that one of the effective mathematics practices, namely, questioning based on the problem-solving/ investigation/ conjecturing, is neglected by teachers. Another finding was that it was a common practice to have a teacher posing a question and answering it alone or together with the learners (Ngoepe, 2014). This practice is common to most teachers and it does not prompt learners to solve problems or investigate, but rather positions them to wait and get the answer from their teacher, which is at odds with the theory of constructivism. It emerged that it was difficult to know whether all the learners had the same level of understanding of the subject matter or whether they followed the lesson without reflecting upon what was being said. It was again found that several classes had learners in groups although during class teaching these groupings did not seem to be involved in intellectual debate. The finding indicates that teachers are not really doing research or reflecting on their practices. Creating groups in the classroom and not using group work effectively is pointless. It was found that in almost all the observed lessons, learners normally did not have textbooks with them during lessons and that the teacher was the only one talking all or most of the time while learners listened attentively to the teacher. This practice is informed by those teachers who are trying to keep discipline by making sure that learners are kept quite while they (teachers) are teaching. Another common action was for learners to copy worked out exercises from the chalkboard. The study did not offer suggestions for effective instructional practices but mostly classified the teacher's instructional practices as either didactic, teacher-centred and so on. The study generally recommended that further research needed to focus on how to help teachers to use effective strategies in teaching mathematics. It is the reason why the current study focuses on instructional practices, both identifying the teachers' current practices and then following up with professional development of the teachers on effective instructional practices.

In another study in South African context, Sepeng (2013) explored mathematical classroom practices in four South African multilingual classroom settings. The study followed an ethnographic design using four mathematics classes as individual cases and four mathematics teachers as part of the larger case. Data were collected through a classroom observation schedule and took place over a period of six months. The findings revealed that teachers used both the language of learning and teaching

(LoLT) and learners' home languages when explaining mathematical concepts being taught in the classrooms. It was further observed that the quality of discussions in small groups was high amongst group members, whereas the whole-classroom discussions were limited, particularly discussions between the teacher and the learners during the lesson. Although learners were afforded opportunities to use the language they preferred for discussion and problem-solving in their small groups, the use of English by their teachers suggested the teacher as a figure of a powerful authority, which had an effect on the language used by the learners in the classrooms.

A project in South Africa called Wits Maths Connect Secondary (WMCS) in which Adler and Sfard (2016) took part was aimed at improving the teaching and learning of mathematics in 10 selected schools in one district in Gauteng, South Africa. Those schools were selected because they were classified as ‘underperforming’ in mathematics. While the ultimate goal was to impact learning, the intervention was through professional development with the teacher and learners themselves (Adler & Sfard, 2016). There were five schools from “no-fee paying” quintile 1 and five “low-fee paying” quintile 2 schools. The professional development on both content and pedagogy were followed by lesson study. It was found that mathematical messages were often incoherent, with disconnects within and between examples and their accompanying explanations (Alder & Sfard, 2016). From the teachers, one representative teacher was selected. It was found that the teacher was well-meaning, hardworking, committed to his learners and highly likeable, but the instructional practices were deemed as wanting in more than one respect. This study did not use the STAM framework. Although the focus was on the lesson study, the purpose was to professionally develop teachers and improve on learners learning of mathematics. It should be noted that this study is similar to the current study, though its framework was based on lesson study, and its focus was not on developing and implementing a framework for EMIPs.

The use of STAM has been found to help practising teachers to reflect on their teaching and to use teaching strategies that lead more to a learner-centred approach. Usage of the STAM framework for guiding lesson preparation and teaching could be helpful to develop learner-centred forms of teaching and learning. Studies have been reported which indicated that the use of STAM was found to stimulate the professional development of teachers (Adams & Krockover, 1999; Ngoepe, 2003; Simmons & Kamlay, 1999).

From the findings of Ngoepe, the important thing that emerged, which needs to be thoroughly scrutinised, was the unproductive questioning by the teacher. From Sepeng (2013), it is evident that the use of English language limited learners’ discussions, collaborations, and limited problem-solving and engagement. This factor is basically the one way in which the teacher could stimulate learners’ thinking and learning (Gall, 1970).

Based on the studies outlined above, it is therefore relevant to develop and implement the framework for EMIP. The goal of the EMIP framework in this study is to develop mathematic teachers' practices in effective mathematics instructional practices which seem to challenge teachers and could refine learners' mathematical reasoning, solving and conjecturing during classroom instructional practices. In the South African context, after 1994, the curriculum has been changed several times. As a result, professional development activities have been done mainly through workshops at central venues for the teaching of the changed curricula. The workshops are not able to provide teachers with sufficient time, content and opportunities to be meaningfully engaged in acquiring EMIPs skills, if ever that was the intended purpose of the workshops.

It should be noted that once-off workshops without follow-up support result in disconnected and decontextualised experiences for teachers due to the different contexts where they come from. Another factor that should be taken into account is that novice teachers have little chance of attending the workshops. Some enter the system during the time of the workshop while some enter the system after the workshops. It is for this reason that this study seeks to develop and implement the framework for EMIPs of the two selected teachers.

2.6 CURRENT REFORMS OF INSTRUCTIONAL PRACTICES

Currently, instructional practices are moving towards reforming mathematics education by the inclusion of ICT in teaching, computer-aided instructions for mathematics, embedding real-world problems in the teaching of mathematics (Williams, 2015) and professional development on specific concepts like modelling and effective instructional practices. South Africa is not left out as many educational programmes are rolled out in order to redress the problems and move towards current educational reforms. According NCTM (2000) the inclusion of ICT could be very important in teaching and learning mathematics, since it influences what is taught and enhances learners' learning. ICT cannot be used in isolation. There should be proper EMIPs, which could guide the use of technology. Inclusion of technology without proper instructional practices would be meaningless. In the development and implementation of the framework for EMIPs, it is noted that the use of technology should be included. But the framework basically deals with professional development of teachers on EMIPs which also focuses little on the integration of technological devices. The study does not mainly focus on the usage of technological devices per se. There are few studies that focus on teacher professional development on the EMIPs framework; hence the focus of this study.

2.7 CHAPTER SUMMARY

Studies in the field of instructional practices have made important contributions to the field of education by informing educational transformation, methodological review and teaching practices and approaches. In this chapter, the literature review on the historical aspects and definition of instructional practices as they evolved for the study that was purposed to develop and implement a framework of effective mathematics instructional teaching practices was outlined. The features that characterise EMIPs are listed and elaborated upon. The constructs of lesson planning, teaching practices and reflective practices are dwelt upon to bring out the complexity of teaching and learning of mathematics. The importance of EMIPs is described including the studies which investigated instructional practices on an international and national (South African) level. Further, current reforms on instructional practices and the reason for the focus on the development and implementation of the EMIPs are highlighted.

The following chapter provides a theoretical framework on instructional practices that guided this study and Desimoni's (2009) professional development model based on Shulman's (1986) PCK. The chapter describes what professional development is and explains what researchers view as PCK and the role it plays in the development and implementation of the framework of EMIPs.

CHAPTER 3

THEORETICAL AND CONCEPTUAL FRAMEWORK

3.1 INTRODUCTION

This chapter explains the theory of social constructivism as a theoretical framework of the development and implementation of EMIPs. It is chosen because this theory emphasizes the importance of culture and context in the process of knowledge construction and accumulation by gathering rich data which will lead to formation of ideas. An application of social constructivism theory on learning, knowledge construction, content, learner's role, communication and teacher's role in the instructional practices is discussed. In addition, aconceptual framework of professional development, which embeds PCK, is described in detail. The constructs of communication or discourse, subject (content) knowledge, pedagogic knowledge, and curriculum knowledge are clarified. The development of the framework for EMIPs is explained. Lastly, the implementation of the framework of EMIPs is explained.

3.2 THE THEORY OF CONSTRUCTIVISM

This study is located on the theory of constructivism. Constructivism is an epistemological view of knowledge acquisition that emphasises knowledge construction rather than knowledge transmission and the recording of information conveyed by others (Owusu, 2015). The term is widely used in many disciplines (Baker, McGaw & Peterson, 2007). In this study, the discussion is about constructivism in education. The term is used with very different meanings. The term is used to describe a paradigm as used in Chapter 4, a theory of learning and teaching as well as curricula and assessment (Liu & Mathews, 2005) as it is used in this chapter. The main feature of constructivism is that knowledge is actively constructed, its application emphases processes, collaborative learning and teaching for understanding (Crotty, 2012). The theory of learning, constructivism is bound by five core beliefs. Those beliefs are:

- learners' opinion is sought and valued; assumptions and suppositions are challenged;
- the learning experience must be related to the leaner's life experience and relevant to learners' lives;

- the constructivist teacher gives a broad understanding of a subject rather than focusing on small bits of information; and
- the constructivist teacher assesses the whole learning experience of learners rather than assessing only what can be measured by ‘paper and pencil’ assessments (Crotty, 2012).

The ineffective instructional practices and research on the teaching and learning frameworks, prompted the study of the development and implementation of the framework for effective mathematics instruction. Considerable research on the teaching and learning frameworks has been done. The following are few examples:

- STAM framework (Gallagher et al., 1995);
- A Framework for Professional Practice (Danielson, 1996);
- ISTE Classroom Observation Tool (ICOT®) (International Society for Technology in Education, 2008);
- Mathematical Classroom Observation Protocol (National Center for Research in Mathematics, 1992);
- Lesson Flow Classroom Observation Protocol; Teaching Practice Inventory (Wieman & Gilbert, 2014);
- Mathematics questionnaire (Weiss, Banilower, McMahon, & Smith, 2001);
- Inside the Classroom: Teacher Interview Protocol (Horizon Research, 2000); and
- Teaching Dimension Observation Protocol (Hora & Ferrare, 2013) for instructional practices.

In a nutshell, they were derived from constructivism theory and purposed for effective teaching and meaningful learning.

There are many perspectives of constructivism: pragmatic approach (Dewey, 2011), social constructivism (Brunner, 1960; Vygotsky, 1987), radical constructivism (Von Glaserfeld, 1995) and critical constructivism (Habermas, 1972). The study draws on one type of constructivism theory, the social-constructivist theory of learning or what is known as sociocultural theory recently (Cobb, 1994; Van de Walle, Karp, & Bay-Williams, 2016; Vygotsky, 1978; Wachira, Pourdavood, & Skitzki, 2013). In this study, the words social constructivist theory and sociocultural theory may be used interchangeably. The researcher used the theory of social constructivism to forecast, describe and direct the research process during the development and implementation of the EMIPs. A brief overview of each type of constructivism is described in order to inform and substantiate the choice of social constructivism.

3.2.1 Radical Constructivism

Radical constructivism is the idea that all learning must be constructed, and there is no utility or meaning that is teacher- or textbook-driven. In mathematics classrooms, radical constructivism strives to enforce concepts underlying the construct that they are busy with other than algorithms of how to do it. Further this type of constructivism encourages the constant awareness of learners' use of mathematics in their real lives. According to Von Glasersfeld (1984), the radical constructivism theory is "radical because it breaks with convention and develops a theory of knowledge in which knowledge does not reflect objective ontological reality but exclusively an ordering and organisation of a world constituted by our experience" (p. 5).

3.2.2 Pragmatic Approach

According to Warin (2009) a pragmatic constructivism is "characterised in a particular epistemological based on the quest parametric objectivity" (p. 1). Nørreklit (2011) indicates that in pragmatic constructivism, reality is considered as the relationship between the (individual and collective) actors and the world in which they operate. This type of constructivism emphasises four dimensions (factual basis, possibilities, values and the communication) of reality which should be integrated in the actor-world relation for successful effective actions.

3.2.3 Critical Constructivism

Critical constructivism is a form of social constructivism that emphasises the social and political consequences of rectifying and decontextualising knowledge (Bentley, 2003). Further, Bentley indicates that critical constructivism acknowledges the social nature of all knowledge construction and therefore the cultivation of critical communities of inquiry and the achievement of democratic social order. In terms of teaching and learning, this type of constructivism is also pluralist in the sense that it promotes "epistemological democracy which favours the enrichment of the field of possibilities for learners through their participation in different knowledge games" (Bentley, 2003, p. 5). In addition, Kincheloe (2005) posits that critical constructivists argue that knowledge is temporally and culturally situated, therefore knowledge and phenomena are socially constructed in a dialogue between culture, institutions, and historical contexts. Critical constructivism maintains that historical, social, cultural, economic, and political contexts shape our perspectives on the world, self, and other.

3.2.4 Social Constructivism

Based on the perspective of social-constructivist theory, the study was seeking a learning environment that could be created through interactive inquiry-based activities where learners and teachers construct their mathematical knowledge. This perspective asserts that the construction of knowledge occurs mainly when people (learners and teachers) cooperate (collaborate) with their peers. In this study, collaboration and cooperation were amongst several constructs that teachers and learners were trained to focus on. According to Wachira et al. (2013), collaboration and dialogue are seen as important to learning success because the social context that is constructed during their interaction helps to enhance learners' thinking and learning in the classroom. Van de Walle et al. (2016) support the perspective when stating that an important aspect of social-constructivist theory is that, the way in which information is internalised, or learned depends on whether it was within the zone of proximal development (ZPD) of the learner. The framework was providing teachers to challenge learners in order to identify their ZPD. Van de Walle et al. (2016) further, state that the social interaction is essential for learning to occur and that learning is dependent on the way new knowledge falling in ZPD of the learner who must then be assisted by interacting with tools of mediation and the culture within and beyond the classroom. With this view, the development and implementation of effective framework of mathematics instructional practices put more effort on social interactions of both teachers during the training and implementation, and learners in their respective classes. Further, the framework maintained the interaction of real-life context and the environment in which learners were familiar with. If the information does not fall within the ZPD of the learner, then the teacher needed to scaffold the information. This theory brings up main factors which relate directly to effective instructional practices namely: communication, cooperative learning, the role of the teacher, the classroom environment and resources. These factors are basically the pillars of the STAM framework as indicated by Gallagher et al. (1995). From the social constructivism three prominent concepts emerged: Cooperative learning/ Collaboration, ZPD and Scaffolding. The next section gives a detailed explanation of the three constructs and how they were applied to this study.

3.2.4.1 Cooperative learning

Mabrouk (2007) and Roberts (2016) state that cooperative learning is when learners are working in teams (collaborate) on an assignment, or project under conditions in which certain criteria are satisfied. Slavin (2008) refers to cooperative learning as the teaching methods in which the children work in small groups to help one another learn, meaning they collaborate. In the development and implementation of the framework, Slavin's (2008) definition of cooperative learning is used as it is provided the exact meaning of the intention and the framework of the study. Slavin (2008) further indicates that in the cooperative learning classroom, learners are expected to help each other, to discuss and argue with each other, to assess each other's current knowledge and fill in gaps for individual understanding. The constructivist teacher should create an environment which encourages cooperative learning as a teaching method in order to engage learners in discussion, problem-solving, reasoning and conjecturing. It is worth noting that in the development and implementation of the framework for EMIP, how cooperative learning was implemented was not of concern, but the study focused on whether there was effective cooperative learning in the mathematics classroom, which fostered effective learning. This emphasises the idea that learners learn better when they collaborate or work cooperatively (Slavin, 2008). The teaching and learning should be driven by cooperative learning, a tenet of social constructivism.

3.2.4.2 Zone of proximal development in effective mathematics instructional practice

According to Verinikina (2008), Wells (1999) and Vygotsky (1978), ZPD is the distance between what a learner can do with and without help. Further, Vygotsky (1978) indicates that the purpose of ZPD is to explain the social and participatory nature of both teaching and learning in the framework for the development and implementation of EMIPs, the ZPD was used for two purposes: for observation of the teachers by the researcher and for the role of teachers during responsive teaching in the implementation phase. Firstly, teachers have their own ZPD which establishes what they are able to do. The framework was purposed to support teachers in responsive teaching and help them in becoming self-regulated. Secondly, the ZPD was considered in terms of responsive teaching while the teacher interacted with the learners. During the implementation phase, teachers were observed to see whether they were making sure that learners' ZPD was taken into consideration. Teachers were encouraged to pose difficult questions to learners and let them come up with their way of finding solutions. That was to check the level of the learners' ZPD and where it was lacking; then teachers needed to scaffold learning where necessary.

3.2.4.3 Scaffolding in effective mathematics instructional practice

Scaffolding refers to a process whereby teachers model or demonstrate how to solve a problem, and then withdraws from actual teaching while the learners work on other problems, offering support as needed (Verenikina, 2008). The concept of scaffolding emanates from Vygotsky's social constructivism theory which is used to capture the nature of the support and guidance in learning. Verinikina asserts that scaffolding is a direct application and operationalisation of the concept of ZPD. In order further to qualify for scaffolding, teaching and learning events focused on the following:

a) enabling the learners to carry out the task which they would not have been able to manage on their own;
b) bringing the learner to a state of competence which will enable them eventually to complete such a task on their own; and
c) being followed by evidence of the learners having achieved some greater level of independent competence (Verinikina, 2008).

In the development and implementation of the framework for EMIPs, scaffolding was used for two purposes.

- Teachers had their own ZPD in terms of lesson planning, teaching practices and reflection. Teachers were given new tasks that they were unfamiliar and they had to manage their own tasks of lesson planning, teaching practices and eventually reflections. Wherever they felt their competences to do the task were absent, the researcher used scaffolding for the teachers.
- Learners were given new tasks by their teachers to enable them to carry on and manage themselves; the teachers were observed to determine whether they were able to bring the learners to a state of competence, which was essential to their completing the task on their own.

3.3 APPLICATION OF SOCIAL CONSTRUCTIVISM

The application of social constructivism in instructional practices is based on the following constructs: learning, content, learner's role and teacher's role,

3.3.1 Social-Constructivist View of Learning

Learning is the process for the construction of cognitive structures by individuals (Piaget, 1980; Vygotsky, 1978). The construction is a self-initiated; self-organised and conscious recognition of a concept in such a way that meaning is generated. This process is completed by the interaction between learners' old and new knowledge. The social constructivist theory supports the collaborative construction of knowledge through social negotiation, not competition among learners for recognition (Jonassen, 1994). Maddux, Johnson and Willis (1997) indicate that within a collaborative group, there should be dialogue such that group members apply four cognitive strategies: questioning, summarising, clarifying and predicting. On the instrument of the framework, there was an item which focused mainly on collaboration and questioning. This was an effort to create the ZPD in which the learners gradually assume more responsibility for their learning, and through this, forge group expectations for high-level thinking, and acquire skills for vital learning and success in everyday life.

Wachira et al. (2013) state that when the proper learning environment is created as perceived by social constructivists, it could help learners in constructing their mathematical knowledge by providing inquiry-based activities which are meaningful. That is why the inclusion of creating the classroom environment for rapport and respect is important in the EMIP framework.

3.3.2 Social-Constructivist View of a Teacher in Instructional Practices

The role of the teacher should be changed from the initiator and the indoctrinator into the helper and the driver for the learners constructing meaning initiatively. The role of the teacher should be that of the designer of the teaching environment, the guider of the learners' learning and the academic consultant for learners. According to Crotty (2012), both the teacher and the learner take an active role in the learning process. There is a suggestion that a balance is needed between the teacher and the learners (Crotty, 2012). In the development and implementation of the EMIP, the teachers were trained to able to engage learners in a productive struggle, scaffold new content, encourage multiple approaches, create opportunities for reflective thought and create an environment for doing mathematics (Van de Walle et al., 2016). Under the theory of constructivism, teachers should focus on making connections between facts and fostering new understanding in learners. Teachers as instructors were trained to tailor their teaching strategies to learner responses and encourage learners to analyse, interpret and predict information. Teachers also were trained to rely mainly on open-ended questions and to promote extensive dialogue among learners.

The theory puts forward new explanations for learning and teaching. According to this theory, learners are the subject in teaching. The teacher should encourage learners to constantly assess how the activity is helping them gain the understanding (WNET Education, 2004). WNET Education (2004) further, points out that the teacher coaches, moderates and suggests, but allows the learners room to experiment, ask questions and try things that do not work. In terms of the framework for the study, when teachers and the researcher sit down and reflect on the video of their teaching, they could be able to develop and understand what their roles should be in implementing EMIPs. This could help teachers develop new strategies by making changes to the next lesson plan.

3.3.3 Social-Constructivist View of Learners in Instructional Practices

Learners enter the classroom with their rich previous experiences and hold their opinion on daily life and even universal issues. Some special explanations and assumptions may be formed by learners based on previous experiences and cognitive abilities as new unknown issues appear (Vygotsky, 1978). Therefore, teaching should take into consideration the previous knowledge and experience of learners as they growth point of the new knowledge and introduce learners to generate new knowledge from previous knowledge. Van de Walle et al. (2016) indicate the point clearly by saying, if you are teaching a new concept, for example, division, it must be developed using what learners already know about equal subtraction and sharing. Learners should be allowed the freedom of devising their own ways of doing the problem and be able to explain, compare, interact with their peers about their solution and engage in reflective thinking. This is also supported by Tracey and Morrow (2012) in their social learning perspective when emphasising the importance of social interaction and social influences, which play an important role in the development of EMIPs by providing the interaction between the researcher during the training of the use and implementation of the framework and during the observation of the interactions amongst the learners during the teaching.

Learners should be left to struggle with the problem and come up with different solutions. The teacher should help in scaffolding the concepts for the learners and give them a chance to explain their way of getting to the solution regardless of whether the solution to the problem is correct (Vygotsky, 1978; Van de Walle et al., 2016). Scaffolding in this study refers to the assistance to a learner provided by an adult or any competent peer during learning. According to Vygotsky (1978), with appropriate adult help, children can often perform tasks that they are incapable of completing on their own. With this in mind, scaffolding – where the adult continually adjusts the level of his or her help in response to the child's level of performance – is an effective form of teaching. Scaffolding not only produces immediate results, but also instils the skills necessary for independent problem-solving in the future. Furthermore, scaffolding refers to the assistance to the teacher provided by an expert during the development and implementation of the EMIP framework. At this stage, teachers are referred to as learners.

The social constructivist theory encourages learners to use active techniques (experiments, real-world problem-solving, conjecturing and or generalisation) to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing. Within this perspective of the theory, the EMIPs framework envisions that learners should learn by solving problems/ conjecturing/ investigating. The implementation of the framework, therefore, talks to theory since one of the characteristics is: Implement tasks that promote reasoning and problem-solving/ conjecturing/ investigating.

3.3.4 Communication in Instructional Practices

Communication is a means by which classroom discourse can be achieved (Wachira et al., 2013). Through communication, learning, discussion, meaning and thinking occurs. The social constructivist theory states that, through social interaction, learners are able to communicate within themselves and with their peers (Wachira et al., 2013). According to Jung and Reifel (2011) and Brenner (1998), communication especially in mathematics education arises from the argument that learning proceeds effectively within a social context. Learners are also encouraged to discuss, communicate their ideas, meaning, results and reasons and construct their understanding as part of community of learners (NCTM, 2000).

Communication involves considerable use of previous and current terminology and is learned by the learners, not so much in mathematics learning, but in other fields of learning. The used and learned language sometimes comes into conflict with the language used in mathematics learning. Literature suggests that such language tricks learners into interpreting mathematical language wrongly (Even & Tirosh, 2008). The wrong interpretation leads to learner misconceptions, which is one cause of poor performance and lack of mathematical understanding. For example, in chemistry adding hydrogen to oxygen produces water (H_2O). The commonly used language in this scenario is "and" or "plus" in ordinary language; for example: 3x + 4 could be given as $7x$ or 7 by learners, because of their use of the language "$3x + 4$" as in "H and O". From these examples, it becomes clear that without using proper vocabulary with peers and the teacher, learners could become confused.

3.3.5 Knowledge Construction in Instructional Practices

Knowledge is only an explanation and an assumption but not the final answer for all questions. In fact, it might be discarded along the way and new assumptions will appear. Knowledge cannot summarise the world rules precisely, meaning that we cannot apply knowledge to certain problems directly. We have to analyse certain issues based on practical conditions. Constructivists agree that knowledge is not etic, i.e. existing for its own sake, and outside of a specific entity. Although forms of knowledge are symbolised by language and signs, it does not mean learners have the same understanding of these statements, just as 100 people will have 100 different understandings of equivalent fractions. These understandings are based on individual learners' experiences and backgrounds, that is, what is determined by specific learning experiences (Jia, 2010). Lerman (2014) indicates that the construction of knowledge takes place when learners work on problems with the teacher, often one- to-one or with a group of learners who asks questions as the learners' work. Lerman (2014) argues that the explanations help the teacher in modifying the model of the learners' knowing and also help the learners' construction of appropriate knowledge. According to the social constructivist theory, learners' knowledge differs not only quantitatively, but also qualitatively from that of an adult. The basic assumption of the social constructivist theory is that knowledge is not static but is constructed by unique individuals. The sociocultural theory of Vygotsky (1978) put it by using the ZPD concept. This concept refers to the observation that children, when learning a particular task or a body of information, they start out by not being able to do the task, they can do it with the assistance of an adult or older child mentor, and finally they can do without assistance (Van de Walle et al., 2016).

3.3.6 Content in Instructional Practices

The social constructivist theory stresses that content must be built and developed using what learners already know about the content, use cultural tools, and build new knowledge (Van de Walle et al., 2016). This indicates that the pre-existing content of the learner learned either at home or previous lesson should be the starting point of the lesson. In the constructivist classroom, curriculum emphasises big concepts, beginning with the whole and expanding to include the parts.

3.3.7 Social-Constructivist View of Classroom Culture and Environment

There is a view that culture and social processes are integral to mathematics activity (Even & Tirosh, 2008). The classroom culture should reassure learners that their thinking, arguments and reasoning are valuable. The teacher should not be the sole authority for determining the correct answer. There are different mathematical cultures in the classroom. According to Even and Tirosh (2008) and Yackel and Cobb (1996), one of the main characteristics of the revised mathematics culture in the classroom is characterised by social norms such as explanations, justification, argumentation, respect and intellectual autonomy as well as 'socio-mathematical norms'. Though most researchers do not align the mathematical culture in the classroom to a specific theory of learning, it becomes evident that if the mathematics culture in classroom is created in such a manner that it moves away from the behaviourist paradigm of teaching, it could fit well with the theory of social constructivism. The mathematics classroom culture should, without fail, include and emphasise all the learning strands for mathematical proficiency and all kinds of knowledge: strategic, procedural and conceptual (Even & Tirosh, 2008). The mathematics culture in the classroom should not use one specific approach but rather have a rich repertoire of strategies which allows class discussion and the development of norms such as learners making conjectures, explaining their reasoning, validating their assumptions, discussing and questioning their own thinking and the thinking of others, and arguing about what is mathematically true (Even & Tirosh, 2008). Van de Walle et al. (2016) add to the above by saying that the culture that should be cultivated in the classroom should provide a classroom environment for doing mathematics by making sure that practices and expectations encourage risk taking and a culture where ideas are valued and respected but critically challenged.

The social constructivist learning environment should provide multiple representations of reality – that is, it should avoid oversimplification by representing the complexity of the real world (Jonassen, 1994). The environment should emphasise knowledge construction instead of knowledge reproduction. The classroom culture should allow learners to access their prior knowledge, use cultural tools and build new knowledge based on real-life experiences.

3.4 CONCEPT OF PROFESSIONAL DEVELOPMENT IN SOCIAL CONSTRUCTIVISM

Buysse, Winton, and Rous (2009) define professional development (PD) as facilitated teaching and learning experiences that are transactional and designed to support the attainment of professional knowledge, skills, and dispositions as well as the application of this knowledge in practice. The Business Dictionary (2016) states that PD is a process of improving and increasing capabilities of staff through access to education and training opportunities in the workplace, through outside organisations, or by watching others perform the job. Hidden Curriculum (2014) support this by defining PD as a variety of specialised training, formal education, or advanced professional learning intended to help administrators, teachers, and other educators to improve their professional knowledge, competence, skill, and effectiveness. In this study both definitions are adopted and used. The main reason for the adoption and use is because both definitions indicate important points which are directly related to the study: specialised training or education of employees or staff to improve their professional knowledge or competence or skill by either calling somebody from outside to train or educate them or outsourcing this to training providers. In this study, the focus of PD will be on what actually happens in the classroom, specifically on the importance of teacher development in changing teachers’ mathematics classroom practices by improving their competence and effectiveness.

According to Pausigere (2014), researchers have their own preferences for what PD should focus on. Hiebert (1999) states:

> Research on teacher learning shows that fruitful opportunities to learn new teaching methods share several core features: (a) ongoing collaboration of teachers for purposes of planning with,(b) the explicit goal improving learners' achievement of clear learning goals, (c) anchored by attention to learners' thinking, curriculum, and pedagogy, with, (d) access to alternative ideas and method and opportunities to observe these actions and to reflect on the reasons for their effectiveness. (p. 15)

Based on Pausigere and Hiebert's arguments while reviewing the mathematics teaching and learning, research indicates that PD should pay attention to the importance of high standards, content focus, and in-depth opportunities for teachers in all levels.

Hiebert's (1999) view of PD grounded my study on PD, since the study seeks to collaboratively train the teachers in the process of developing and implementing a framework for EMIPs based on lesson planning, teaching practices and reflections (reflective practices). Pausigere (2014 further indicates that, though that is the case, other writers say PD should focus on subject (content knowledge) and subject matter (PCK). Lindvall (2017) adds to the sentiments shared by Pausigere (2014) and Hiebert (1999) by saying that not all PD programmes are effective. Lindvall (2017), therefore, suggests what is called 'effective PD' which should have core critical features of what might be included in the PD programmes.

The literature provides a long list of what might be included as PD (Bubb, 2005; Desimone, 2009; Little, 1987). Little (1987) describes PD as "any activity that is intended partly or primarily to prepare paid staff members for improved performance in present or future roles in the school district" (p. 49) or elsewhere. Desimone (2009) indicates that PD is directly related to the work of teaching, can take the form of core teaching, mentoring, reflecting on actual lessons, group discussions surrounding selected authentic artefacts such as learners' work or instructional tasks or improving the teaching approach of the teacher. Bubb (2005) adds the following: observing someone teaching your class; discussing lesson observations, a colleague taking an assembly; and team/ partnership teaching. In support Coetzee, Van Niekerk, Wydeman, and Mokoena (2015) state that classroom management improves as teachers develop their talents and skills as educators.

Based on various arguments (Coetzee et al., 2015; Desimone, 2009; Little, 1987; Bubb, 2005), it becomes clear that what actually must be included in PD are the activities which are related to the work of the employees. Bubb (2005), Desimone

(2009) and Coetzee et al. (2015) indicate that PD mainly includes reflection on actual lessons or observing someone teaching your class and instructional practices. PD does not happen automatically: it is a planned action. From my observation as a teacher, most teachers are not doing reflection on their actual lessons after teaching or rather discuss their practices with other teachers or permits for observation by a peer teacher. Teachers are seemingly neglecting this aspect of being developed professionally by not doing reflection of their everyday lessons. Reflections and peer observations help in determining what went right and what went wrong, how could this lesson be improved and what the good practices are that could be used again in the next lesson. According to Desimone (2009), the following framework presents a basic model for PD as seen in Figure 3.1. (a).

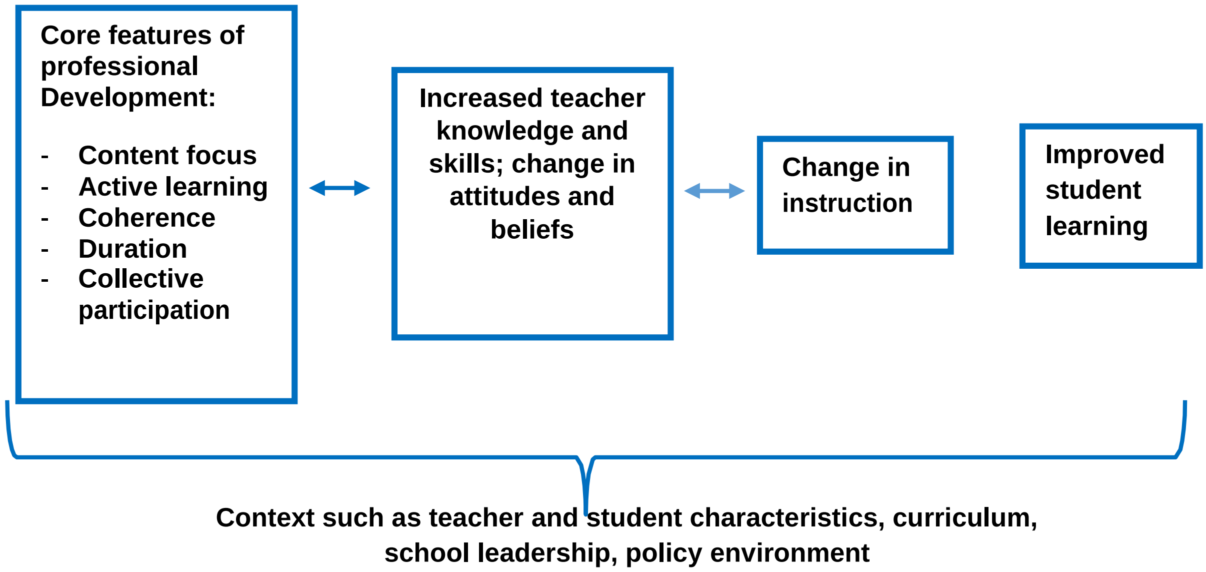


Figure 3.1: *A model for PD*

This model is used and adapted to guide the framework for the development and implementation of EMIPs. This model accommodates PD (theory of teacher change) for teachers.

The Education Alliance (2006) states that PD needs to give teachers the skills to support learners' mastery of academic standards, enhance the content knowledge of teachers, be research-based, align with learner standards in policy, be sustainable, intensive and focused on classroom practice. It is for this reason that in the current study, it is believed that the reflective interviews and watching of the videos as described in Chapter 3, could provide another form of PD to the teachers because they deal with classroom practices. Furthermore, from this PD, teachers could acquire skills to support EMIPs as it appears on Desimone's (2009) model. This is also supported by Goodell (2000) who found that the process of reflection enabled pre- service teachers to construct their own understanding of the value of teaching mathematics for understanding. The process of reflection is based on the constructivist theory of learning. The intervention of the study focused mainly on the PCK as embedded in the framework of Desimone which includes content knowledge, teaching and curriculum. The teaching component comprises of teachers' practices (planning, teaching, use of resources and assessment) and learners' practices (learning, interactions and use of resources).

3.4.1 The Concept of PCK

Koehler and Mishra (2009) define PCK as the teacher's deep knowledge about the process and practices or the methods of teaching and learning the subject matter. The definition indicates clearly that for teachers to be effective, they need to be able to understand the processes of how to engage and challenges learners to understand the content matter. This fits well within EMIPs framework. According Turnuklu and Yesildere (2007), PCK refers to knowledge of learners and knowledge of teaching the subjects. This is further supported by Shulman (1987) when stating that PCK includes knowledge of learners and their characteristics, knowledge of educational contexts, knowledge of educational ends, purposes and values, and their philosophical and historical bases. According to Shulman (1995), PCK includes:

> the ways of representing and formulating the subject that make it comprehensible to others'… 'an understanding of what makes the learning of specific topics easy or difficult; the conceptions and preconceptions that learners of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons (p. 130).

There is an agreement between the arguments made by Koehler and Mishra (2009), Turnuklu and Yesildere (2007) and Shulman (1987). It is clear that PCK is of great importance for effective teachers in order to enhance EMIPs, and the arguments link well with the constructivist theory of learning within which this study is grounded. On the other hand An, Kulm, and Wu (2004) indicate that PCK has three components, namely: knowledge of content, knowledge of curriculum and knowledge of teaching. They suggest the following model which points out how knowledge of teaching is important.

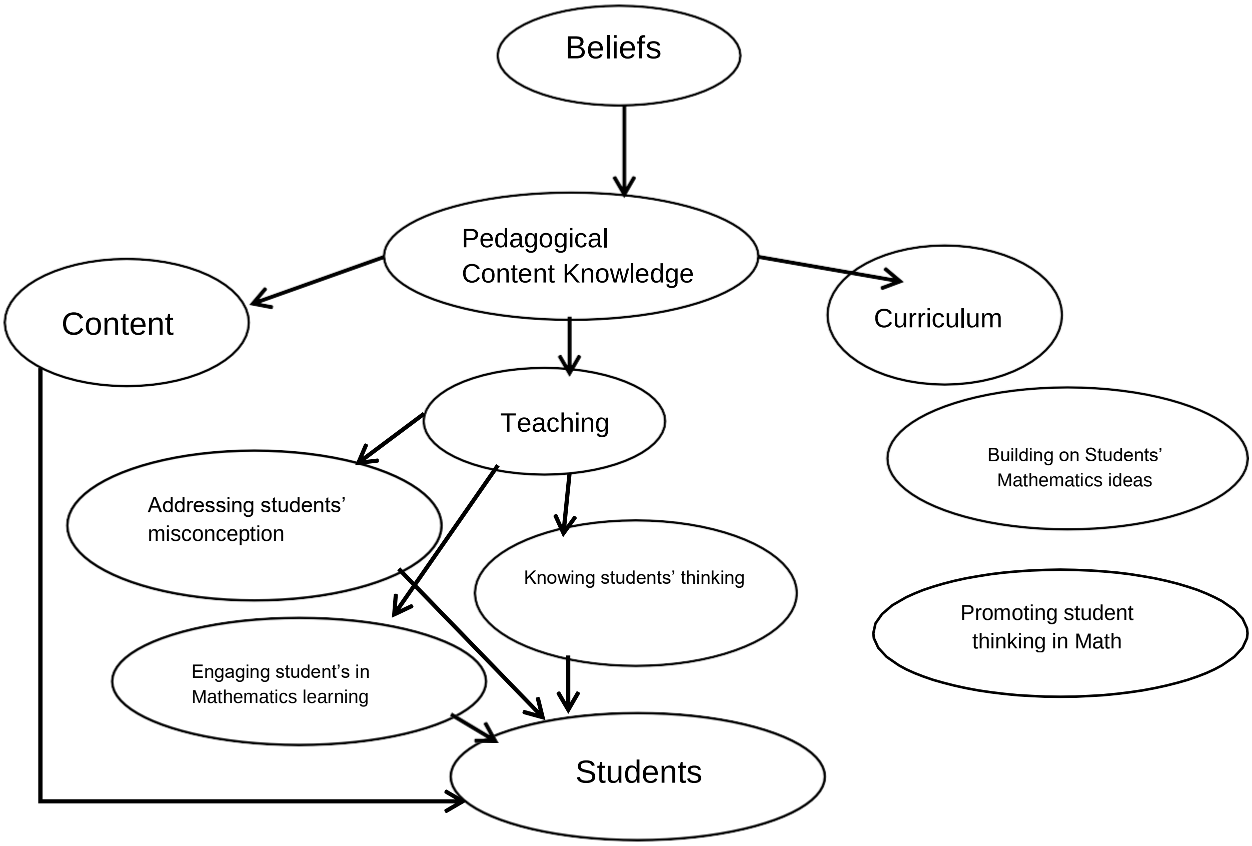


Figure 3.2: *PCK model*

Source: An et al. (2004, p.145)

It emerges from the structure that PCK entails three components: content, teaching and curriculum. The three components are not equal in value. Looking at the structure, though all components lead towards learners learning which is the main aim of PCK, it is evident that the component of teaching practices which the study is concerned with, has a greater weight than other components. Though this is the case, the three components are interdependent. The components cannot be divorced from one another. The knowledge of content alone without the teaching could be as ineffective as the knowledge of teaching or curriculum without content. Turnuklu and Yesildere (2007) add that having a deep understanding of mathematical knowledge (meaning mathematics content only) is necessary but not sufficient to teach mathematics. EMIPs, therefore, need the teacher to be able to integrate the three components. It is for this reason that this study puts more emphasis on the component of teaching, since it is the one that seems to affect the learners' learning the most as other studies (Adams & Krockover, 1999; Cai et al., 2009; Haas, 2002; Ngoepe, 2003; Simmons & Kamlay, 1999) as indicated in section 2.5 in Chapter 2 which deals with studies on instructional practices.

3.4.1.1 Content subject knowledge

According to Koehler and Mishra (2009), content knowledge is the teacher's knowledge about the subject matter to be learned or taught. The definition differentiates content knowledge from pedagogical knowledge. Actually, it indicates that content knowledge falls within PCK. According to Özden (2008), content knowledge is "the concepts, principles, relationships, processes, and applications a learner should know within a given academic subject, appropriate for his/her and organisation of the knowledge" (p.634). According to Garet, Porter, Desimone, Birman, and Yoon (2001), there is little research on what teachers actually learn in PD activities; i.e., their content. Garet et al. (2001) further point out that the PD that focuses on content knowledge of mathematics and science is helpful for learners' conceptual understanding. This is supported by Koehler and Mishra (2009) in saying the knowledge of content leaves much to be desired by teachers. Koehler and Mishra (2009) further state that teachers should comprehend the deeper fundamentals of the disciplines in which they teach. Their arguments are supported by Shulman (1986) in stating that content knowledge includes knowledge of concepts, theories, ideas, organisational frameworks, evidence and proofs.

Literature (Koehler & Mishra, 2009; National Research Council, 2001) points out that there are consequences of not having content knowledge. It is the reason that in recent years, the teachers' knowledge of the content matter has gained increasing interest from policy makers and researchers. Therefore, PD should be aimed at providing content focused on improving teachers' content knowledge. In the development and implementation of the framework for EMIPs, teacher were trained on the mathematics content which they were busy with. Although, content plays an important role in teaching and learning, it is not useful for teaching and learning without knowledge of how to teach. More emphasis is thus given to pedagogical knowledge (teaching knowledge or PK). The next section explains PK.

3.4.1.2 Pedagogical knowledge

The teaching component involves many activities (addressing learners' misconceptions, engaging learners in mathematical learning, knowing learners' thinking, building on learners' mathematical ideas, and promoting learners' thinking) that the teacher should do in order to achieve the desired outcomes. These activities are basically what the EMIPs envisage. Further, the teaching activities are underpinned by the social constructivist theory as the theory of learning that guides the study. The inclusion of PD based on the PCK could therefore strengthen the development and the implementation of the framework for EMIPs, in the sense that the component of teaching in PCK could be developed. The assumption made in this study is that since most teachers were trained with content knowledge, with the introduction of the new curricula such as Curriculum 2005, NCS, RNCS and CAPS little was done on how to teach the curriculum. It was taken for granted that teachers know the content and the curriculum. Though the curricula were vying for new teaching reforms as they were underpinned by theory of constructivism, it seems difficult for the teachers to be "workshopped" very quickly and be expected to implement the radical curriculum changes; hence teaching is still viewed and practised as didactical (Adler & Sfard, 2016; Ngoepe, 2014). It is for this reason that teachers are found to use different teaching forms, especially the traditional ways of teaching other than what is envisaged in the CAPS curriculum.

Research encourages current teaching reforms which are underpinned by the theory of teaching and learning of constructivism so that learners acquire the mathematical process skills of problem-solving, reasoning and proving, reflecting, selecting tools and computational strategies, connecting, representing and communicating (Adler & Sfard, 2016; Ngoepe, 2014). The next section explains curriculum knowledge.

3.4.1.3 Curriculum knowledge

Curriculum knowledge is a set of teaching and learning prescriptions (Scott, 2014). According to Scott (2014), the school curriculum includes a range of cognitions, skills and or dispositions that are available within he society. On the other hand, Shulman (1986) describes curricular knowledge in terms of four components: programmes and materials, indications and contradictions, lateral and vertical. In terms of the component of programmes and materials, curriculum knowledge is "knowledge of the full range of programmes designed for the teaching of particular subjects and topics given level [and] the variety of instructional materials available in relation to those programmes" (Shulman, 1986). A choice of the curriculum has to be made based on the human practices of that particular society. Therefore, it is imperative for teachers to know the communities or society where their learners come from and construct the curriculum to best suit those communities or society.

In essence, teachers who have curriculum knowledge are able to adapt their mathematics instructional practices towards EMIPs. This is because curriculum knowledge serves to inform the teacher what is to be taught, what materials are needed for the deliverance of the content, what type of learners are envisaged and how to deal with that type of learners in terms of knowledge construction, learning, communication, scaffolding and their ZPD. In the development and implementation of the framework for EMIPs, the teachers were taken through the curriculum, firstly, by checking where they were at the moment of the study; and secondly, by identifying the 'what to be taught' and what was expected to be achieved with that topic, the resources that were needed to deliver that topic, what needed to be improvised, what technological devices were needed and the type of assessment needed.

3.5 THE SUMMARISED THEORETICAL FRAMEWORK OF THE STUDY

The theoretical framework for the study is summarised in the Figure 3.3 below. The figure indicates a theoretical framework which stems from the social constructivist theory of teaching and learning. Specific aspects are indicated which were of focus in the development and implementation of the effective instructional mathematics framework.

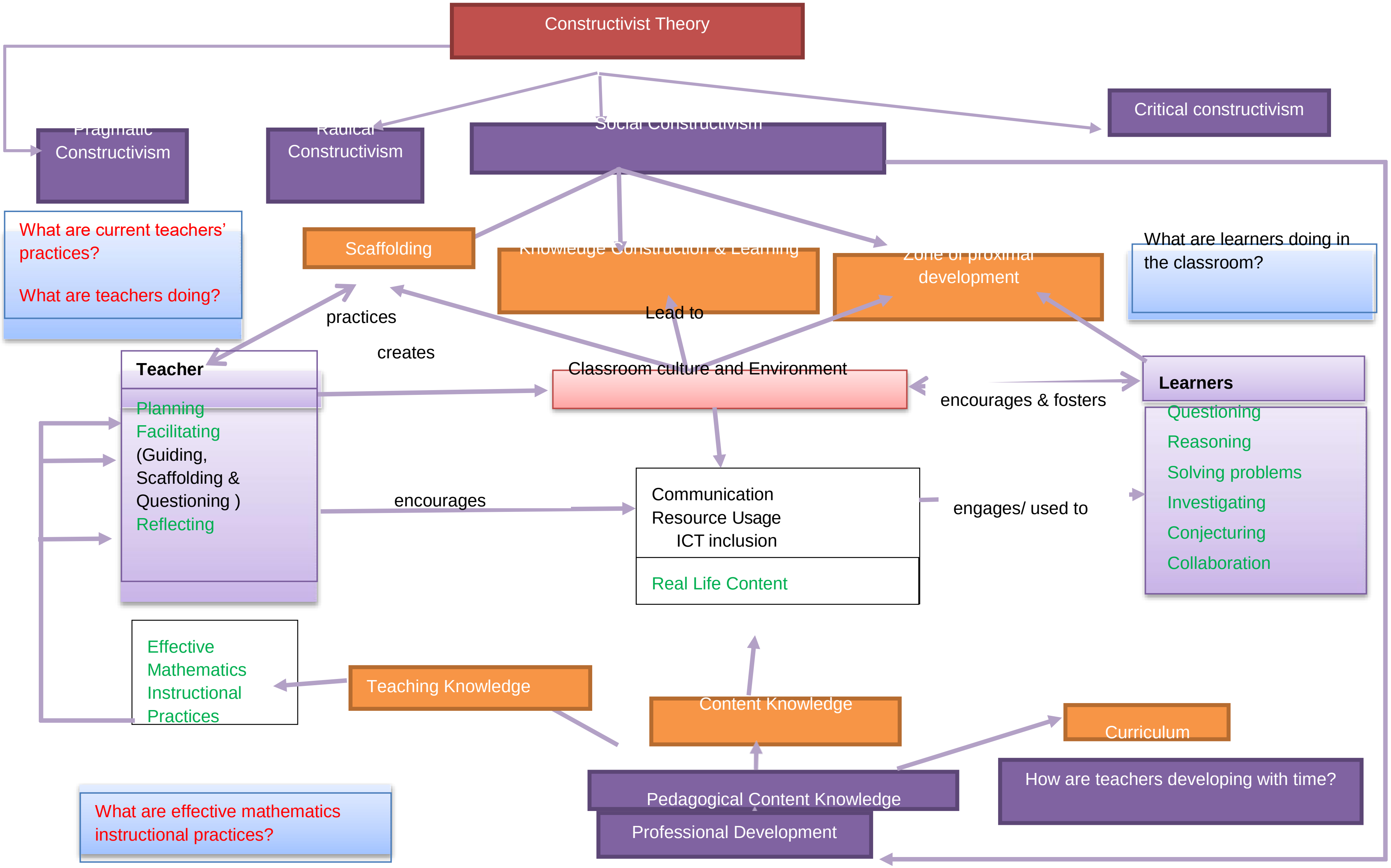


Figure 3.3: *The theoretical framework for the study*

The framework for EMIPs stems from theoretical framework of social constructivism as depicted on Figure 3.3. The constructs of scaffolding, knowledge construction and ZPD are to be used in a two way as indicated. Firstly, for learners and secondly for teachers

3.6 DEVELOPMENT OF EFFECTIVE MATHEMATICS INSTRUCTIONAL PRACTICES FRAMEWORK

The above theory of learning, what constitutes PD, characteristics of EMIP were explored and combined to form the following framework which guides the study. The elements of the framework developed are based on the theory of social constructivism, the model of PD, the PCK, the characteristics of EMIP and current teachers' instructional practices.

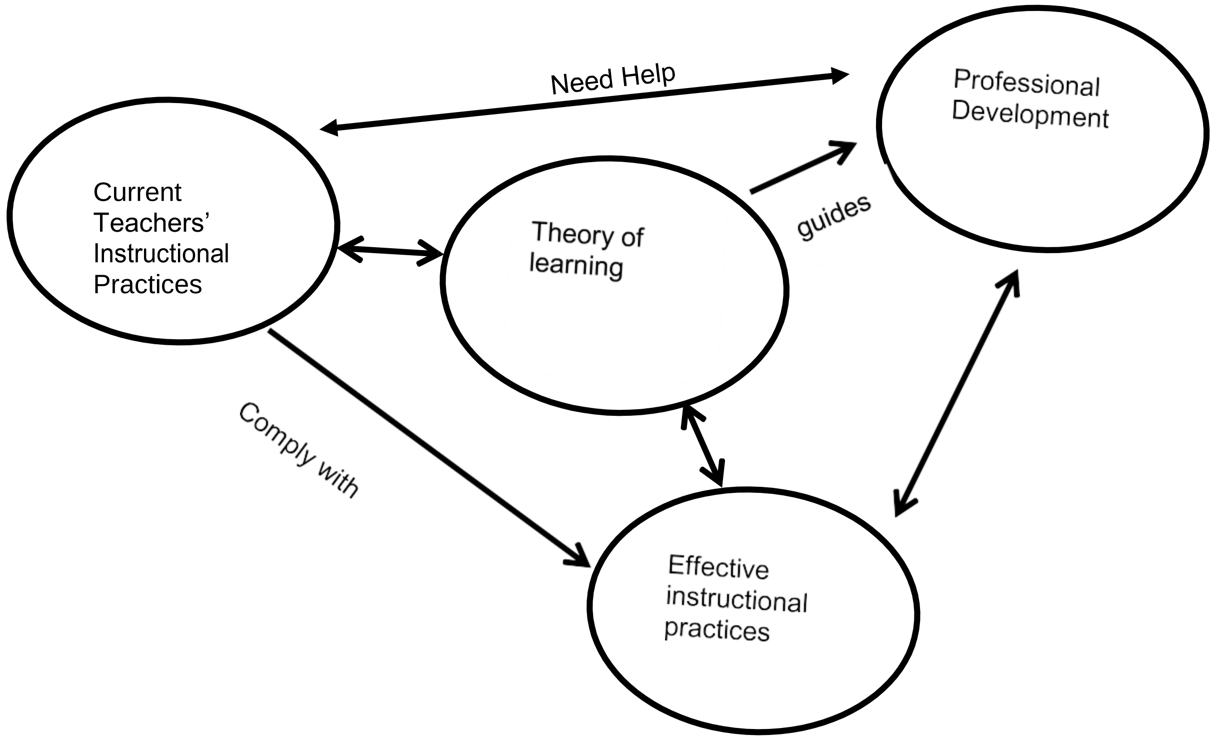


Figure 3.4 (a): *EMIP framework*

The framework is then simplified into Figure 1.1 as shown in chapter 1. The framework starts from the Teaching and Learning, Mathematical Understanding and Mathematics Achievement at the right-hand side and eventually to the left-hand side and returns to the start. The starting point is the problem area of the study: Ineffective mathematics instructional practices, which from the framework is represented by the current instructional practices. The starting point in the framework needs to identify firstly, the practices of the teachers. After identifying the practices, depending on the findings, the intervention in the form of PD is rolled out. The PD will be based on the three items: lesson planning, teaching practices and reflective practices. Mathematical understanding and mathematics achievement in the framework has been used for dual purposes: as a problem area which is caused by the main research problem of ineffective instructional practices and as a desired outcome of the whole process after teachers have undergone PD. The external cyclic arrows indicate the way in which the framework should be followed in order to continuously have PD on EMIPs.

Within mathematical understanding comes content knowledge and PK. The two constructs form part of PCK. So, in essence, the framework starts from the theory of teaching and learning of constructivism which includes PD. The PD includes PCK which results in instructional practices.

The instructional practices are from the studies (Ngoepe & Treagust, 2003; National Center for Educational Evaluation [NCEE], 2013; Pretorius, 2000) seen as one of the main factors that affect both mathematical understanding and mathematics achievement. The framework indicates that once the problems are identified, then the causal factor, namely, instructional practices are considered. There is a need to move from the current instructional practices towards effective instructional practices. Based on the model the movement could be done by focusing the process on the theory of learning: social constructivism. The theory guides the development and the implementation of the framework and focuses on other studies which used similar frameworks.

3.7 IMPLEMENTATION OF EMIP FRAMEWORK

The EMIP framework was implemented in one secondary school in Limpopo, Malokela circuit of Sekukhune district. Two teachers teaching Grade 10 mathematics and Grade 11 mathematics took part in the study. The EMIP framework was adjusted to fit the school and the three classes' cultures. Teachers from a different classroom context and culture who were using ineffective instructional practices, or the didactic approach, were given help and support in developing and implementing the aspects of EMIPs.

As the two teachers are from the same school but different classroom contexts, all of them are reported.

3.8 CHAPTER SUMMARY

This chapter addressed aspects related to the theoretical framework, which underpinned the study of the development and implementation of EMIPs. The different types of constructivist theory were also explained and the choice of the social constructivism was described and motivated. The application of social constructivism in the classroom is highlighted; i.e., how the social-constructivist views the following: learning, the learner's role, communication, the teacher's role, knowledge construction and communication in the classroom. The concepts of PD which embeds PCK was fully clarified.

This chapter illustrated that PCK involves the knowledge of the content; the subject content and the knowledge of the teaching of the subject. It emerges that when doing PD, there is a need to focus more on the PCK and not content knowledge or pedagogical knowledge as separate entities as there is no one which is more important than the other.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 INTRODUCTION

In the previous chapters a detailed literature review, theoretical and conceptual framework for the study were presented. The purpose of the study was to develop and implement a framework of EMIPs. In achieving the purpose, the following questions were pursued:

- What are the current mathematics teachers' instructional practices?
- What is the framework of effective mathematical instructional practices?
- How the development and implementation of effective mathematical instructional practices framework changes teachers' instructional practices?
- What is the impact of effective mathematical instructional practices on learners' questioning skills and the teacher's instructional practices?
- How do effective mathematical instructional practices affect learners' resources choice and usage?

This chapter gives a description and discussion of the paradigms and research methodology. The discussion includes the qualitative research approach which includes the purpose, case study design, sampling procedure, data collection strategies, interviews, observations, data analysis, ethical considerations and validity. The description of the STAM and other frameworks used for the development of the instruments and implementation of the framework of EMIPs are explained.

This research is based on some underlying philosophical suppositions about what constitutes 'valid' research and which research method(s) is/are appropriate for the development of knowledge (Creswell, 2014). In order to conduct and evaluate this study, it was therefore imperative to know what the suppositions were. The paradigm relevant to guide the study of the development and implementation of the framework of effective mathematics instructional teaching practices was that of constructivist/interpretive.

4.2 PARADIGMS

A constructivist/interpretive (phenomenological) paradigm was chosen to situate the study. This study was situated within the phenomenological paradigm because the views of the researcher determined the meanings about the phenomenon being investigated (Imenda & Muyangwa, 2006). The term paradigm has its origin and comes from the Greek word '*paradeigma*'. According to Kuhn (1962) the word '*paradeigma'* means pattern. The word was used first by Kuhn (1962) to denote a conceptual framework shared by a community of scientists. The word '*paradeigma'* provided the study of the development and implementation of the framework of EMIPs with a convenient model for examining problems of ineffective teaching and exploring and suggesting solutions (Kuhn, 1962).

In the context of this study, the paradigm was viewed as an integrated cluster of substantive concepts, variables and problems (ineffective instructional practices) aligned with corresponding methodological approaches (qualitative approach) and tools (COI, LPOI, RVAI, and Analytic Framework for Identifying Teacher Change [AFITC]). The term paradigm refers to a research culture with a set of beliefs (teachers teaching strategies beliefs), values, and assumptions (that teachers' teaching is predominantly didactic) that a community of researchers has in common regarding the nature and conduct of research (Kuhn, 1977). It was from this context in this study that beliefs, values and assumptions were stated and studied in detail. A paradigm thus implies a pattern, structure and framework or system of scientific concepts; in this case, the development and implementation of a framework of EMIPs.

According to Cohen, Manion, & Morrison (2007), there are three research paradigms: a positivist research paradigm, pragmatic research paradigm and constructivist/interpretivist research paradigm which has been already been explained in detail and is used in the study. Milondzo (2006) and Cohen et al. (2011) state that the positivist paradigm is essentially concerned with objectivity, measurability, predictability, controllability, patterning, the construction of laws and rules of behaviour, and the ascription of paradigm. It worth noting that while positivist research focuses on quantitative mathematical calculations, pragmatism is a deconstructive paradigm that advocates the use of mixed methods in research, "sidesteps the contentious issues of truth and reality" (Feilzer, 2010; p.8), and "focuses instead on 'what works' as the truth regarding the research questions under investigation" (Tashakkori & Teddlie, 2003, p. 713). Pragmatism deals with action and change and the interplay between knowledge and action (Goldkuhl, 2012). The pragmatism paradigm stresses an intervention into the world instead of observing the world.

According to Goldkuhl (2012), there are many forms of constructivism/interpretivism such as conservative (hermeneutics), constructivist, phenomenological, critical and deconstructionist. For this study, the phenomenological paradigm was selected as Imenda and Muyangwa (2006) postulate that it implies that the researcher interprets the meanings about the world as done in this study. They argue that, that which appears to the researcher could be different from that which appears to the people making up a given research sample, in this case the teachers. What is of the utmost importance is that, it should appear in the conscience of the researcher and the research sample (teachers) what the truth is. This study sought to explore a given phenomenon (development and implementation of a framework of EMIPs) as understood and construed by the teachers. The purpose of the phenomenological research paradigm was to establish the essential characteristics and ideas of the framework, in which the views of the beholder (the researcher in this study) make meaning of what is effective and what is not (Imenda & Muyangwa, 2006). In the development and implementation of the framework for EMIPs, the researcher focused on PD based on PCK. The constructs of lesson planning, teaching practices, classroom environment, conceptual understanding, use of ICT, and reflective practices were the concentration. The study focused on observations of the teachers, their practices, classroom environment, Use of ICT and reflective interviews to develop and implement the framework of EMIPs during the teachers' PD process. According to Guba and Lincoln (1994), in this paradigm, the researcher and the object of investigation (in the case of this study the teachers) were assumed to be interactively linked so that the findings were literally created as the investigation proceeded. The paradigm allowed individual constructions that were refined only through the interaction with the participants (in this case, the researcher and teachers) and findings were interpreted by using the individual teacher cases and give meaning and my own truth of what transpired. The argument was supported by Hogue (2011) in stating that in the constructivist paradigm there is not a single truth; rather, all truth is relative and constructed by individuals or society.

There are several studies which used the constructivist paradigm (Ngoepe, 2014; Pitsoe, 2008; Wachira et al., 2013). It is reported that these studies were successful. They were able to find out and construct their own meaning out of the world they were engaged in. The development and implementation of the framework for EMIPs was located within the phenomenological paradigm in order to review the way that teachers interpret, develop, implement and improve their mathematics instructional practices. The reason for locating the study to this paradigm was so that I could make my own observations and construction of the truth and provide my own interpretation of what transpired from the observations. Based on this paradigm, a choice for the research methodology was made to guide the development and implementation of the framework.

4.3 RESEARCH METHODOLOGY AND DESIGN

Lancaster (2005) and Cohen et al. (2011) define research methodology as the general category of research approach used in a research study and which relates particularly to the process of data collection, and logical analysis of information. The definition from Cohen et al. (2011) and Lancaster (2005) indicates the need to use a relevant approach in the form of methodology to undertake research. The research methodology that was used in collecting data on the development and implementation of the framework for the development of EMIPs was the qualitative approach. 7According to Patel (2015), the constructivist paradigm usually uses qualitative research. Other studies (Ngoepe, 2014; Pitsoe, 2008; Wachira et al., 2013) which investigated classroom practices found the qualitative approach relevant.

4.3.1 Qualitative Approach

Creswell (2009) defines qualitative research as research that relates the researcher with the world. Furthermore, the world is socially constructed, and science is driven by human interest. Cohen et al. (2011) posit that qualitative research is research which is more concerned with understanding the social phenomenon from the participants' perspective. In the context of this study, the social phenomenon to be understood was the development and implementation of a framework of EMIPs.

The term ‘qualitative’ was twofold: to understand the world in terms of the constructivist paradigm and the purpose of the research, and to indicate how data were collected and analysed and represented.

4.3.2 Case Study Design

A case study research design was followed in the development and the implementation of the framework for EMIPs. According to Cohen et al. (2011), the interpretive, subjective dimensions of educational phenomena are best explored by case study methods. A case study was used because it was the most appropriate format for conducting school-based research (Yin, 1994). The case study involved the study of a phenomenon (development and implementation of the framework of EMIPs) explored through two cases (two teachers) within a bounded system (Creswell, 2009). According to Creswell (2009), a case study is a type of design in qualitative research. The purpose of the case study was to understand instructional practices of two teachers (perhaps a very few small number) or a situation in great depth. When developing and implementing the EMIPs framework, the focus was on the role played by teachers in terms of questioning, availability and use of resources, assessment and the classroom environment, and the role played by learners (learners’ activities). Researchers such as Ngoepe (2003), Ngoepe (2014) and Wachira, et al. (2009) also used the case study method to investigate classroom practices as solutions to their research problems.

A qualitative, descriptive and interpretive case study design was employed in this study due to reliance on observations, lesson plans and video recordings as a means of collecting data in a natural environment. (Creswell, 2009; Fourie & Deacon, 2015; Walliman, 2011; Yin, 2011). The case study design enabled the researcher to understand and experience both the teachers’ and the learners’ actions better (Creswell, 2009). The other reason for choosing a case study was that it provided a means through which judgement was provided on the effectiveness of particular DBE policies; for example, workshop policy, pace setter policies, teacher and learners classroom practices or innovations (Leedy & Omrod, 2010). Likewise, Major and Mangope (2012) used a qualitative case study to compare the teacher quality and learner performance in Southern African countries of Botswana and South Africa. Equally, Pretorius (2013) used a qualitative case study on teacher effectiveness in the South African context. So, a case study seemed to be a reliable and viable option for this study.

4.3.3 Sampling

Sampling involves selecting individuals or perhaps clusters from a population (Leedy & Ormrod, 2010; Creswell, 2014) to form a sample. Non-probability sampling characterised this study, in which a particular group (two teachers and their Grade 10 and Grade 11 mathematics learners from a single school) was targeted (Cohen et al., 2011), in the full knowledge that it did not represent the wider population of teachers and learners, but simply represents itself. This type of sampling was non-random, subjective and purposive in that the researcher selected the sample using the same criteria. The teachers and learners did not have a randomly equal chance of being selected from a sampling frame. Cohen et al. (2011) indicate that non-probability sampling is done with a small sample where no attempt is made to generalise and may be used in ethnographic research, action research or case study.The following explains how samples were selected.

4.3.4 Selection of Samples

One school was sampled, and from within the school, two teachers and their mathematics classes (Grade 10 and 11 mathematics) were sampled.

4.3.4.1. Sampling of school

Malokela circuit is in the greater Sekhukhune district in Limpopo Province. It has 10 secondary schools in total. Initially three schools and one Grade 10 mathematics teacher per school were sampled, due to the geographic and economic location of the schools. As a result of timetable clashes and periods allocations in those schools; for example, some used 35-minute and others 45-minute periods, the sample was reconsidered. This sample was determined by conceptual requirements and not primarily by representativeness (Moser & Korstjens, 2018). This led ultimately to purposively sampling one secondary school in Malokela circuit because of convenience of access to the researcher (Leedy & Omrod, 2010), a uniform timetable and tha fact that it had more than two mathematics teachers. Two classes namely: Grade 10 and 11 mathematics, from the school formed part of the sample.

4.3.4.2 Sampling of class

Leedy and Ormrod (2010) indicate that, in purposive sampling, people or other units are chosen for a particular purpose, namely to access in-depth knowledge about a particular issue (Cohen et al., 2007). In this study, the mathematics teachers and Grade 10 and 11 mathematics learners were "typical" of a group or those who represented diverse perspectives on the issue of EMIPs. Due to the problems of changing the number of schools from three to one, purposively and conveniently, mathematics teachers and learners of the school that were chosen were sampled and took part in the development and implementation of the framework for EMIPs. The choice also enabled the teacher participants to walk to a common meeting place (the office of the mathematics teacher) without transport costs during training and during the reflection part on the lesson by watching the video-recording together. The teachers and learners from the school were also observed during the development and implementation of the framework for EMIPs.

4.3.4.3 Description of the site

Mason, Kate, Webb, Danieals, Featherstone, Bywaters, Mirza, Hooper, Brady, Bunting and Jonathon (2019) indicate that before selecting a case study site, it is necessary to identify the host within which the case will be hold. Based on that, the site (school) is situated in a remote rural area in Sekhukhune district in Malokela circuit of Limpopo (host) were the majority of the women are not working and rely on support grants and or men as husbands to support them. Gaining access to the site is explained in detail on section 4.4.1. The school is located in the middle of the bush surrounded by farming fields of the community 2,7km away from the village. The main gravel road from the village to town runs 500m away from the school. The village does not have internet café. Photocopies could only be made at the school. The majority of the learners cannot access internet for educational purposes except those who have smart phones. The school consist of three four-roomed classroom blocks, one big multipurpose centre, one kitchen-store room building, four mobile classrooms and three ablution facilities (one for girls, another for boys and teachers). Out of the three classroom blocks, two consist of the office of the HOD each and the last one is the office of mathematics teachers, which is also used as the change room for both mathematics and physical sciences lessons. The multipurpose centre has two large rooms where one is used as the teachers' staffroom and the other is used as both a strong room and principal's office. In the kitchen-store building, there is one room used as an office for the deputy principal. Noted was that, with these setting the site was chosen because it could provide the necessary data. The school is resourced with six laptops, two printing machines, an overhead projector, one duplicator, two photocopiers, enough textbooks to cater for each learner and two overhead projector screens. During the last week of my stay, a certain company provided the school with two smartboards. It is also worth noting that the school has eight surveillance cameras, which are controlled and viewed in the principal's office.

Of note is that learners started classes at 07h20 as a normal practice except the Grade 12 who started at 06h20 everyday for morning lessons. Moreover, the Grade 12s attended Saturday lessons offered by their teachers. Very few flexi-periods per grade were seen on the timetable. Since the school was far from the village, there were no people moving outside the school other than learners and teachers, thus making schooling/ learning safe.

4.3.4.4 Description of the Grade 10 classroom (See site on sec 4.3.4.3)

The Grade 10 mathematics classroom in which the data were collected is located on the first block of the school on the right-hand side from the entrance gate. It is the second classroom from the main gate. Unlike in other school contexts all the windows, window panes and the door are intact. A green chalkboard can be seen in the front, a grey noticeboard at the back and a steel cabinet (cupboard) and connecting plugs are located at the back of the classroom. There are also ceiling and working electrical bulbs on the roof. The classroom walls are painted in a light yellow paint and there are no posters, guides or any resourceful information on the walls or notice board. The floor of the classroom is made of cement and concrete which looks dry and grey as a result of not being polished. There is a weekly roster in which girls are allocated schedules to sweep the floor daily while boys clean windowpanes and the chalkboard.

4.3.4.5 Description of the Grade 11 classroom (See site on sec 4.3.4.3)

The Grade 11 mathematics classroom consists of a chalkboard, noticeboard and two steel cabinets (cupboard), connecting plugs and electrical bulbs and it serves as the mathematics teachers' office. The green chalkboard is fixed at the front. There is a data projector in the classroom and data projector screen which is placed at the front next to the chalkboard. All the windows panes are intact and there are curtains and blinds. The floor is tiled in a cream tile. The walls are not painted nor plastered. There are no mathematics information displays either on the walls or the notice board.

4.3.4.6 Descriptions of teacher participants (See site on sec 4.3.4.3)

As mentioned earlier, two male teachers from the same school participated in the study.

Teacher 1: He teaches Grade 11 mathematics. He is about 28 years old of age and holds Bachelor of Education degree SPF (BED SPF) with Mathematics and Life Sciences as majors. He began as a novice teacher in the school in October 2014 and taught Grade 09 and 11 Mathematics, and Grade 10 Life Sciences.

Teacher 2: He teaches Grade 10 mathematics. He is 29 years old and holds a Bachelor of Education degree SPF (BED SPF) with Mathematics and Life Sciences as majors. He started working as a novice teacher in the school in January 2014 and taught Grade 11, Grade 10 and 9 Mathematics in 2014.

4.3.4.7 Description of learner participants (See site on sec 4.3.4.3)

- Grade 10 mathematics learners: The Grade 10 mathematics classroom consisted of a total of 30 learners of 11 girls and 19 boys where one learner was a repeater. Twenty-nine of the learners had been in the Grade 9 mathematics classroom the previous year. There were no learners from neighbourhood schools. It was assumed that the majority of the learners were positioned equally in terms of educational standards and contextual background.
- Grade 11 mathematics learners: The Grade 11 mathematics classroom consisted of a total of 23 learners of 14 girls and 9 boys where one boy was a repeater. Twenty-two learners had been in the Grade 10 mathematics classroom the previous year. These learners in the grade were positioned equally in terms of their standard of education and their contextual background.

4.3.5 Data Collection Instruments

Multiple data collection forms for gathering data were used (Cohen et al., 2007; Leedy & Ormrod, 2010) namely, observations, interviews, written documents, audio-recording and video-recording were used in order to help answer the research questions. In this study, the following data collection instruments were developed and used: Classroom Observation Instrument (COI), Lesson Plan Observation Instrument (LPOI), Researcher Video Analysis Instrument (RVAI) with Video Recorder, Analytic Framework to Identify Teacher Changes (AFITC) and interviews (Reflective). The reason for developing and using various techniques of data collection by the researcher was to confirm the findings between one method and another, provide more comprehensive data, and increase the validity of the studied phenomenon (Bekhet & Zauszniewski, 2012).

4.3.5.1 Observations

Observation instruments were key to data collection. McMillan and Schumacher (2001) define observation as a data collection method in which the researcher deduces fidings related to the variable of interest. According to Marshall and Rossman (2006), observations entail the systematic noting and recording of events, behaviours and artefacts (objects) in a social setting chosen for the study. Through the observations, the signals, facial expression, gestures, tone of voice and other social interactions of the teachers were observed, which suggested the subtle meanings of language (Chindanya, 2011). The observations were used to discover complex interactions in natural social settings and were a fundamental and important method in this qualitative study (Marshall & Rossman, 2006), see appendix K. On the other side, it is a very time consuming method, which requires prior preparation and the availability of the researcher to visit the place where the event occurs (Queiros, Faria & Ameida, 2017) Although the observation instruments were developed and used, they were intentionally left flexible and free- flowing to add whatever is seen in order to understand the phenomenon (Leedy & Ormrod, 2010). Corbin and Strauss (2008) stress the importance of observations by saying that it is not unusual for persons to say they are doing one thing but in reality, they are doing something else. The only way to know this is through observation.

There are two types of observation: participant observation and non-participant observation (Creswell, 2014). Participant observation was selected for the purpose of this study. In this type of observation, the researcher becomes involved in an interactive data-collection experience of the daily activities of participants over an extended time period (in this case, three weeks) and records descriptive field notes. The researcher did not collect data to answer a specific hypothesis, but inductively derived the explanations from the field notes (McMillan & Schumacher, 2001). In the development and implementation of the framework of EMIPs, participant observation was used because the researcher interacted with the participants (teachers and learners) through lesson planning, teaching, assessing and interviewing. In order to observe what was transpiring in the development and implementation of the framework, instruments were designed to use for the task of observation.

The COI was developed based on the constructs that need to be explored, developed, implemented and improved, namely, teacher's questions in the classroom; creating an environment of respect and rapport; assessment; resources; and mathematics concepts. In addition, the AFITC from Pang (2012) was adopted and used to observe the teacher changes (if any) for six days each, i.e two days per week. The next section explains the development of the instrument.

- *COI Development*

The COI was developed by an adaptation from a variety of instruments and models (STAM, Danielson' model and etc) which were used to investigate instructional practices in school settings. See section 4.5 under the development of instruments for full explanation of which items we used from which instrument. The COI is an instrument that was used to observe the instructions of the teachers before and after they were trained through the process of the framework. The purpose of the instrument was twofold: to identify and classify the instructional practices of the teachers before training and to capture how the lesson was flowing, teacher's role, learner's role, time allocation, resources, assessment and environment. During the pilot phase, it was found that from the COI the construct of learner questioning the teacher was not essential. It was removed and replaced with the construct of communication due to the background of the learners in that village. Learners were not used to questioning the teacher even if given an opportunity. This is because in their culture, a young person does not question adults. It was found that the construct of creating an environment of respect and rapport to be important to manage relationships with learners and ensuring that relationships among learners are positive and supportive. This construct was aimed at identifying teacher interactions with learners, including both words and actions. According to Danielson (2013), teacher's interactions with learners set the tone for the classroom. Through their interactions, teachers convey what they are interested in and care about their learners.

Learner interactions with other learners including both words and actions are as important as a teacher's treatment of learners. How classmates treat learners is arguably even more important to their learning (Danielson, 2013). At its worst, poor treatment causes learners to feel rejected by their peers. When the treatment is best, positive interactions among learners are mutually supportive and create an emotionally healthy classroom environment. Teachers not only model and teach learners how to engage in respectful interactions with one another but also acknowledge such interactions. Further, another construct of mathematics concept used by both the teacher and learners was added. The pilot study observations prompted the inclusion of the dimension because it was found that in some cases the teacher used wrong concept in the mathematics learning. Learners were taught that a number jumps equal sign instead of additive inverse and that they are cancelling out instead of division or multiplicative inverse. The final COI (See Appendix K) contained the following constructs:

a) Teacher's question in the classroom – this had three aspects to look at: What kind of questions was the teacher asking? How was the quality of the questions that the teacher asks? and Were the questions checking on learners' knowledge?).
b) Creating an environment of respect and rapport - this construct consisted of five items: Were learners talking to each other? Were learners in each group discussing their solutions? What words and actions did the teacher use? What words and actions were the learners to each other? Are learners explaining their solutions to the whole class?.
c) Assessment – this entailed three items: Was assessment meant for understanding or grading? Was assessment based on the conjecture/ investigation/ problem? What type of assessments were used in the lesson?.
d) Resources – the construct included five items as follows: What kind of resources were present/used? Were the resources related to the content/ problem/ conjecture / investigation? Were the resources accessible to learners? Who directed the use of the resources? Was ICT used?
e) Mathematics Concepts – this construct contained two items. Was the teacher using correct mathematics concepts? Were learners using correct mathematics concepts in their discussion or explanation of their solution?

- *Lesson Plan Observation Instrument Development*

The LPOI was generated from STAM framework (Gallagher & Parker, 1995); Danielson' (2013) framework (LPOS) instrument and other instruments. This instrument was developed and used to observe the lessons plans for the teachers before they could go into the classrooms. The purpose of the instrument was to capture how the teachers plan lessons; consistency of the lesson plans with the framework. The development of the LPOI was prompted by assumptions that teachers enter into their classes with a textbook without planning. If planning were there, they were not proper or were skeletal. A repeated process in which reviews of lessons plans from teachers not involved in this study and other policy documents on lesson plans were used to refine the instrument. The instrument (79) consisted of objectives, content, teacher's role, learner's role, time allocation, resources, prior-knowledge, misconception and concepts, assessment and environment perceived.

The purpose of the lesson planning was to identify that the teacher displays knowledge of the important concepts in the subject, and how this related to one another and other subjects (Danielson, 2013) and that it addresses the need of the framework for EMIPs. The focus of the lesson planning apart from the identified items, were three: knowledge of content and the structure of the discipline, knowledge of prerequisite relationships and knowledge of content-related pedagogy.

- *Researcher Video Analysis Instrument*

The RVAI (see appendix M) is an instrument that aimed at identifying and classifying the current instructional practices of mathematics teachers and the changes during the development and implementation process and it was the benchmark that is envisaged to be matched or move beyond by the teachers. The purpose of the instrument was to observe and develop the teachers towards EMIPs. The instrument was used to review the video by the researcher. The RVAI is discussed in detail below.

- Video Recording

The video recording provided an archive for substantiating and revisiting findings. In addition, it was used to identify exemplary practices during teacher PD for reflection. It also served for triangulating the observation and the reflective interviews after every lesson presented. Video recording research is an increasingly important method in the learning sciences since it provides unique analytical affordance to researchers (Ramey, Champion, Dyer, Keifert, Krist, Meyerhoff & Villanosa, 2016). Video data afford unique access to context surrounding phenomena of interest, but there is little guidance on how to incorporate this context into analysis.

- *Analytic framework for identifying teachers change*

The AFITC from Pang (2012) (see table 4.1) was adopted to examine what had changed and what had not in the process during the development and implementation of EMIPs. Pang (2012) used this framework in the incorporation of recommended approaches for ordinary Korean teaching practice. As seen in Table 4.1, five dimensions with 24 sub- dimensions were drawn from the literature review of typical and recommended teaching practices, which were similar to EMIPs. While each bolded criterion signifies a recommended approach, the remaining ones represent typical teaching practice. Furthermore, the framework was adapted by including six columns next to the original two columns to cater for two observations per week.

Table 4.1:

Analytic framework for identifying teacher changes

Dimensions	**Criteria**	**Week 1**		**Week 2**		**Week 3**	
		Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
1. Overall characteristics							
1.1 Consistent	**Is the main topic presented consistently throughout the lesson?**						
1.2 Progressive	**Is the main topic presented progressively (from easy/concrete to difficult/abstract)?**						
1.3 Systematic	**Is the overall instructional flow systematic? (learning motivation? learning objectives? main activities? practice? evaluation/summary**						
2. Learning objectives							

Dimensions	Criteria	Week 1	Week 2	Week 3
2.1 Conceptual understanding	**Does the lesson focus on learners' understanding of a mathematical concept, principle, or law?**			
2.2 Mathematical process				
2.2.1 Problem-solving	**Does the lesson focus on solving a given problem?**			
2.2.2 Reasoning	**Does the lesson focus on fostering learners' mathematical reasoning ability?**			
2.2.3 Communication	**Does the lesson focus on fostering learners' mathematical communication ability?**			
2.3 Positive disposition	Does the lesson focus on fostering learners' positive attitude toward mathematics?			
3. Instructional strategies				
3.1 Considering content	Does the teacher use instructional strategies sensitive to the content to be taught?			
3.2 Considering learners	Does the teacher use instructional strategies tailored to learners' differences?			
3.3 Instructional materials				

Dimensions	Criteria	Week 1	Week 2	Week 3
3.3.1 Manipulative	**Does the teacher employ instructional materials for learners' manipulative activities and exploration?**			
3.3.2 Reconstruction	**Does the teacher reconstruct the textbook in a way that considers the content and learner characteristics?**			
4. Mathematical discourse				
4.1 Questioning	**Does the teacher use open-ended questions to provoke learners' thinking?**			
4.2 Feedback	Does the teacher provide timely feedback sensitive to learners' understanding?			
4.3 Teacher role				
4.3.1 Question/ answer and demonstration	**Is the discourse dominated by the teacher's question/answer pattern and demonstration?**			
4.3.2 Emphasising communication	**Does the teacher emphasise the importance of mathematical communication?**			
4.3.3 Soliciting and using learners' ideas	Does the teacher solicit learners' multiple ideas and use them in the lesson?			

Dimensions	Criteria	Week 1	Week 2	Week 3
4.4 Learner role				
4.4.1 Chorused and simple responses	**Are learners' responses mainly chorused and simple?**			
4.4.2 Presenting one's own ideas	**Do learners have an opportunity to present their own ideas to the whole class?**			
4.4.3 Peer communication	**Do learners have an opportunity to communicate their ideas directly with peers?**			
5. Learning environment				
5.1 Group organisation				
5.1.1 Whole-class	**Is the whole-class organisation used mostly throughout the lesson?**			
5.1.2 Small-group or individual activity	**Are small-group or individual activities used appropriately given the characteristics of content and learners?**			
5.2 Classroom atmosphere				
5.2.1 Permissive	**Does the classroom atmosphere allow all learners to participate actively through shared norms?**			

Dimensions	Criteria	Week 1	Week 2	Week 3
5.2.2 Mutual respect	**Does the classroom Atmosphere encourage learners to discuss their ideas based on mutual respect and trust?**			

During the pilot study, it was found that the analytic framework captures and helps in identifying the teacher changes; hence, it was not altered. Other teachers acted as evaluators, including the researcher, to code individually each of the six lessons according to each criterion of the analytic framework in terms of ticking what transpired in the classroom from the video by putting a tick and comment wherever needed. If the teacher crossed the sub-dimension or left a blank, it means that part was missing from the lesson. The framework was used before the training and during implementation where each week, teachers were observed twice using this instrument to check if there was a change in their practices.

4.3.5.2 Reflective interviews

In this study, informal conversational reflective interviews were used. Woods (2011) defines reflective interviews as a non-experimental design conversation with a purpose. The qualitative interviews sought to describe the meaning of central themes in life world of the participants in order to understand the meaning of what the participants say (Mosler & Korstjens, 2018). Open-response questions were asked to obtain data about participants' meanings (how individuals conceive of their world and how they explain or make sense of their important events in their lives) (McMillan & Schumacher, 2001). Reflective interviews are qualitative in nature (Woods, 2011). The qualitative interviews took a form of an informal conversational interview, as there was no interview guide and the context dictated the questions to be asked; i.e., there were no predetermined question topics or phrasing (McMillan & Schumacher, 2001). This is also supported by Creswell (2009) in calling it an unstructured open-ended interview in which there are no structured questions in place but the context determines the questions; hence, the responses of the teachers to the lessons observed determined the interview questions. No questions were asked in same order to the participants, thus increasing the interviewer's flexibility as an advantage, which helped to maintain and enhance the naturalness and relevancy of the responses. For example:

Researcher: E re naa, is the topic based on a problem? Let me ask, what was the problem? If there was no problem, is the topic based on the conjecture to be solved/ Teacher 1: Ae, there was no conjecture.(The teaching was not based on a conjecture or problem to be solved) Researcher: What was it? Teacher 1: Hmmm, it was to, to check the, how can I put it? What separate the terms? Researcher: What separate the terms? *(MHN is paging the worksheet*) O seke wa ya ka moo (do not go that side), let's look at it, when we say a conjecture we mean a general statement that we can see, Ok when this happens we can see this. What was the general statement then? Teacher 1: General? Researcher: Statement that we want the learners at the end to get? Teacher 1: (silent) Researcher: Ee, o wa mo kwa, akere wena (do you hear what he says) the lesson was planned by you. You know what is it that when I get out, I wanted that this, generic things that the learners should get is this one. Teacher 1: At the end ne ke nyako gore ba kgone go group like for example if re nale something like this then remaina le -1 4 time over eight ba kgone grouper and ba kgone go tseba that this have 1,2,3 wanted them for example (at the end I wanted them to be able to group like for example if we have something like this, then we remain with -1 4 times over 8 so that they could be able to group and know that this have 1,2,3 wanted them for example) Researcher: Was the time spread evenly to allow learner input? Is there time for group work, is there a time for individual learner. Teacher 1: there was a time for individual learner Researcher: Remember we are still on the lesson plan, we look here (*pointing at a statement on the lesson plan*. Let's look here where you are saying I am going to group learners. Here learners will be participating on the (they are laughing). Is it there? Teacher 1 and Teacher 2: Aego (JF: It is not there)

Topics were not selected in advance but the researcher decided to ask about them, based on what was observed during the teaching and/or lesson plan.

The reason for using this type of interview was that the questions changed from the immediate context (from the lessons observed). In addition, the questions were asked in their natural course of events. This was because the instructional practices that the teachers may have come up with could not be anticipated and this is an integral part of participant observation (McMillan & Schumacher, 2001). Lastly, the reflective interviews provided more information on the teachers' mathematics instructional practices and their held views.

4.3.6 Data Collection Procedure

The data collection procedure was based on the constructivist approach and the actual process of the framework of EMIPs: (i) lesson planning (ii) teaching and learning (classroom practices) and (iii) reflective interviews. A constructivist approach to PD provided teachers with an opportunity to construct their own knowledge in a supportive environment and empowered them to be autonomous learners. In order for the PD to achieve that, the development programme provided the teachers with an opportunity to interpret and reflect on their own learning and teaching, construct alternative meanings and expand their perspectives (Fung, 2000). The overall design of the programme followed four stages: Elicitation, confrontation, exploration and application (Fung, 2000).

- Elicitation

Firstly, teachers were observed using the framework for EMIPs to identify their current instructional practices in order to classify them (see section 4.3.5.1.). Furthermore, this stage was meant to help teachers to become aware of their current practices. The stage was important because the constructivist view of learning acknowledges the impact of prior knowledge and experience in constructing knowledge. The researcher here wanted to determine the prior knowledge of teachers on instructional practices and to build on that towards the EMIPs.

- Confrontation

Secondly, teachers were asked to visualise the inadequacies of their current practices (if any) in meeting the demands of the framework of EMIPs. They were also trained on using the framework for EMIP starting with the characteristics of effective instructional practices and the planning of an effective lesson, the content, the responsive teaching that was envisaged and hence what would be done after every lesson planned (watching the video recorder) and reflective interviews.

- Exploration

This involved teachers in constructing a new teaching approach with challenges and advice from the researcher where necessary. At this stage, they had to prepare lesson plans and worksheets that conformed to the framework and teach according to those lesson plans.

- Application

Teachers implemented the framework in their classes. They used their prepared lesson plans and worksheets. The researcher observed one teacher at a time and and used the following instruments: LPOI, COI, RVAI and, in some cases, the AFITC. After every lesson, reflections on the teaching by viewing the video and completing the RVAI was done together with all the mathematics teachers. During the viewing of the video, reflective interviews were employed and recorded to make meaning of what the teacher was explaining. As a form of PD, the other teachers were available to watch the video and check on the good and bad parts of the instructional practices and add their voices also. The process continued for three weeks. The framework started with the lesson planning, followed by responsive teaching practices and lastly, the reflective interviews. Then the process was repeated for 10 days each teacher. The following table summarise the framework's operation.

Table 4.2:

EMIP framework for developing teachers' competence in teaching mathematics

Programme milestone	**Framework EMIP Activities**	**Week 1**					**Week 2**					**Week 3**				
		Day1	**Day2**	**Day3**	**Day4**	**Day5**	**Day1**	**Day2**	**Day3**	**Day4**	**Day5**	**Day1**	**Day2**	**Day3**	**Day4**	**Day5**
Phase 1: Background	Consultation with school administration and teachers (3x) in a group (30 minutes)	✓														
Phase 2: Identification of the teachers' practices	Observations of teachers (3) in their respective classes before training		✓													
Phase 3: Training	Training about the framework: Lesson planning, Responsive teaching practices Reflective interviews			✓	✓	✓										
Phase 4: Applying the framework	Planning lessons						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Observing lessons						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Teaching out planned lessons						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Post lesson video analysis						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Reflective interviews						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

The EMIP framework consisted of four phases as summarised in Table 4.1:

Phase 1: This phase was to gain access to the school, have consultations and make formal arrangements with the school managers and the participants in order to lay the foundations and establish and build rapport.

Phase 2: In this phase, the teachers were observed using the EMIPs instruments (LPOI, COI, RVAI, AFITC) in different classrooms and different times in order to identify and classify the practices of the teachers in the study. Teachers conducted their lessons in their usual way of teaching without having knowledge of the frameworks.

Phase 3: This stage comprised teachers' training on the framework. The taught content was analysed and the teachers prepared one lesson each to check their PCK. Teachers were introduced and taken through the process of the EMIP framework. This was the stage where teachers were given the opportunity to use the EMIPs framework with guidance from the researcher.

Phase 4: This is the stage where teachers independently prepared the lessons plans based on the framework, taught the lessons and eventually reflected on each lesson. The reflections were done as a group of 2 teachers, with a research assistant plus researcher for each teacher's lesson. The responses to the reflection served as feedback on the conduct of the development and implementation, as a basis for planning the next lesson and to make recommendations about improving the EMIP framework.

The process aimed to develop teachers to adopt the EMIPs framework to teach the mathematics unit which the work schedule indicated. For the Grade 11 teacher, the first unit was Financial Mathematics which eventually ended and a new unit on probability was started as the CAPS programme outlined. For the Grade 10 mathematics class, the content unit was measurement, which was also completed and the teacher started the data handling unit as stipulated by their programme. It was expected that at the end of the three weeks teachers should have produced their own lesson plans and materials using a constructivist approach. It was a very difficult activity to handle especially because they were not used to making lesson plans. It should be noted that the research programme took three weeks. In each lesson plan and presentation, teachers were provided with an opportunity and encouraged to share with others their own teaching experience through watching the video and, to comment on each other's practices, to challenge one another and to explore and negotiate with the researcher effective mathematical instructions. The structure of the research design layout is indicated in Figure 4.1 below:

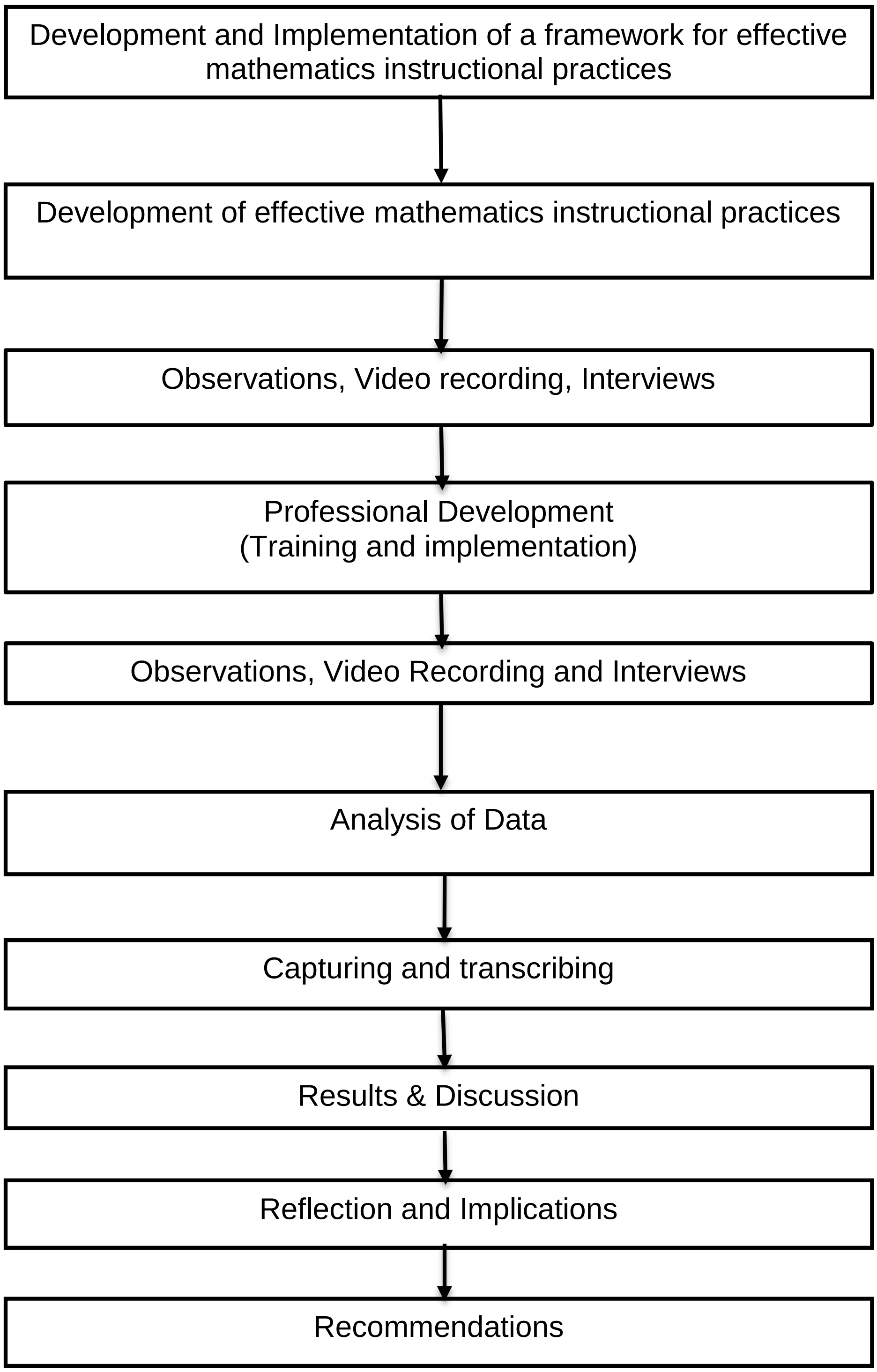


Figure 4.1: *Structure of research design*

4.3.7 Data Analysis Description

In this case study, data were analysed qualitatively to provide a detailed description of the case (each teacher's instructional practices), categorisation of data, interpretation of single instances, identification of patterns and synthesis and acknowledgement of subjectivity and biasness, in short, making sense, noting patterns, themes, categories and regularities (Cohen et al., 2011; Leedy & Ormrod, 2010). Detailed descriptions of the data from the activities based on the instruments were written down. Then the data were organised, categorised into themes and interpreted inductively. The data were interpreted by means of a descriptive narrative. According to Cohen et al. (2011), there are ways of organising and presenting data analysis: by individual people, groups of people, by issue and by instrument. In this study, the type of organising and presenting data analysis followed was by individual people. The total responses and actions of a single participant were presented based on each instrument used, and then analysis moved on to another individual until they were completed. In this study the data analysis focused on the data collected using the following instruments: LPOI, COI, TVAI, interviews, and AFITC. I prepared and organised the data (i.e text data as transcripts, or image data as in photographs) for analysis, the reducing the data to themes through a process of coding, see an example of coding on section 4.3.7.4, and finally represented the data in figures, tables or a discussion (Creswell, 2014). In each instrument, codes were used to analyse the data. The lesson plans were examined to determine whether teachers regarded the constructs of the framework of EMIPs in their planning. Furthermore, teachers were observed during the teaching of the planned lesson to determine if they were conforming to the framework practices and the planned lessons as indicated on the observation. Interviews were employed after every lesson presented to examine the adequacy of the practices. The data were analysed inductively by sorting data into categories to establish patterns and themes (Creswell, 2009). All the interviews conversations, the lesson presentations were transcribed one by one and read, studied and analysed. The final report provides for the views of the participants, circumspection of the researcher, a complex description and interpretation of the problem. From the literature review (Creswel, 2014; Leedy & Omrod, 2010) and through a process of coding and condensing codes and finally representing the data in figures, tables or discussion, the following themes emerged: teachers' questions in the classroom, creating an environment of respect and rapport, assessment, resources and mathematics concepts. Categories were as follows:

Table 4.3:

Codes for themes, categories and sub-items

Themes	Categories	Sub- items
Teacher and learners' role, Questioning and Answering, Classroom environment and communication, Assessment, Classroom Arrangement, Resources and mathematics concepts	LP = Lesson Plan TM = Teaching Methods T/C = Topic / content RI = Resources Identified LE/A = Learner Engagement /Activities CA = Classroom Arrangement PM = Possible Misconceptions IICT = Inclusion of ICT TLR = Teacher and Learners' role QA = Questioning and Answering CEC = Classroom environment and Communication RU = Resources Used MC = mathematics concepts OC = Overall Characteristics LO = Learning Objectives IS = Instructional Strategies MD = Mathematical Discourse LE = Learning Environment	PNA = Plan Not Available PAS= Plan Available but scanty/skeletal PAMRI= Plan Available and meet required Items TE/D = Telling and Explaining/ Demonstration PS/C/I= Problem-Solving/ Conjecturing/ Investigation CL = Collaborative / Cooperative Learning A= Available NA= Not Available NI= No Inclusion WTI= Willing to Include I= Inclusion WMC = Wrong mathematics Concept WME = wrong mathematics explanation CMC =Correct mathematics concept CME = Correct mathematics explanation E = engaged NE = Not Engaged CR = Chorus Response IR = Individual Response GRR = Group representative response UQ = unproductive Questioning TQ&A = teacher question and answering] KSQ = knowledge Seeking Question

For example, before the training the following lesson on page 97- 98 was observed for Teacher 1: Teacher 2 and researcher analysed using the codes on the table. All lessons were analysed using the above codes, categories and themes.

4.3.7.1 Classroom observation instrument

The recorded activities on the classroom observation instruments that took place were analysed on two occasions (before training and after training) based on the following dimensions (teachers' questions in the classroom, creating an environment of respect and rapport, assessment, resources and mathematics concepts) which each item were having items. Firstly, the dimension of teacher's questions in the classroom consisted of three items, which were intended to check on:

- the type of questions;
- the quality of the questions
- the purpose of the question the teacher was posing.

Secondly, the dimension of creating an environment of respect and rapport consisted of five items. The items sought to identify the following:

- were learners talking to each other?
- were they discussing their solutions as groups?
- what actions and word were they saying to each other?
- what is the role of the teacher in terms of communication, scaffolding and facilitating the learning? and eventually,
- were the learners from each group communicating and explaining their solutions to the whole class?

Thirdly, a dimension on assessment which had three items was also there. The objective of this dimension items was to check on

- the purpose of assessment;
- whether the assessment was for grading or meant for understanding; and
- to identify the type of assessment the teacher used.

Fourthly, the resources dimension consisted of five items which were to check:

- the kind of resource;
- that the purpose of the resource was for investigation, problem-solving, conjecturing and so on;
- whether the resources were available to each learner;

- who directed the use of resources; and
- whether there was an inclusion of ICT.

Finally, the last dimension was that of mathematics concepts which had two items. The items were purposed to check on

- the correct usage of mathematical concepts; and
- the explanations by both the learners and or the teacher.

4.3.7.2 Lesson plan observation instrument

When reviewing the lesson plans, the analysis was also reviewed before and after the training based on the following key items: topic, time division, objectives, content teacher's activities, learners' activities and arrangement, resources, environment and assessment based on LPOI. The researcher used the LPOI to check on the items of the lesson plans and wrote comments on each item on the instruments. The purpose of 'the before' and 'the after training' were used to check if there was a change in teacher instructional practices after the PD. The comments were categorised and emerging themes were classified. Codes were used to categorise the emerging themes. The following is one example of how the lesson plans were analysed (a total of 9 for teacher 1 and 11 for teacher 2) (Figure 4.2).

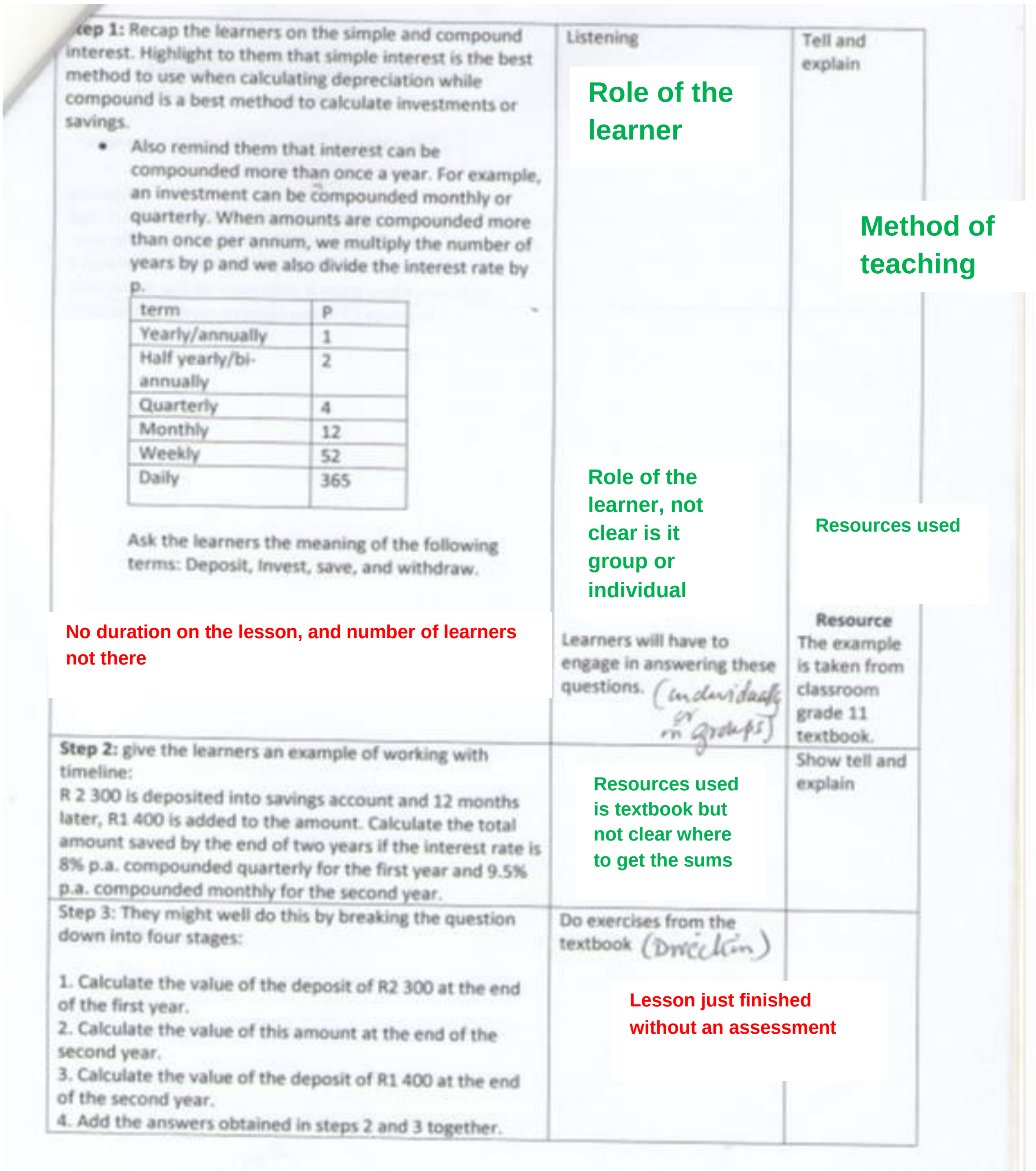
<table>
<tr>
<td>Step 1: Recap the learners on the simple and compound interest. Highlight to them that simple interest is the best method to use when calculating depreciation while compound is a best method to calculate investments or savings.
Also remind them that interest can be compounded more than once a year. For example, an investment can be compounded monthly or quarterly. When amounts are compounded more than once per annum, we multiply the number of years by p and we also divide the interest rate by p.
<table>
<tr><td>term</td><td>P</td></tr>
<tr><td>Yearly/annually</td><td>1</td></tr>
<tr><td>Half yearly/bi-annually</td><td>2</td></tr>
<tr><td>Quarterly</td><td>4</td></tr>
<tr><td>Monthly</td><td>12</td></tr>
<tr><td>Weekly</td><td>52</td></tr>
<tr><td>Daily</td><td>365</td></tr>
</table>

Ask the learners the meaning of the following terms: Deposit, Invest, save, and withdraw.</td>
<td>Listening

Learners will have to engage in answering these questions. (individually or in groups)</td>
<td>Tell and explain

Resource
The example is taken from classroom grade 11 textbook.</td>
</tr>
<tr>
<td>Step 2: give the learners an example of working with timeline:
R 2 300 is deposited into savings account and 12 months later, R1 400 is added to the amount. Calculate the total amount saved by the end of two years if the interest rate is 8% p.a. compounded quarterly for the first year and 9.5% p.a. compounded monthly for the second year.</td>
<td></td>
<td>Show tell and explain</td>
</tr>
<tr>
<td>Step 3: They might well do this by breaking the question down into four stages:

1. Calculate the value of the deposit of R2 300 at the end of the first year.
2. Calculate the value of this amount at the end of the second year.
3. Calculate the value of the deposit of R1 400 at the end of the second year.
4. Add the answers obtained in steps 2 and 3 together.</td>
<td>Do exercises from the textbook (Direction)</td>
<td></td>
</tr>
</table>

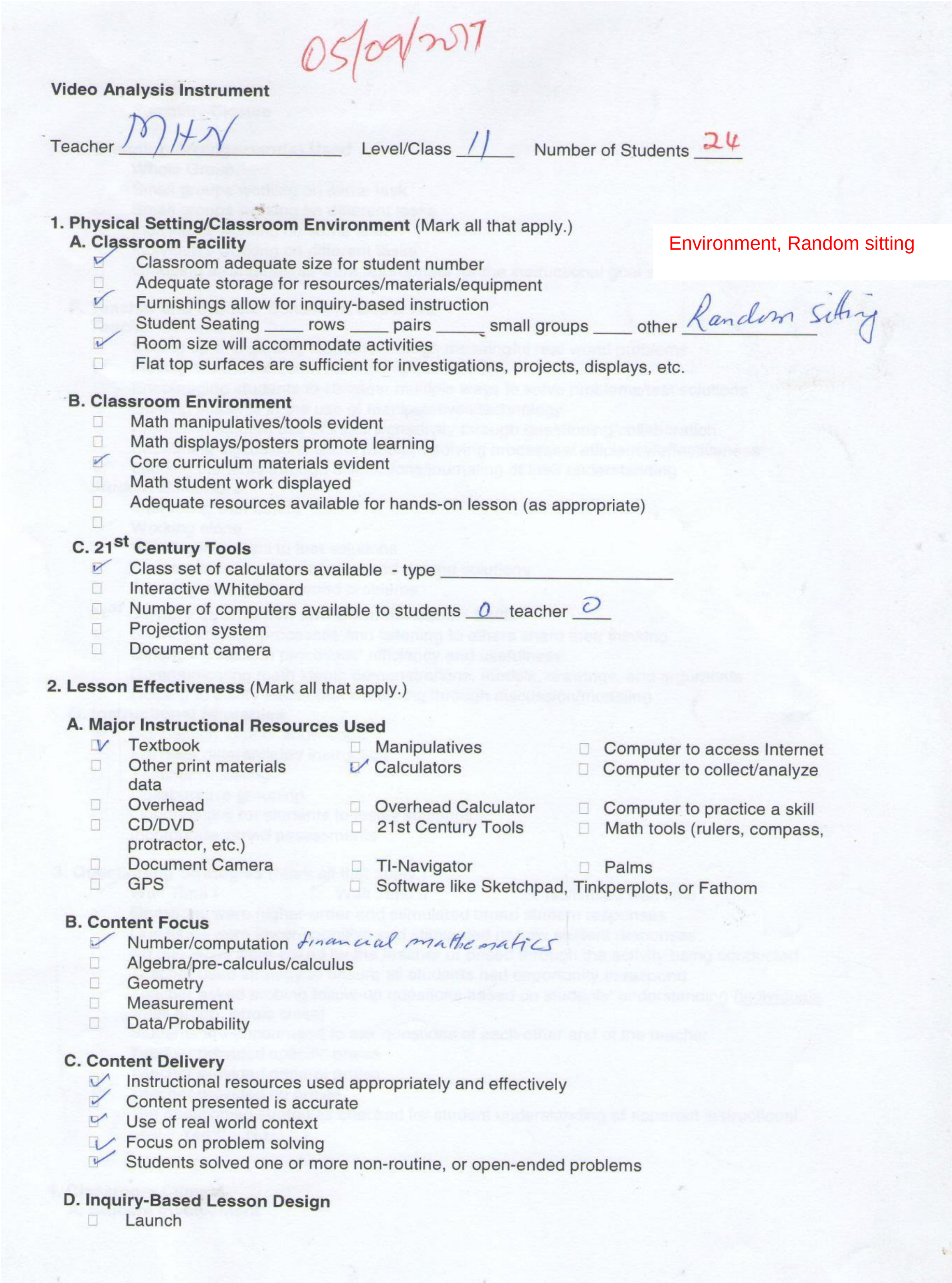


Step 1: Recap the learners on the simple and compound interest. Highlight to them that simple interest is the best method to use when calculating depreciation while compound is a best method to calculate investments or savings. • Also remind them that interest can be compounded more than once a year. For example, an investment can be compounded monthly or quarterly. When amounts are compounded more than once per annum, we multiply the number of years by p and we also divide the interest rate by p. term – p; Yearly/annually – 1; Half yearly/bi-annually – 2; Quarterly – 4; Monthly – 12; Weekly – 52; Daily – 365 Ask the learners the meaning of the following terms: Deposit, Invest, save, and withdraw.	Listening Learners will have to engage in answering these questions. (individuals or in groups)	Tell and explain Resource The example is taken from classroom grade 11 textbook.
Step 2: give the learners an example of working with timeline: R 2 300 is deposited into savings account and 12 months later, R1 400 is added to the amount. Calculate the total amount saved by the end of two years if the interest rate is 8% p.a. compounded quarterly for the first year and 9.5% p.a. compounded monthly for the second year.		Show tell and explain
Step 3: They might well do this by breaking the question down into four stages: 1. Calculate the value of the deposit of R2 300 at the end of the first year. 2. Calculate the value of this amount at the end of the second year. 3. Calculate the value of the deposit of R1 400 at the end of the second year. 4. Add the answers obtained in steps 2 and 3 together.	Do exercises from the textbook (Direction)	

Figure 4.2: *Example of lesson plan analysis*

4.3.7.3 Video recorder

The analysis was done by watching the video tape (at least two people) to avoid biasness, and matched to the RVAI to provide what actually transpired for every moment of the lesson. Video provides an open invitation to the researcher to look beyond spoken word and find meaning from other dimensions of participant activity. Further, add that the richness and complexity of video data often results in iterative cycles of analysis that include revisions to theoretical frameworks. The analysis was based on ticking items and sub-items that was observed as indicated on the RVAI that's follows. The findings were coded, categorised and themes emerged.



05/09/2017

Video Analysis Instrument

Teacher MHN Level/Class 11 Number of Students 24

1. Physical Setting/Classroom Environment (Mark all that apply.)

Environment, Random sitting

A. Classroom Facility

- ☑ Classroom adequate size for student number
- ☐ Adequate storage for resources/materials/equipment
- ☑ Furnishings allow for inquiry-based instruction
- ☐ Student Seating ____ rows ____ pairs ____ small groups ____ other Random sitting
- ☑ Room size will accommodate activities
- ☐ Flat top surfaces are sufficient for investigations, projects, displays, etc.

B. Classroom Environment

- ☐ Math manipulatives/tools evident
- ☐ Math displays/posters promote learning
- ☑ Core curriculum materials evident
- ☐ Math student work displayed
- ☐ Adequate resources available for hands-on lesson (as appropriate)
- ☐

C. 21st Century Tools

- ☑ Class set of calculators available - type ____
- ☐ Interactive Whiteboard
- ☐ Number of computers available to students 0 teacher 0
- ☐ Projection system
- ☐ Document camera

2. Lesson Effectiveness (Mark all that apply.)

A. Major Instructional Resources Used

- ☑ Textbook
- ☐ Manipulatives
- ☐ Computer to access Internet
- ☐ Other print materials
- ☑ Calculators
- ☐ Computer to collect/analyze data
- ☐ Overhead
- ☐ Overhead Calculator
- ☐ Computer to practice a skill
- ☐ CD/DVD
- ☐ 21st Century Tools
- ☐ Math tools (rulers, compass, protractor, etc.)
- ☐ Document Camera
- ☐ TI-Navigator
- ☐ Palms
- ☐ GPS
- ☐ Software like Sketchpad, Tinkerplots, or Fathom

B. Content Focus

- ☑ Number/computation financial mathematics
- ☐ Algebra/pre-calculus/calculus
- ☐ Geometry
- ☐ Measurement
- ☐ Data/Probability

C. Content Delivery

- ☑ Instructional resources used appropriately and effectively
- ☑ Content presented is accurate
- ☑ Use of real world context
- ☑ Focus on problem solving
- ☑ Students solved one or more non-routine, or open-ended problems

D. Inquiry-Based Lesson Design

- ☐ Launch

Figure 4.3: *Example of completed video analysis instrument*

4.3.7.4 Interviews

The reflective interviews were transcribed, coded using the codes described earlier, shown as excerpts, inductively analysed and interpretations were made. The description of interviews is made on section. For example the following representative interviews indicate how the other interviews were analysed by the codes after the transcription.

Researcher: E re naa, is the topic based on a problem? Let me ask, what was the problem? If there was no problem, is the topic based on the conjecture to be solved/

Teacher 1: Ae, there was no conjecture. **(No Conjecture [NC])**

Researcher: What was it?

Teacher 1: Hmmm, it was to, to check the, how can I put it? What separate the terms?

Researcher: What separate the terms? *(MHN is paging*) O seke wa ya ka moo (do not go that side), let's look at it, when we say a conjecture, we mean a general statement that we can see, Ok when this happens, we can see this. What was the general statement then?

Teacher 1: General? (Teacher not knowing the conjecture in mathematics, **WMC/E)**

Researcher: Statement that we want the learners at the end to get? Teacher 1: (silent)

Researcher: Ee, o wa mo kwa, akere wena (do you hear what he says) the lesson was planned by you. You know what is it that when I get out, I wanted that this generic things that the learners should get is this one.

Teacher 1: At the end ne ke nyako gore ba kgone go grouper or like for example if re nale something like this then re remaina le -1 4 time over eight ba kgone grouper and ba kgone go tseba that this have 1, 2, 3 wanted them for example **(WMC/E)**

Researcher: Was the time spread evenly to allow learner input? Is there time for group work, is there a time for individual learner?

4.3.7.5 Analytic framework for identifying teacher changes

The AFITC was analysed by looking at the criterion (tick and/ cross and explanation given) using the five dimensions with the 24 sub-dimensions which were drawn from the literature review. The three (3) teachers and the researcher discussed why they gave it a tick or a cross in order to resolve differences. In cases where the both the teachers and the researcher did not agree on the criterion, the researcher initiated discussion among all

teachers for the specific criterion. This type of analysis was derived from Pang (2012) which used this type in conjunction with video recorded. Repeating this process with three selected lessons [one per week] (as Pang, 2012 indicated) made teachers develop a better understanding of the criteria chosen. After reaching acceptable reliability, each teacher marked the correct choice with regard to each criterion while watching each teacher's videotaped lessons one by one with written transcripts. Since learners had to explain how they solved the problem in front of the class, their presentations were no longer limited to chorused or simple responses as those in the initial teaching practice. Note that these changes were not dramatic, but the path to such changes was consistently noticeable.

4.4 ETHICAL CONSIDERATIONS

Mouton (2004) indicates that ethical issues arise when people interact with each other and with other being like animals and the environment. Whenever human beings are the focus of investigation, one must look closely at the ethical implications of what is being proposed to be done. Education research focuses primarily on human beings (McMillan & Schumacher, 2014). This study focused on teachers and their practices. In this study, the following were observed: gaining access and acceptance in the research setting, informed consent, rights of respondent privacy, protection from harm and honesty with professional colleagues and criteria for trustworthiness (Cohen et al., 2011; Leedy & Ormrod, 2010).

4.4.1 Gaining Access and Acceptance in the Research Setting

For gaining access to the premises in the research setting, the researcher wrote a letter to inform and ask for permission from the DBE: the district director; the circuit manager, the chairperson of the SGB and the management of the school where the study took place. (See the attached letters of permission in the appendices). This is supported by Cohen et al. (2011) in stating that the first stage of ethics is the gaining of official permission to undertake one's research in the target community which, in the context of this study, are the teachers and learners.

4.4.2 Informed Consent

Informed consent is defined as the procedures in which individuals choose whether to participate in an investigation after being informed of facts that would likely to influence their decision (Cohen et al., 2011). The researcher fairly gave an explanation of the procedure to be followed and their purposes. A description of the attendant discomforts and risks reasonably to be expected (like being watched and video- recorded when teaching), a description of the benefits reasonably to be expected (exploration and

improvement of instructional practices), a disclosure of appropriate alternative procedures that might be advantageous to them and an instruction that the person was free to withdraw consent and to discontinue participation in the study at any time without prejudice to the participants were explained to the sample. The informed consent was particularly important since the participants might have been exposed to stress, invasion of their space or loss of control over what happened in their classroom (Cohen et al., 2011).

4.4.3 Matter of Privacy, Anonymity, and Confidentiality

On the matters of privacy, anonymity, and confidentiality, a written assurance to all the participants was given in advance about the confidentiality of the research; that their names would not be mentioned in the report but that codes would be used and that the results would be honestly made available to them before they were published. It addressed the issue of rights, honesty with professional colleagues, anonymity, privacy and protection from harm.

Further, in order to comply with and adhere to the University's Research Ethics Committee's policies and procedures, the research proposal was forwarded to the ethics committee for ethics clearance certificate before undertaking the study and the ethical clearance certificate was issued (Appendix A).

4.4.4 Criteria for Trustworthiness

The following verification procedures were used to build the trustworthiness in this study: prolonged engagement and persistent observation (three weeks); triangulation using multiple data collection instruments (COI, LPOI, RVAI and the AFITC); peer review and debriefing; reflection; clarification of researcher's bias; member checking; and rich/thick description (data transcription) (Lincoln & Guba, 1985).

In the development and implementation of the framework for EMIPs, a variety of techniques were employed to ensure credibility of data and data analysis and for obtaining and processing reliable information. Triangulation in order to seek multiple and comparative opinions about the same issue was another means of strengthening data collection and analysis. The type of triangulation used was methodological triangulation. According to Guion, Diehl and McDonald (2011), methodological triangulation is the triangulation which involves the use of multiple qualitative and/ or quantitative methods to study the programme. Data triangulation was employed by using multiples of data collection instruments: observations through COI, LPOI, RVAI, AFITC and interviews. Furthermore, the researcher planned to maintain confirmability by providing raw data that could be traced to original sources and by describing how the data were to be interpreted and placed into themes and categories as supported by Lincoln and Guba (1985).

4.5 THE DEVELOPMENT OF INSTRUMENTS

There are many instruments used for classroom observation and for many reasons as indicated on the next two sentences. Some instruments were designed for observing teaching practices, some for research, for development and so on. Most of the instruments were developed in Western countries. The instrument development in the study was guided and developed from the following frameworks:

- STAM framework (Gallagher et al., 1995);
- A Framework for Professional Practice -Danielson framework for professional practice (Danielson, 1996, 2013);
- ISTE Classroom Observation Tool (ICOT®, 2008);
- Mathematical Classroom Observation Protocol (National Center for Research in mathematics, 1992);
- Lesson Flow Classroom Observation Protocol; Teaching Practice Inventory (Wieman & Gilbert, 2014);
- Mathematics Questionnaire (National Survey of Science and Mathematics Education, 2000);
- Inside the classroom: teacher interview protocol (Horizon Research, 2000); and
- Teaching Dimension Observation Protocol (Hora & Ferrare, 2013).

4.5.1 Secondary Teacher Analysis Matrix

STAM is a framework and an instrument used for observation of teachers and principals to identify practices for science and mathematics subjects (Gallagher et al., 1995). There are two versions of STAM, one for mathematics and one for science. The STAM versions were developed by Gallagher et al. (1995) in the Michigan State University. The STAM is a constructivist observation tool that was first used during research conducted by the Salish I Research Collaborative. The study investigated the connection between pre-service preparation of science teachers, recommended science teaching practices, teacher practice and learner achievement. It was found that interaction with STAM observation rubric was influencing the PD of the novice teachers involved in the study in positive ways. According to Gallagher et al. (1995), the matrix was designed for use with secondary teachers, new to the profession, as well as experienced teachers attempting to improve their effectiveness.

In this study, the mathematics STAM version (with other frameworks that are explained below) is used in developing the framework and for the development for lesson planning and instruction with the focus on mathematics education. Wherever the acronym STAM is seen in the study, it refers to the mathematics version of STAM. The STAM helps in analysis of classroom activities and transitions. The STAM was used together with a video recorder to record the classroom activities from the beginning of the lesson until the end of the lesson. The STAM consists of 22 descriptors. This also prompted the use of video in the development and implementation of effective mathematics instructional.

The STAM focuses on mathematics content, the role played by teachers, the role played by learners (learners' activities), availability of resources, and classroom environment. STAM consist of rows which are numbered from 1-22 and six columns labelled A–F. Teaching styles are used as labels for the six columns. They are didactic, transitional, conceptual, early constructivist, experiences constructivist, and constructivist inquiry. Dimensions of what is going on in the classroom are used as labels for rows. There are 22 rows: (1) Structure of content; (2) Examples and connections; (3) Limits; exceptions; and multiple interpretations; (4) Processes and history of science/mathematics; (5) Methods; (6) Labs; demos; hands-on labs for science; hands-on; calculators; computers for mathematics; (7) Teacher-learner interactions about subject matter; (8) Teacher's questions focused on content; (9) Kinds of assessment; (10) Uses of assessment in addition to grading; (11) Teacher's responses to learners' ideas about subject matter; (12) Writing and other representations of ideas; (13) Learners' questions; (14) Learner versus learner interactions about subject matter; (15) Learner initiated activity; (16) Learners' understanding of teacher's expectations; (17) Richness of resources; (18) Uses of resources; (19) Access to resources; (20) Decision making; (21) Teaching aids; and (22) Learners' work displayed. Groups of rows are combined into areas labelled as follows: Rows 1–4 are combined into the area labelled, Content. Rows 5–11 are labelled Teacher Actions. Rows 12–16 are labelled Learner Actions. Rows 17–19 are labelled Resources. Rows 20–22 are labelled Environment. For this study, STAM is adopted using only the category of constructivist inquiry.

In this study, the following items of the STAM were adopted and augmented: teachers' actions and assessments (the focus was on teacher questions in the classroom, what kinds of assessment are employed), learners' actions (learner-learner interactions) and resources (accesses to resources) for the development and implementation of the EMIPs of the teachers. It should be noted that some of these items also appear in other frameworks and some sub-items were added. These were used in the development of the COI. For the lesson plan observation, the following items were taken from the STAM: Content, Assessment, Resources, and Resources.

4.5.2 Danielson Framework for Professional Practice

The Danielson Framework for Professional Practice (Danielson, 1996) is a constructivist framework for classroom practices, which provides guidelines on what a teacher does when teaching. This is useful in laying out the various areas of competence in which professional teachers need to develop expertise. The framework consists of four domains, which have 22 component activities. The domains are as follows: (1) planning and preparation; (2) the classroom environment; (3) instruction; and (4) professional responsibilities.

What interested me in Danielson's framework were the first and fourth domains – planning and preparation; and professional responsibilities although both the second and third were also important. Most protocols dwell much on classroom observation neglecting the initial part of the instructional practices lesson plan. The components in Domain 4 represent the wide range of a teacher's responsibilities outside the classroom like reflecting on teaching, maintaining accurate records, communicating with families, contributing to the school and district, growing and developing professionally, and showing professionalism. Teachers who demonstrate these competencies are highly valued by their colleagues and administrators, as well as being seen as true professionals. For my study, focus was on reflecting on teaching and growing and developing professionally as it formed part of the framework for effective instructional practices. Domains 2 and 3 have activities also found in STAM. The items on Danielson's (1996) framework were adopted and unified into the new instrument.

4.5.3 Mathematical Classroom Observation Protocol

Mathematical Classroom Observation Protocol is a constructivist classroom protocol that was created by the National Center for Research in Mathematics (1992), and further developed by Gleason, Livers and Zelkowski (2015) by adding a scale for academic language support for English Second Language (ESL) learners. The protocol works like a rubric. It has eight factors that it focuses on: Intellectual support; depth of knowledge and learner understanding; mathematical analysis; mathematics discourse and communication; learner engagement; academic language for ESL (which consists of two sub-factors: use of L1-home language and use of ESL scaffolding strategy); funds of knowledge/ culture/ community support; and use of critical knowledge/ social justice. Each factor is assessed on a five-point scale (1-5) where 1 is rated when there is no evidence of the factor and 5 is rated for strong occurrence of the factor. For this study, the items of communications and learner engagement were used with that of STAM and Danielson in the development of the COI.

4.5.4 The ISTE Classroom Observation Tool (ICOT®)

The ISTE Classroom Observation Tool (ICOT®) is a free online constructivist tool that provides a set of questions to guide classroom observations on a number of key components of technology integration (Schneidmiller, 2008). ICOT was developed by staff and consultants in the Education Leadership Department at the International Society for Technology in Education [ISTE] (2008) with support from Hewlett-Packard Company.

The instruments have the following criteria to look for during observation: room description and learner characteristics; learner groupings; teacher roles; learning activities, how essential was technology to the teaching and learning activities; technologies used by the teacher; technologies used by the learners; National Educational Technology Standards addressed; and a three-minute technology chart (Schneidmiller, 2008).

The ISTE Classroom Observational Protocol instrument was included in the study due to its inclusion of technological devices to move with current learning trends. It helps in tracking the use and relevance of technology throughout the lesson observation. The part on technology was included in the development of the COIs in this study though it was modified to avoid the three-minute technology chart and instead was used to check the use of technology during the whole lesson. The COI also included the constructs of room description; learner groupings; teacher roles; learning activities. Technologies used by the teacher were also included and helped in supplementing the ones from STAM, Danielson and the mathematics Classroom Observation Protocol.

The different instruments were not merely taken as is, because some omitted items that were on other instruments and because some instruments were very long. It is for this reason that very user-friendly instruments were developed based on the teaching model envisaged in the study.

4.6 PILOT THE STUDY

The pilot study was a trial run of the development and implementation of the EMIPs by collecting data using a small sample (one grade 8 teacher in another school) other than the sample of the study (Mertler & Charles, 2011). The pilot study enabled the researcher to assess the feasibility of a full-scale study, assessed whether the research instruments (COI, LPOI, RVAI, AFITC) were realistic and workable, determined the resources such as finance, staff were needed for the planned study, developed and collected preliminary data (Okeke & van Wyk, 2016). Further, the purpose of the pilot study was to avoid wasting time and money on the study and check whether there was potential for the study to succeed.

- Classroom Observation instrument

During the pilot study, the COI was administered. The instrument was used to observe the teacher teaching by recording what was observed in the classroom, based on the constructs on the instruments. The result of the pilot study indicated that there were gaps on the COI. The construct of learner’s questions was not observable. Due to learners’ background, and context, learners did not question the teacher. It was found that the construct of creating an environment of respect and rapport was important to manage relationships with learners and ensuring that relationships among learners were positive and supportive. This construct was aimed at identifying teacher interactions with learners, including both words and actions and was taken from the Danielson framework. This is because teacher's interactions with learners set the tone for the classroom (Danielson, 2013). Through their interactions, teachers convey what they are interested in and care about their learners. Learner interactions with other learners, including both words and actions were as important as the teacher's treatment of learners. How learners are treated by their classmates is arguably even more important (Danielson, 2013). At its worst, poor treatment causes learners to feel rejected by their peers. When the treatment is best, positive interactions among learners are mutually supportive and create an emotionally healthy classroom environment. Teachers not only model and teach learners how to engage in respectful interactions with one another but also acknowledge such interactions. Further, another construct of mathematics concept used by both the teacher and learners was added. This was prompted by the pilot study observations where the teacher used the wrong concept in the mathematics learning. One astonishing observation was that learners were taught that a number jumps the equal sign and changes the sign instead of additive inverse; and that they cancel out rather than dividing or multiplying inverse. This prompted the inclusion of the construct of correct mathematics concepts dimension on the classroom observation instrument.

- The analytic framework for identifying teacher changes

This instrument was found to be working well within the setting of the pilot study; hence it was not changed.

- The video analysis instrument

The purpose of piloting this instrument was to check whether it would capture exactly what transpired in the classroom including those issues that could be missed during taking of field notes, and to check on the visibility, reversibility and audibility during analyses. It was found to be compatible and hence no alterations were made.

- The lesson plan observation instrument

The LPOI was to check on the planned lesson and evaluate it. It was found to be working very well and was not altered. The video recorder and the audio-recording equipment were thus retained.

4.7 CHAPTER SUMMARY

This chapter outlined the research methodology, the paradigm used in the development and implementation of the framework of EMIPs, which guided the choice of the research design and the data collection through observation and interviews. Further, sampling and data analysis were explained. The chapter concluded by reviewing the history of other framework instruments and development of the instruments used in my study of a framework for the development and implementation of EMIPs, namely: LPOI, COI, RVAI and AFITC. The findings from the pilot study were also outlined to indicate why the refinement of the instruments was necessary, in some instances. The next chapter provides the details of the empirical investigation.

CHAPTER 5

DATA PRESENTATION, ANALYSIS AND DISCUSIONS

5.1 INTRODUCTION

The purpose of this qualitative case study was to develop and implement a framework of EMIPs. Anecdotal evidence indicates that a majority of teachers in schools enter into their classes with a textbook without lesson planning. If planning were there, it would be minimal or skeletal. Also, that they are generally using the old methods of teaching (didactic) which are at odds with current teaching reforms. The first objective was to establish mathematics teachers' current instructional practices before training and to record the lessons during the development and implementation process to culminate in what I call a framework of EMIPs. The development of the framework was based on observations (lesson plan observation and teaching observation), video recording and reflective interviews. The second was to capture what the literature says and link it to the findings in terms of EMIPs. The objective was to align the framework to these lessons and to document the framework's ability to reach the objectives and outcomes originally specified in Chapter 1. The data collected through lesson plan observation, classroom observation, video recording, interviews and the analytic framework for identifying teacher change instrument were used to answer the questions of this study. In doing so, the following research questions were answered:

- What are the current mathematics teachers' instructional practices?
- What is the framework of EMIPs?
- How does the development and implementation of effective mathematical instructional practices framework change teachers' instructional practices?
- What is the impact of effective mathematical instructional practices on learners' questioning skills and the teacher's instructional practices?
- How do EMIPs affect learners' resources choice and usage?

This chapter is organised into four sections. Section 5.1 is the introduction and section 5.2 through 5.4 presents the results of the study in the order of the research questions above. The results from the LPOI, the COI, reflective interviews, RVAI and lastly, AFITC on each research question are presented, analysed and discussed below.

5.2 BEFORE TRAINING

5.2.1 Presentation, Analysis and Discussion of Data

Data collected from various sources during the development and implementation of the framework of EMIPs were compiled and transcribed for presentation, analysis and discussion. The data analysis, presentation and discussions of this study were arranged into two sets: Before Training and After Training for each teacher about the framework of EMIPs. This is because the arrangement is according to the nature of the data collections instruments, namely, analysis and findings of each instrument before the training and after training. The codes TEACHER 1 and TEACHER 2 were assigned to Grade 11 teacher and Grade 10 teacher respectively for recording and analysis purposes.

5.2.1.1 Research Question 1: What are the mathematics teachers' current instructional practices?

To answer this question, the Before Training segment on the EMIP framework involved the administration of each instrument to each teacher. In this section, data collected through the use of each instrument is presented, analysed and discussed in the order: LPOI, the COI, reflective interviews, RVAI and lastly, AFITC. The organisation of the data presentation and discussions are provided below for each instrument for each teacher.

- Instrument 1: Lesson Plan Observation Instrument

The lesson plan instrument focused on the following: topic, time division, objectives, content, teacher's activities, learners' activities and arrangement, resources, environment and assessment. See the lesson plan instrument in Appendix L. The results from each teacher are as follows:

Teacher 1: Grade 11 mathematics

Description of the teacher's lesson plan observed:

The teacher had a lesson plan (See Appendix P) and the lesson plan was evaluated against the LPOI instrument (See Appendix L). Teacher 1's lesson plan had the following on it: Grade to which the lesson belongs – Grade 11, the content – Financial

Mathematics; the topic which was timelines and the objective of the lesson, namely, to solve problem using a timeline. In addition, there were skills and attitudes that the lesson plan envisaged developing in the learners. The following skills were envisioned: learners should be able to interpret statements and represent the given information in a timeline; learners should also understand that interest can be compounded more than once a year; learners should be able to use correct formulae and be able to convert. For example if the duration is 6 years compounded quarterly what might be the value of n? The following attitudes were also envisaged: the learner was to be responsible regarding money usage and was encouraged to invest in future. Further, there were teacher's activities, learners' activities and the teaching method on the lesson plan.

The lesson presentation as the teacher had planned under the teacher's activities, started with step 1 which was:

> "*the teacher recaps the learners on the simple and compound interest, highlights to the learners that simple interest is the best method to use when calculating depreciation while compound is the best method to calculate investments or savings*".

It was also planned that the teacher would remind learners that interest could be compounded more than once a year. During that activity, the planned roles of the learners were to listen only. Then the teacher would ask the learners the meaning of the following terms: deposit, invest, save and withdraw. It was envisaged that the learners' activity was to answer these questions. It was not indicated on the plan whether the learners were to answer individually, in pairs or in groups. Secondly, in step 2 the teacher planned to give learners an example of working with timeline as follows:

> *"R2 300 is deposited into savings account and 12 months later, R1 400 is added to the amount saved. Calculate the amount saved by the end of two years if the interest rate is 8% p.a. compounded monthly for the second year".*

It was not apparent what the role of the learners would be when the teacher gave giving this example since it was left blank on the plan. In step 3, it was indicated that the learners might well do examples by breaking the question down into four stages:

- Calculate the value of the deposit of R 2 300 at the end of the first year.
- Calculate the value of this amount at the end of the second year.
- Calculate the value of the deposit of R1 400 at the end of the second year.
- Add the answers obtained in steps 2 and 3 together.

Opposite the teacher's activity, it planned was that learners would do exercises from the textbook. It should be noted that there was no clear direction on which page the learners would find the exercises or the number of exercises to be done.

Observations from the LPOI

The LPOI (see Appendix L) was intended to check the following: topic, time division, objectives, content, teacher's activities, learners' activities and arrangement, resources, environment and assessment. The observations for Teacher 1 are as follows:

Topic

On the topic, the main focus of the instrument was to check whether, on the teacher's lesson plan, the topic was based on the problem to be solved or conjecture or an investigation. Furthermore, on the instrument under the topic, it sought to check whether there was a chance of formulating a conjecture or general rule or investigation. It emerged that the topic was just chosen, because, it was there in the programme given by the DBE as a pace setter. The teacher did not identify the problem that he could pose or a conjecture that learners could formulate or investigate. It appeared that the teacher aimed at teaching the concept by means of algorithms. The teacher indicated that he would recap and from recapping give an example to learners which in turn the learners were to solve.

Time division

The instrument provided for duration of the lesson on the plan in order to identify the time spread for the whole lesson and whether it allowed for learners' input. In addition, it was to check whether there was individual time or pair time or group work time as envisaged by effective mathematic instructional practices. On the lesson plan, no time or a time spread for the activities was indicated. The planning was inconsistent with what EMIPs prescribed.

Objectives

The EMIPs outlines that the objective of a lesson should be based on either an investigation or conjecturing or formulating a general rule or solving a problem and that it should arise from the previous lesson. The teacher's plan did not address any of the basic objectives. The teacher's objectives were that learners should be able to interpret statements and represent the given information on timelines, understand that an interest rate can be compounded more than once a year and be able to convert the duration. It was not clear how the teacher was going to measure learners' understanding and what were learners supposed to convert.

Teacher's activities

When completing the instrument, it was noted that the lesson plan did not have the following on it: prior knowledge, duration, number of activities, resources and core concepts to be covered. It was also found that the only method of teaching envisaged by this teacher's lesson plan was telling and explaining method throughout the lesson. The teacher aimed at dominating the lesson, whether intentionally or unintentionally. The EMIPs describes the role of the teacher as either the facilitator, or investigation guider and/ or the teacher's activities should be question-dependent. In addition, the teacher should allow learners to communicate their solutions during the learning process and the teacher's activities should include assessments which were neglected by this plan. The teacher did not identify the problem that he could pose or a conjecture that learners were to formulate and/ or investigate.

Learners' activities

The EMIPs as envisioned indicate learners' activities as: cooperatively learning, individuals working alone and with others, conceptual, applied to investigation, and communicating amongst themselves about the solution processes. On the plan the role of the learners was just to listen as indicated. Further, they were to answer questions. It was not clear or stated whether this should be done individually, in pairs or in a group. It was not also indicated whether learners would be writing or not.

Resources

The focus of the resources was to identify who had authority on the choice of resources, whether the resources were relevant to the problem/ conjecturing / investigation, whether multiple resources should be used and whether ICT was included. It was observed on the lesson plan that the only resources used were the usual ones (chalk, chalkboard, duster and textbook) by the teacher. It was noted that even the textbook was not correctly used since the teacher just indicated that learners do exercises in the textbook and there was no page number, exercise numbers and any other relevant information.

Environment

This section seeks to identify whether the environment caters for learning; for investigation/ conjecturing/ problem-solving; and whether there is enough space for discussion amongst learners. It was noted that there was no problem posed to learners to be solved, no conjecturing and/ or investigation from the lesson plan. There was nowhere were the teacher planned to create a space for learners to discuss their processes to the solution. This emerged after the teacher planned to teach an example to learners and then the learners repeat the work using the same example. This indicated that the teacher that the learners should reproduce exactly what they were taught, which translated into the fact that he planned to teach algorithms.

Assessment

The purpose of the construct of the assessment on the LPOI instrument was to identify the following: whether assessment was included in the whole lesson; whether assessment was continuous and based on investigation or problem-solving or conjecturing; whether there were multiple forms of assessment used; and whether the purpose of assessment was for planning the lesson or for instructional purposes. It was observed that there was assessment planned to be given to learners although it was not clear on which page the assessment was found and what exactly the learners would be doing. There was only one form of assessment envisioned by the teacher instead of continuous assessment as proposed by EMIPs.

Basing on the construct of the LPOI, it was evident that the teacher's planning was inconsistent with the EMIPs. Of note, was that this teacher was not concerned about the learners' prior knowledge in order to build new knowledge as stipulated by EMIPs. For the fact that this teacher was not able to demarcate the time for teacher and learners' activities which shows that the planning was at odds with current teaching reforms, CAPS and still conformed to traditional teaching methods.

TEACHER 2: Grade 10 mathematics

Description of the lesson plan

The teacher had a lesson plan as indicated on Appendix P. The lesson plan had spaces provided for grade, topic, subtopic, date, prior knowledge, duration, teacher's activity, learners' activities, assessment activities and resources. On the grade space, Grade 9 was written; the topics envisaged on the lesson plan were functions and relationships, algebraic expressions and equations, graphs, surface areas and volumes. Under the column for teacher's activity there were the following: revise examples of functions, linear and parabola; revise algebraic expressions (terms, coefficient, constants and substitutes, expand and simplify, factorise, common factors and trinomials); and surface areas and volumes. The learners' activities were as follows: learners listen to the teacher. It was also observed that under the resources column, the following were written: chalk, chalkboard, duster, Grade 9 platinum textbook and Siyavula textbook.

Observations from LPOI

Topic

On the topic, functions and relationships, algebraic expressions, graphs, surface areas and volumes were indicated. The topic was very broad. It was not clear whether the teacher was mixing different topics. Although it was not the focus of the LPOI (See Appendix L), an error on the lesson plan was that Grade 9 was indicated, when he was teaching Grade 10. By writing Grade 9 while planning to teach grade 10, the teacher indicated that he may have not correctly chosen the relevant grade topic, or that he had done proper planning but it seemd that he had instead used cutting and pasting because the plan was computerised. Under the subtopic, nothing was written.

Date

The space for the date was blank. The lesson plan did not indicate whether it was planned for a one period or days or weeks or when was it going to be presented.

Duration

There was no duration or time spread on the lesson plan although spaces were provided for this. It was difficult to identify how long each activity would last or the duration of the lesson itself. This indicated that the lesson plan did not show the time spread for each activity that was to be presented as envisioned by EMIP. The importance of duration or time spread is to divide the total duration into manageable time intervals for each of the activities, which were not indicated.

Prior knowledge

The space under prior knowledge was not completed. Prior knowledge is important to every lesson in the sense that it links the previous knowledge with the current knowledge to be taught, or the existing knowledge in learners which needs to be linked to or altered to conform to the current knowledge.

Teacher's Activities

It was planned that the teacher would revise examples of functions, linear and parabola; algebraic expressions (terms, coefficient, constant and substitute, expand and simplify; factorise, common factors and trinomials); and surface areas and volumes. However, the plan did not have the following on it: number of activities and core concepts to be covered. It was indicated that the role of the teacher on the first activity was to revise. A good planned lesson should indicate the role of the teacher and corresponding to the role of the teacher, there should be the learners' activities. On the second activity, only surface areas and volumes were indicated. It was not indicated what the teacher would be doing in tems of surface areas and volumes. Further, the teacher activities were not clear. For example, it was found that one of the teacher activities was as follows: surface area of prisms (triangular prism, square prism/cube, cylinder and rectangular prism) and volume of prism (area of base x height). Hence this was not regarded as an activity.

Learners' activities

It was observed that on the learners' activity, the only activity that the learners would be doing was to listen to the teacher. This brought the idea that the only method of teaching envisaged by this lesson plan was the telling and explaining method since learners were only to listen to the teacher. The role of the learners was to listen and write down notes, watch the teacher (demonstrating), and copy the example in their scribbler books. EMIPs compel teachers encourages learners to solve problems in a way that is meaningful to them and to explain how they solved the problem (Grouws, 2004; Shellard & Moyer, 2002). This aspect was neglected by the teacher.

Assessment

The teacher left the assessment part blank. So, it seemed that the teacher planned the lesson which did not have an assessment either intentionally or unintentionally. This was at odds with any previous or current teaching and learning reforms, let alone the EMIPs. The findings from LPOI for both teachers are summarised as follows in Table 5.1.

Table 5.1:

LPOI construct summary table for the two teachers' lesson plans

LPOI construct	**Teacher 1**	**Teacher 2**
Grade	Grade 11 and was correct	Grade 9 was incorrect since he was in Grade 10
Topic	Financial Mathematics and the subtopic was timelines	Functions and relationships, algebraic expression and equation, graphs, surface areas and volumes. There was no subtopic
Time division / Duration	Not available	Not indicated
Objectives	Available	Not available
Content	Available	Not Available
Prior Knowledge/ Introduction	Not available	Space available but not completed
Teacher's activities	Available but not clear as they were indicated as steps	Available as revision but no current topic activities

LPOI construct	Teacher 1	Teacher 2
Learners' activities and arrangement	Available as listening and repeating the example	Space available but not completed
Resources	Not available	Available but two different grades textbooks for Grade 9 and Grade 10
Environment	Not planned	No planned environment
Assessment	Available	Space not completed

The table indicates that both teachers planned for the sake of availability, not to help the teaching and learning. Very important but neglected constructs were that of the duration or time spread, prior knowledge, environment and assessment. The EMIPs framework stresses the issue of planning for teaching, learning and assessment which should always be linked but, in this case, they were not really planned as required. EMIPs stresses that learners should be able to communicate, solve problems or conjecture. These aspects were neglected by both teachers.

5.2.2 Instrument 2: Classroom Observation Instrument

The COI was focused on the following: teacher's questions in the classroom, creating an environment of respect and rapport, assessment, resources, and mathematics concepts as explained in detail in Chapter 4. It was complemented by the video recorder to triangulate and capture other aspects that the COI could have missed.

Teacher 1

Lesson Description

The teacher entered the class with a duster, chalks and a textbook. He also had a lesson plan on two sheets of paper. He greeted the learners in Sepedi "Dumelang" and, without waiting for learners' response, he continued with the lesson presentation by saying *"…if I remember very well, last time we did, ehh, simple and compound, akere (is it not)?, I am just repeating for you for what we did last time, simple and, and ehh, compound. So, I just want you to find the link between the two akere (is it not) and the last time we said that these two they use them to calculate ehh, the future values, that if you…".* The teacher continued with his presentation which did not follow the lesson plan. Although he wanted to differentiate which method between simple interest and compound interest is best for calculating the depreciation of an object and which is best for investment as planned, he could not achieve this because learners found it difficult to identify which objects were depreciating. This was because the teacher's introduction did not follow the plan. It was planned that the first step was to recap simple interest and compound interest, remind learners that interest could be compounded more than once a year and ask the learners the meaning of the terms: deposit, invest, save and withdrawal. During the presentation, the teacher started by asking which objects were depreciating and which were not. Learners struggled to identify or differentiate the objects and to explain why objects depreciated. The teacher gave a car as an example of a depreciating object and wanted learners to give another example. One learner mentioned a house and there was support from other learners that a house depreciated in value. Trying to indicate that a house is not a depreciating asset like a car, the teacher introduced the term 'invest' by asking *"when you buy a house do you invest or what and when buying a car do you invest or what?"* Learners were confused and indicated that a house loses value in terms of money.

The following discussion shows that there was confusion about how depreciating objects are identified. Eventually the teacher indicated that the inflation rate affected changes in price. He asked learners whether the price of bricks which are the building blocks of a house remained the same. One learner, in response to the teacher, indicated that the parts which are the building blocks of cars do not remain the same and the price of cars is affected by inflation. The teacher could not follow up to solve the learners' problem of how to identify depreciating objects; instead, he said the object's value depreciated according to the interest rate. By saying that, he confused the learners further. Furthermore, he asked another question seeking to identify which method was best for investment. The learners chose both simple and compound interest. He wanted to know their reasoning for their choices. The rest of the lesson was spent trying to identify which one was best for investment. So, the lesson ended up with two unresolved questions: how to identify depreciating objects and which method is best for investment. In the same lesson, there were some incorrect mathematics concepts that were used by both the teacher and the learners. There was no assessment as indicated by the plan.

Observation from COI and Video Recorder

It was noted was that the teacher did not take into consideration the construction of knowledge by the learners. For example, the COI indicated that the teacher did not scaffold understanding to the learners when they could not identify which objects depreciated and which did not. The teacher could not deal with learners' problem. It also emerged that both the teacher and the learners used wrong mathematical concepts or explanations. Adding to that, the presentation was inconsistent with the lesson plan. Throughout the lesson, this teacher used home language (Sepedi) in the teaching and learning which is problematic for learners in terms of assessment. From the video recordings and the COI for the classroom presentation of the lesson by the teacher, the following themes were identified: teacher dominated the talking; teacher was not sure about the content; chorus response by learners dominated the lesson; no coherence in questioning or the questioning did not help the learner to identify the link or objects which depreciated; and there was no group work/ cooperative learning/ collaborative learning. The teacher mostly used wrong mathematics concepts or explanation. The themes are discussed below:

Teacher dominating the talking

The teacher took almost 25 minutes of the period demonstrating and explaining. The following excerpt indicates the teacher dominating:

TEACHER 1: Yeah! Ke yona nthwe re be go re bolela ka yona re re simple e no swana le a straight-line depreciation (Yeah! That is the thing we are speaking about saying simple interest it is like a straight-line depreciation). Ra ba ra draw graph go go laetša gore ke straight line (We even draw a graph to show that it is a straight line). E ra gore e depreciator at a what (It means it depreciates at what)? At constant amount. For this one, we said, let's compare them (he draws a table for comparison). Gore ka mo e yo ba simple ka mo compound (it means that side is simple and that other side is compound). Again we said after 3 years, now ntho ye re e boletšeng mo ke gore (what we said here), which means we are selling the what? The car after 3 years, akere (is it not)? And then, re boletše ra re (then we said that) the depreciation interest rate ke bokae(is how much)? 8% and then re boletše rare ge re bolela ka (we said that when we speak about) depreciation re bolela ka eng (what are we talking about)? Go ra gore e dirang (this means what happens)? E ya

fokotšega akere (It is decreasing is it not)? So now let's us use the formula for simple interest $A = P(1 + in)$, Oh, now because we are talking about depreciation the middle sign e yoba (it becomes negative) minus, $A = P(1 - in)$. Now ka mo (this side) ehh, $A = P(1 - i)^n$. Okay, now let's check here, ka na ba go boditše gore (by the way you are told) you bought this car ka bo kae (how much)? R150 000.Akere (is it not)? And ge o ka hwetša karabo ya gago e feta R15000 mola re bolela ka depreciation (if you find your answer being greater than R150000 while we are talking about depreciation), go ra gore (it means) you did some miscalculation. Go ra gore koloi e wele eng (it means a car lost what)? E wele value (its value decreased). Go ra gore tšhelete yo ba (it means its money will be) less than present amount. So, ehh yoba (ehh, it will be) if we can write the data, we have what, this will be your principle amount (*pointing at R150000*) and this will be your what the interest rate (*pointing at 8%)* which is your I and your n is 3, go ra gore roba le(it means there will be) (*substituting on the simple interest formula*)

$$A = P(1 - in)$$
$$A = 150000(1 - 0.008x3)$$
$$A = R114000.00$$

Now for this one, go ra go re mo ro ba le (it means here we are going to count) R150 000 and then 1 minus , value ya and as we have said that interest rate we always do what with the interest rate. We always do what, we divide by 100, what is the value of, 8 over what 100 which is 0,08 over and then eh, there is something, so here they never said the depreciation is compounded monthly or what, so our depreciation is per annum, so gora gore (so it means) it is 0,08 over 1. So the answer is R114 000

$$A = P(1 - i)^n$$
$$A = 150000(1 - 0.008)^3$$
$$A = R116803$$

So, a re tle ka mo (When coming here), P = R15 000 in to 1 – 0.08 over 1 close brackets and n = 3 (*substituting on the compound formula*). Because it is per annum go no ra go re re divider ka one (it means we divide by one). So, the answer is R116 803.

So at the end go ra go re (it means), ehh, option 1 (*pointing at simple interest formula*) ehh go ra go re e depreciatang ka kudu ke efe (so which one is depreciating too much)?

All: Simple

While the teacher talked alone for 25 minutes and wrote on the chalkboard, learners sat silently watching him. Learners were passively looking at the teacher and were not engaged. The teacher was explaining and questioning learners without even waiting to hear if they were ready to try to answer. This was at odds with the key features of EMIPs. What also interested me was that the teacher's lesson was aimed at timelines; but he spent the whole period focusing on the difference between simple interest and compound interest depreciation which were apparently the lesson's prior knowledge since he claimed they did that lesson the previous week. The teacher talking so much is inconsistent with EMIPs. According to Woods and Sellers (1997), effective mathematics teaching should be based on a problem to be solved or conjecturing, which was not done by this teacher.

Teacher not sure about the content:

It again emerged that the teacher was not sure about the content.

A question was as follows:

"A car which has a price value of R150 000 depreciates by 8% for a period of 3 years. Calculate the cost of the car after three years if the depreciation is calculated on (a) a straight line, (b) on a reducing balance, (c) what is the value of the car after 3 years on a straight line and on a reducing balance"

The following solutions were written on the chalk board:

$A = P(1 - in)$

(a) $A = 150000(1 - 0.008\,x3)$ **straight line depreciation**

$A = R114000\ .00$

$A = P(1 - i)^n$

(b) $A = 150000(1 - 0.008)^3$ **reducing balance depreciation**

$A = R116803$

(c) For simple: the value of the car is 150 000- 114 000= R36000 and
for reducing balance: the value of the car is R150 000-116803= R33 197

From the excerpt, the teacher asked the learners how much the value of the car after 3 years on a simple and on a compound depreciation would be. Both the teacher and the learners took the principal amount and subtracted the value of A after 3 years and got R36 000 for simple interest and R33 197 for compound interest as the values of the car using different methods. Instead of saying the car depreciated by R36 000 and R33 197 respectively, they said the value of the car was R36 000 for simple interest and R33 197 for compound interest. That was an incorrect explanation/ use of concept (WMC). Apart from that, the teacher did not use correct prior knowledge or introduce the topic based on the prior knowledge correctly in order to lead into the objectives or topic of the day. That showed that the teacher‘s content was wrong. A knowledgeable teacher should identify proper prior knowledge and anticipate the possible misconceptions that learners might encounter and how to deal with them. It is possible that learners could have been challenged with regard to prior knowledge, especially if the concept had been done the previous year. If this was the case, it might have led to the teach clarifying the concept and taking more time. But, in this case, it had been done the previous week according to what the teacher said. It therefore suggested that this teacher might have not taught the previous topic well.

No coherence in question or the questioning did not help the learner

It was noted that, the teacher was asking questions that were not helping the learner to understand which objects depreciated and which ones did not. Instead he further complicated the matter by asking about investment. The teacher asked about objects which depreciate and gave an example of a car. He then requested learners to give examples of other depreciating objects. The following excerpt indicates the confusion:

TEACHER 1: Eh, dilo tša go depreciator, dilo tša go swana le dikoloi akere, dilo tša go swana le dikoloi dia depreciator, tša go swana le eng gape Aletta? (Eh, depreciating objects, things like a car is it not, objects like car are depreciating, what else Aletta?)

Aletta: Ntlo (House)

TEACHER 1: Le ntlo (Even a house)? Ntlo e ya depreciator (Is a house depreciating?)? Ya depreciator Felicia (Is depreiating Felicia)? Wa mo supporter Lincoln (Are you supporting Lincoln)?

Lincoln: (silent)

TEACHER 1: Kganthe ge o reka ntlo wa investor or eng, Lincoln (By the way when buying a house are you investing or what Lincoln)? Let's just take a simple example. O reka ntlo ngwago ka bokae (You buy a house let's say how much)?, ehh let's just put ka R800 000 akere (Let us suppose we put R800 000, is it not)?, therefore after ehh, if o rekile R800 000, after ehh, 4years, ge o rekiša, o rekiša ka eng the less price or what (If you bought it R800 000, after eh 4year, when selling it, how are you going to sell it, less price or what)? E swana le eng (It is same to), Same thing applies to the car. O reka koloi ka R800 000, after 4years yo so lekana ka the price? Difference ke eng mo? (What is the difference?) Pauline!

From the teacher's question, the learner Aletta answered that a "house" depreciates. Instead of the teacher scaffolding from her answer, he asked who supported her. There was another learner who supported her. Then the teacher asked whether, when you are buying a house, are you investing or what? The point was that learners were not able to identify depreciating objects and why they depreciate and why others do not depreciate. The teacher should have explained which object depreciate and why they do so. Instead, the term investment was introduced by the teacher which then moved away from identifying depreciating objects. This amounted to non-coherence in asking questions. In this instance, the teacher here missed one characteristic of EMIPs – teaching for understanding (IOWA DoE, 2011) and supporting learners in acquiring new mathematics facts (NETAC, 2010).

The teacher was asking low order and rhetoric questions

The teacher asked low-order questions like "Akere?" ("is it not?"), "you do what?" and or "like what? (See T1LP1, Line1-Line25 on the appendices). When the learners did not respond, the teacher answered the question himself. The questioning did not serve any purpose, because it was not checking on learners' understanding of the concept or challenging learners' thinking but was rhetorical. If they did not answer the question, the teacher carried on without worrying about the understanding of the learners. Sometimes he was just making up questions that did need to be answered, like "you are given what? R150 000…" Asking low-order questions means the teacher was using a didactic approach which is inconsistent with EMIPs. According to NCTM (2014), EMIPs should include tasks that promote reasoning and problem-solving and should pose purposeful questions.

There was no inclusion of ICT:

The following excerpt indicates the resources which were used:

Researcher: It was based on the conjecture. What kinds of resources were present in there?
Teacher 1: chalk and duster
Researcher: chalk and duster
Teacher 2: ahh…

It emerged that the teacher relied mostly on only chalk and duster. Although the school had 6 laptops and a projector and the teacher had his own laptop; there was no time where the teacher used any of these resources in order to help learners to identify differences, especially in differentiating between simple depreciation and compound depreciation. These gadgets could be used to quickly differentiate between simple and compound growth and depreciation using tables and graphs. The projector could also show the tables and the graphs more quickly than writing on the board or talking since there is plenty of software to be used in mathematics; for example, A&G grapher.

Teacher 2

Lesson Presentation Description

The teacher entered the classroom with a duster, chalks, a laptop, textbook and a single-page lesson plan. He started the lesson by writing the topic functions and relationships on the chalkboard and proceeded by reflecting back on what they had done previously: functions, algebraic expression, algebraic equations and surface area. He wrote this example of functions: $y = mx + c$ and asked what type of a function it was: linear or parabola? Learners responded in a chorus saying it was a linear function. The teacher here integrated the previous lesson with the current lesson although on the lesson plan, it was not indicated on the prior knowledge section. The introduction was coherent although it did not give individual learners or pairs or group the opportunity to answer questions posed.

From the observations of the COI and video recording for teacher 2, the following themes emerged: teacher dominating the talking; chorus response by learners; home language usage by both teacher and learners other than LoLT; unproductive and no follow-up questioning; wrong mathematics concept or explanations.

Teacher dominating the talking:

It was noticed that this teacher also dominated the talking in the classroom.

TEACHER 2: Alright this is zero and two, alright now. Mo re swanetše ro chooser gore (here we are to choose) which one is number two or which one is number one. Gore o dire bophelo bo be bonolo e re tše tša ka go left e be one and on the right e be number two (To make life easier we take the left be 1 and 2). So go ra gore ro kgetha tšeo e bago x_1 and y_1 to be (-5;0) and (2,0) to be x_2 and y_2. So 2 minus 0 is two and Zero minus minus 5 is positive 5 so the value of m is $\frac{2}{5}$. So in our equation y=mx +C we got m and we are looking for the value of C. Now if we look at this mo re nale y and x and I told you something about this more especially ge re e tla mo finding the value of C. ro e kereya bjang C ya rena? Surprise, how do we get our C. Sthango, how do we get our C? Ro kgetha coordinate. We choose one coordinate yeo ele go gore re tlo substitute x and y. ge re lebelela mo a gona le y_2 le x1 it is just y and x which is a coordinates. Go ra gore we are going to substitute x and y on the following: $y = \frac{2}{5}x + C$. We choose between the two, which one do you choose?

All: the first one (-5,0)

The observations indicated that the teacher dominated the talking. Although he took 10 minutes talking and explaining facing the chalkboard, he did not take note of whether learners were looking at him, understanding and or doing the exercise with him while demonstrating. The teacher dominated the whole lesson. There was no time allocated for group work/ cooperative learning or collaboration amongst the learners or questioning that challenged the learners to give answers. The questions were just posed and not answered, and he continued demonstrating. There was somewhere where the teacher requested learners to find the value of *y*. The following figure indicates that learners were working individually.

TEACHER 2: Ke (it is) y and then for 16 we are going to substitute y not x, akere (is it not)? So, can you quickly find the value of y here the output and the value of x as the input here? (*All learners are writing and the teacher is moving from desk to desk around without a say. Learners were individually substituting 16 in to y and finding the value of x. the following figure is a representative of one of the learners solving.)*

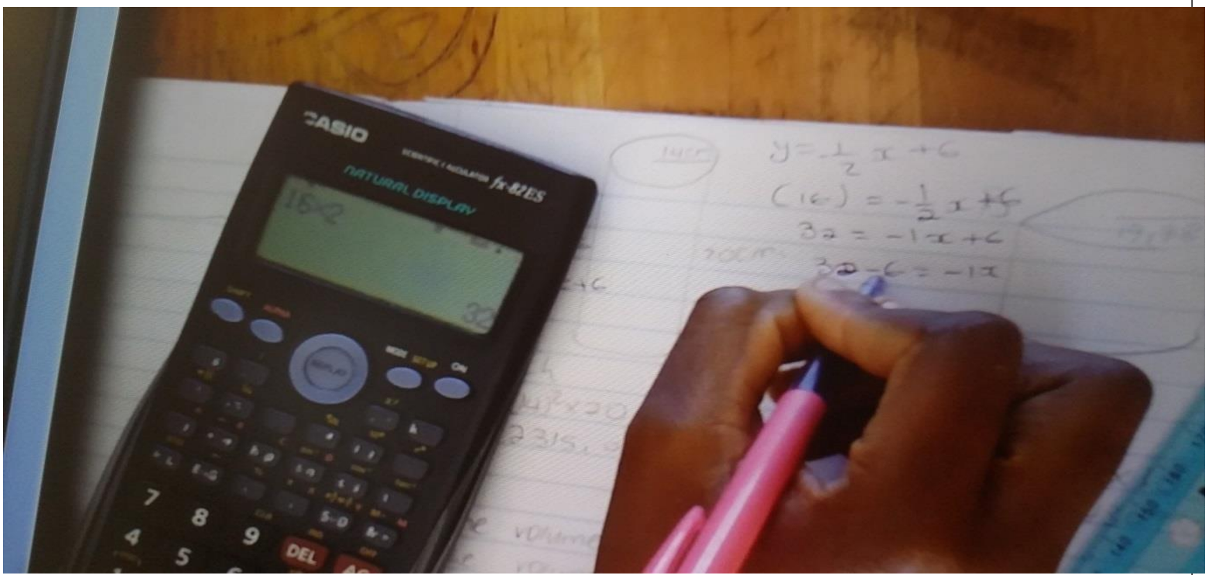


Figure 5.1: *Individual learner solving the value of x by substituting y as 16.*

TEACHER 2: Are you done. Let me see by raising hands for those who are done. And then the rest, le stagile.

It was noted that this teacher did not rely on learners answering questions in pairs or groups. He was still encouraging competition among the learners. By asking learners who were done to raise their hands, it shows that he was considering those few to continue with. The teacher should have facilitated meaningful mathematical discourse as indicated by the NCTM (2014) as one of the EMIPs

Chorus response by learners

In all the responses given by the learners, chorus responses dominated the answering of questions.

TEACHER 2: y2 minus y1 over x2 minus x1. So what did I say about y2 minus y1 over x2 minus x1 especially ge re etla gona mo?(when we are at this point)

Learner: We put the values of X and Y

TEACHER 2: Re nyakang? (what are we looking for?) Ro kgetha dicoordinates (We are going to choose the coordinates), that coordinates we must write them, ro ngwala di value tšela bjalo ka dicoordinates (We are going to write those values as coordinates). Mo(here) we have got -5 and 2 and in terms of coordinates we have

All: (-5;0) and (2,0)

TEACHER 2: Alright tša mo tšona (for this point then)?

ALL: Zero and two

TEACHER 2: 2; 0.

All: Zero and two

The excerpt indicates that instead of the teacher asking learners how to calculate gradient of a line, he was explaining the process. While the teacher was teaching the algorithm, he posed some questions which all learners answered in a chorus. Chorus responses do not give the teacher an opportunity to identify the individual learners' engagement with his teaching. In addition, the teacher could not identify learners who did not answer or understand his teaching at that time. This was inconsistent with EMIPs because the teacher was supposed to elicit and use evidence of learner thinking (NCTM, 2014) during his teaching by making sure that individual learners provided answers. Further, this could foster active and critical learning as one principle of CAPS (DBE, 2011).

Home language usage other than LoLT

The following excerpt indicates the observation that the teacher and learners used more of the home language than the language of teaching and learning:

TEACHER 2: … Alright this is zero and two, alright now. Mo re swanetše ro chooser gore (here we are to choose) which one is number two or which one is number one. Gore o dire bophelo bo be bonolo e re tše tša ka go left e be one and on the right e be number two (To make life easier we take the left be 1 and 2). So go ra gore ro kgetha tšeo e bago x_1 and y_1 to be (-5;0) and (2,0) to be x_2 and y_2…………

Learner 1: Mo ke itše 16 times 2 ka hwetša 32 mo ka re 6 time two ka hwetša 12. Ke moka -1 time x ka hwetša –x. ka ngwala ka mokgwa woo) (Here I said 16 times 2 and got 32. Then -1 times x and got –x. I wrote like this) (pointing to step 2)

Both the teacher and learners were using the home language (Sepedi) more than the LoLT (English). Although in the excerpt it seems that it is the teacher who used the home language, it should be noted that from the whole lesson that was presented (See T2LP1), the responses of the learners were also in Sepedi. There is no problem with code switching when teaching, especially for a concept that seems difficult to explain to learners but teaching the whole concept mostly in Sepedi inconveniences the learners because they do not get used to the terminology in LoLT and how to respond to questions during tests and examinations or even to present their ideas in the LoLT. Learners were unable to use and connect mathematical representations (NCTM, 2014).

Wrong Mathematics Concept or Explanation

The learners used or explained mathematical concepts wrongly. The following indicates the wrong use or explanation of mathematical concepts:

TEACHER 2: What should happen next? We move ‘re raka’ (we chase) 6 it changes the sign when it jumps the equal sign.

The teacher here asked learners what should happen next. Instead of waiting for the responses from the learners, he answered the question by himself by saying *‘re raka’ (we chase) 6.* The teacher here wanted to talk about additive inverse of 6 in order to remain with the variable x. This indicated that the teacher was using wrong mathematics concept or explanation. For teacher to say “‘re raka’ 6”, has some implications for the current and future lessons. Learners would not be able to identify additive inverses. CAPS, in terms of its principle of high skills and high knowledge (DBE, 2014), envisions and encourages that correct mathematics should be taught to learners. With this incorrect mathematics operation, the teaching seemingly diverge from the aims of CAPS.

- Unproductive questioning

The teacher was checking on individual work. For example, the teacher asked if any learners did not get: 7, 9/2, and -20? Furthermore, the teacher asked low-order closed ended questions like: “the horizontal line represents….; the vertical line represents…”. The teacher took too much time writing on the chalkboard. Asking unproductive questions without waiting for learners to give a response poses a serious challenge to learner performance. Learners tend to miss high skills and high knowledge as envisaged by the CAPS (DBE, 2011).

Non-Follow-Up on Questioning

The teacher did not make follow ups on high-order questions. He asked a question which could have been followed up to get learners’ understanding or reasoning:

Teacher 2: Did you know that a square is a rectangle but a rectangle is not a square? All learners: Yes.

Instead of asking them what makes a square a rectangle and not vice versa, the teacher gave learners work to do and he was moving around without checking on the learners’ work. The movement of the teacher was not serving any important purpose. This indicated two things: either the teacher knew what was expected to be done in the classroom but did not do it or he had a limited knowledge of implementing the teaching strategy and could not do it.

Discussion based on Observations from COI and Video Recorder for both Teachers

Based on the above presentations for both teachers, the following themes have emerged from the COI and video recording observations: teacher and learners’ role, questioning and answering, classroom environment and communication, assessment, classroom arrangement, resources and mathematics concepts. Noted is that the themes were likely similar to the constructs on the COI and emerged from the video-recorded teacher presentation. The similarity conformed to triangulation. The data showed results from the different instruments.

Teachers' and learners' role

With both teachers, it was found that the teachers were regarded as the source of information, dominating the talking by telling, explaining and demonstrating. The only teaching strategy or method that seemed viable to the teachers was telling and demonstration which the learners had to imitate. The role of the teacher was perceived by both learners and teachers as the carrier of information and he had to provide the fill the learners' "tanks/baskets". This was in contrary to the constructivist theory which underpins this study; i.e., "that learners are not a blank slate". The role of the learners was perceived as recipients of the information, which was at odds with EMIPs, the theory of learning and teaching, and the theoretical framework of this study. Learners tended to sit and wait for their teachers to deliver the correct information as parcels. These actions were at odds with the EMIPs. The teachers used the didactic/traditional approaches in teaching mathematics, and that made it a boring subject. Although that was the case, the teachers thought they were performing very well. Learners were not mathematically engaged in the whole lessons in both cases of the teachers. When learners were not engaged, they were missing out on the benefits of understanding the content, attitudes and skills such as critical thinking, communicating, reading and writing which are envisaged in the CAPS (DBE, 2011). According to Andrawis (2011), engaging learners, increases learners' retention and understanding of content. Further, Andrawis (2011) indicates that engagement increases learners' attention span and time on task, which both teachers' lessons missed. This could have a detrimental effect on learner performance.

Questioning and Answering

It emerged that the teachers asked questions while the learners did not. The questions that the teachers were asking were of a low order and rhetorical. Most of the commonly asked questions were: *"Do you understand, Akere, (is it not)? Do you see it?".* Sometimes learners answered those questions and sometimes they did not answer but the teachers continued explaining regardless of the learners' answers. By continuing, the teachers indicated that the purpose of the questions was for the sake of trying to keep the learners focused on their explanations and not to check if they understood or not. According to the framework of EMIPs, the teacher should ask high-order questions and pause for a while to provoke thinking, challenge learners and check learners' understanding (NCTM, 2014). If learners find themselves stranded with the challenge or provocation, then the teacher needs to scaffold the learning, go back to first principles and move to more complex applications (NCTM, 2014; Van de Walle et al., 2016). This aspect of challenging learners was missing in both lessons. This led to the conclusion that teachers were using ineffective questioning. Ineffective questioning amounts to ineffective mathematics instructional practices.

Classroom Environment and Communication

The issue of classroom rapport and respect was seen in either of the lessons. Besides this, learners were not given a chance to communicate as peers, within groups or present their solutions to their whole class. As indicated from the observations; both teachers used a whole-classroom arrangement and did not give learners a chance to solve problems, explain to their peers or explain their solutions to their groups. Learners were passive and not engaged in communicating with each other or the teacher except when they were asked a question which they seldom answered. This is because the teachers mostly asked low-order questions, which did not check learners' understanding. The teachers sometimes asked questions and then answered them without waiting for learners to answer. If those questions were answered by the learners, they did so in chorus. This kind of environment is ineffective in mathematics instructional practices. The teachers failed to create a community of discourse (Anthony & Walshaw, 2007) and produce learners that are able to communicate effectively using visual, symbolic and/or language skills in various modes as perceived by CAPS (DBE, 2011).

Assessment

The observations indicated that Teacher 1 did not use assessment often in his lesson. The observation was different from Teacher 2 who asked learners to write and let them give him solutions. Teacher 2 was using formative assessment in his lesson. However, the assessment used by Teacher 2 did not provoke learners' critical thinking skills since the teacher asked closed ended questions. Teacher 1 relied more on talking and demonstrating at the expense of learners' assessment. This was contrary to the framework of EMIPs and CAPS. According to CAPS, assessment should be a continuous planned process of identifying, gathering and interpreting information about the performance of learners by using various forms of assessment (DBE, 2011).

Further, it is intended to provide learners with regular feedback to enhance their learning experience (DBE, 2011).

Classroom Arrangement

Both teachers were seemingly not interested in the way their classrooms were arranged. It was observed that their learners randomly sat anywhere or sometimes in ordinary rows and even the teachers used a whole-classroom setting. This kind of seating was seen on the video. This type of arrangement was in contrast to the EMIPs which caters for cooperative and collaborative learning, individuals working alone, and with others (Cooper, 2006; DBE, 2011; Education Alliance, 2006; Felder & Brent, 2010; Grouws, 2004; IOWA DoE, 2011; NCTM, 2014; Shellard & Moyers, 2002; TIMMS, 2004). In both the cases, the teachers just started teaching even if the learners were not yet settled. They did not check whether the learners had relevant learning materials like textbook and/ or writing books.

Resources

For both teachers, resources seemed not to be of importance except the chalk, chalkboard, textbook and worksheet. They did not realise the importance of ICT in their teaching of mathematics. Although the school had some ICT resources and in some instances the teacher was seen using a laptop, neither teacher really used the resources. They did not seem to be ready to use them either. It emerged that although government and non-government organisations strove to provide schools with resources (in this case, computers, smartboards and data projectors), most teachers are not ready to use those resources. Instead the computers were used for compiling question papers, and sometimes for worksheets and mark sheets. This may be because they are not taking time to plan and teachers just to go unprepared into the class with a textbook. EMIPs require the teacher to include ICT and apply it to investigations/ problem-solving and or conjecturing (DBE, 2011; Felder & Brent, 2010; IOWA DoE, 2011; NCTM, 2014). In addition, CAPS aims at producing learners that are able to "use science and technology effectively and critically…" (DBE, 2014; p. 5).

Mathematics Concepts

Both teachers were found to be unfamiliar with the correct mathematics concepts or explanations. This is in contrast with what Rowland, Turner, Thwaites, and Huckstep

(2009) describe for teacher's mathematical pedagogical knowledge. Rowland et al (2009) indicate that teachers' mathematical PCK enable teachers to change their own subject matter into an accessible form for their learners. The teachers' practices were worrying because they did not explain mathematical concepts well. When the teacher is unable to explain or use mathematics concept correctly, it creates a problem in modifying problems according to learners' levels and could be lead to unfruitful discussions. The following table summarise the themes and subthemes/categories emerged:

Table 5.2:

Emergent themes and categories

Themes	**Talking**	**Learners' role**	**Effective instructional Practices**
Teacher's role	Dominating	Listening, rote learning	Not engaged
	Facilitating	Participating and active learning	Engaged
Question and Answer	Unproductive	Not answering	Fruitless discussions
	Productive	Questioning solutions and providing different solutions	Fruitful discussions and solutions
Classroom environment and communication	Non-conducive and lack of Communication	Silent and not communicating	No classroom rapport
	Conducive and Participative	Allows different ideas and challenging ideas	Classroom rapport
Assessment	No purpose	For departmental requirements	Destructive and sometimes not tested
	For understanding	Checking learners knowledge and guide progress	Constructive and all tested for suitability
Class Arrangement	Whole-Classroom Setup	Prohibits ideas sharing	Behaviour restricted and Individualisation
	Group work / Cooperative	Allows multiple ideas or solutions	Social, and sharing
Resources	Textbook, Chalk, Duster and writing book	Rote learning and time wasting	Unmotivated

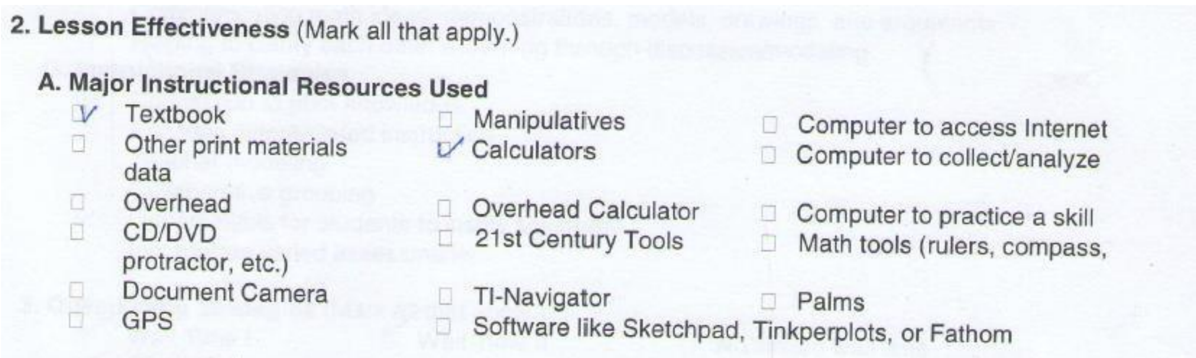
Themes	Talking	Learners' role	Effective instructional Practices
	Inclusion of calculator, Projector, software, laptops, Worksheets	Exploring, saving time and correct visualisation	Engaged and motivated
Mathematics concepts	Wrong usage / Explanation	Difficulty in mathematizing and algorithmic understanding	Destructive and encourages memorisation
	Correct usage / Explanation	Mathematizing easily and conceptual understanding	Constructive and lead to real life situation

5.2.3 Instrument 4: Researcher Video Analysis Instrument

The RVAI recorded the data on the following dimensions: physical setting/ classroom environment, lesson effectiveness, questioning strategies, classroom climate and development of higher-order thinking skills.

TEACHER 2

The physical setting of the classroom was of an adequate size for learners' number (27). The learners were sitting randomly. The room size accommodated activities. The classroom environment indicated that core curriculum material was available and learners' work was displayed. The RVAI indicated that the teacher's major instructional resources used were textbook, calculators, chalk, chalkboard and other print materials (worksheet).


2. Lesson Effectiveness (Mark all that apply.)

A. Major Instructional Resources Used

- ☑ Textbook
- ☐ Other print materials
- ☐ Overhead
- ☐ CD/DVD
- ☐ Document Camera
- ☐ GPS
- ☐ Manipulatives
- ☑ Calculators
- ☐ Overhead Calculator
- ☐ 21st Century Tools
- ☐ TI-Navigator
- ☐ Software like Sketchpad, Tinkerplots, or Fathom
- ☐ Computer to access Internet
- ☐ Computer to collect/analyze data
- ☐ Computer to practice a skill
- ☐ Math tools (rulers, compass, protractor, etc.)
- ☐ Palms

Figure 5.2: *RVAI results*

The main content focus was measurement (See the fully completed RVAI: Appendix M). The mode of content delivery partially used a real-world context and the instructions and resources used were appropriate, relevant and effective. In terms of inquiry-based lesson design, the basis of the lesson was on summary or closure. In terms of grouping arrangement(s) used, the teacher focused on individuals working on the same task. The teacher set up and guided learners through meaningful learning real-world problems, and moved around the room but did not monitor what the learners were writing or if they had questions, leading learners to completion of oral questions in a chorus form.

5.2.4 Instrument 5: Reflective Interviews

Teachers were interviewed after their lessons to reflect on what happened and why during lesson planning and teaching. The reflective interviews were to understand the individual teachers' perceptions on his lesson (both planning and presenting) and for him also to rate the lesson based on the framework. The interviews were transcribed according to each individual teacher as follows:

(It is a reflection time for the lesson of TEACHER 1. Present is TEACHER 1, TEACHER 2, Researcher Assistant and The Researcher)

Researcher: E re naa (it says), is the topic based on a problem? Let me ask, what was the problem?

If there was no problem, is the topic based on the conjecture to be solved?

TEACHER 1: Ae (No), there was no conjecture.

Researcher: What was it?

TEACHER 1: Hmmm, it was to, to check the, how can I put it? What separate the terms?

Researcher: What separate the terms? *(TEACHER 1 is paging*) O seke wa yaka moo (do not go that side), let's look at it, when we say a conjecture, we mean a general statement that we can see, Ok, when this happens we can see this. What was the general statement then?

TEACHER 1: General? (Teacher not knowing the conjecture in mathematics,

Researcher: Statement that we want the learners at the end to get?

TEACHER 1: (silent).

Researcher: Ee, o wa mo kwa, akere wena (yes, do you hear what he says) the lesson was planned by you. You know what is it that when I get out, I wanted that this generic things that the learners should get is this one.

TEACHER 1: At the end ne ke nyako gore ba kgone go (I wanted them to be able to) group or like for example if re nalo (we have) something like this then re remaina le (we remain with) -1 4 time over eight ba kgone grouper and ba kgone go tseba (to be able to group and to know) that this have 1,2,3 wanted them for example.

Researcher: Was the time spread evenly to allow learner input? Is there time for group work, is there a time for individual learner.

TEACHER 1: There was a time for individual learner.

Researcher: Remember we are still on the lesson plan, we look here (*pointing*). Let's look here where you are saying I am going to group learners. Here learners will be participating on the (they are laughing). Is it there?

TEACHER 1 and TEACHER 2: Aego (JF: It is not there).

Researcher: O a e bona? (Do you see it?) It is not there, Ok. Let's go on. Are objective generated by the teacher and the learners, did the learners have an input on the objective, are the objective based on investigation, are the objective arising from previous lesson. Where do you classify your objectives? Where are they? Let's look at them first, let's look at them.

TEACHER 1: Objectives! Previous lesson or what because re e dirile ka term one (because we did it during First term), prior knowledge.

Researcher: Let's go, so we are agreeing that the objectives are arising from the previous lesson. Does the nature of the content on that focus on investigation, where in investigation dominates or is the content constructed from learners' prior knowledge or background, is the content question depended or is the content as part of problem-solving?

TEACHER 1, TEACHER 2: from the learners' prior knowledge and background. Previous lesson or that one is the previous lesson because re e dirile ka term 1 (we did it during term 1).

Researcher: This one, prior knowledge of the learners. Now teachers' activities, we want to look on this one.

TEACHER 2: Eh, Mo (Here), ah, is the content question depended. Like, What does that mean?

Researcher: Let's say I am saying, my question that I am posing to the class is "how to draw the cubic function". So, whatever we are going to do today in this, we are trying to answer how to draw the cubic function. When I am saying I'm getting the x-intercept for what, drawing the… (cubic functions). Whatever that we do must relate to that. The content that we do getting, differentiating, what, what, they related to … (drawing cubic function). At the end, we ask the learner "how do we draw the cubic function?" Now One, by finding the x-intercepts, two, y-intercepts, do you see it?

TEACHER 1: Oh! (*Amazed*) All the question will drive you to draw the cubic function, towards a content question dependent.

Researcher: Then your role, which one, is the teacher activity, is the teacher acting as the facilitator, re tlo(we are going).

TEACHER 1: Mose gabotse ke swanetše ke ngwale?, gape tše dingwe ke ngwala ke tseba gore (does that mean I must write everything?, Some I am writing knowing that..).

TEACHER 1: Ba šomiše (they use the) previous knowledge of division, addition, multiplication and subtraction of fractions to, to, ba e šomiše (use it) simultaneously to solve a complicated problem.

Researcher: But remember your topic, you said it is common fractions, but nna (me) according to what I saw you were dealing with algebraic expression.

TEACHER 1: Mola ga di-algebraic expression (there at algebraic expressions..).

Researcher: Yes, because you wanted them to identify the terms and what separate the terms

TEACHER 1: Ne ke nyaka go ba tlišetša (I wanted to bring) that idea ya gore ka mo ga di (of saying in) fractions re tlo bereka ka di (we use) terms gore naa re na le diterms tše kae (how many terms do we have) so that ba kgone e tlo ba deriver (they can derive it) to BODMAS.

TEACHER 2: So did you do fractions today?

TEACHER 1: Fractions, ne ke le tseleng ya go dira akere wa bona la mathomo ne ke ba fele ya previously? Ne ke nyako ba reminder ne ke tlo tla mo (Fractions, I was still on the way to do, do you see firstly, I gave them previous problem to remind them in order to come here).

Comments:

From the interview, the following emerges: the teacher was teaching routine activities; the teacher was not familiar with what a conjecture is or even if he was teaching to achieve that; he was not familiar with the term conjecture; and the whole-classroom arrangement was used throughout the lesson. Despite the teacher mentioning on the lesson plan that he would use group work somewhere as the lesson proceeded, he continued to use whole-classroom arrangement. He did not follow his plan properly. From that action, it emerged that although some might try to plan lessons, they do it for the sake of evidence for administration purposes not for thorough planning for instructional purposes.

Researcher: Firstly, We are looking on the prior knowledge whether he is linking the prior knowledge with the current content, second we are going to look on the mathematics contents whether he is using the correct terminology, three, looking as to whether he is engaging the learners or is he the one who is engaged?

Let's look on your objectives.

Researcher: A re tšwelepele (let us continue), ehh,…, ke be ke sa bontšha ke re (I was still showing that) your purpose was to teach common fractions but eventually your class was strictly focusing on identification of terms and identification of term separator, ke a kwala (am I clear).

TEACHER 1: Hmmm.

Researcher: Though re be re tsoma (we were looking on) a leading question or and investigation, a re a e hwetša (we did not get).

TEACHER 2: mmmm (yes).

Researcher: So, is the teacher acting as a facilitator, is the teacher guiding investigation, is the teacher's activities question dependent, is the teacher activities including assessment. A re kwe gore naa (let's hear) what is your take on that before my intervention.

Comments:

It emerges that this teacher, even though he had a lesson plan, choosing proper and relevant prior knowledge to link to the new content to be taught was problematic. This teacher wanted to teach common fractions; he used algebraic expressions and requested learners to identify the number of terms and identify the terms 'separator' which did not link well with fractions. This in itself suggested that the teacher was not really familiar with the mathematics content. If he was, why did he choose the term 'separator' of algebraic expressions as the prior knowledge for common fractions? Both the lesson plan and presentation led to another topic which was not what was envisaged. This indicated ineffective mathematics instructional practices since they diverged from objectives of the lesson to something not planned. Although, it should be noted that if learners are not familiar with prior knowledge, the teacher should teach that, in this case it is an irrelevant prior knowledge to the topic or content busy with.

TEACHER 1: Communicator is communicating.

JF: Are learners allowed to communicate their solutions and processes?

TEACHER 2: In your lesson plan, did you see where you structured..

JF: Okay, now you need to choose something, that this one, I was doing. Do the teacher activities include assessment? Is cooperative learning included in the lesson? Is there anywhere, where you wrote that here there will be cooperative learning.

TEACHER 1: Cooperative learning, no I did not see.

JF: Are individuals working alone or with others? It was alone or it was what?

TEACHER 1: A se ke ngwale (I did not write).

Researcher: Ga wa ngwala (You did not write)? There was no investigation. A ke re (paging). Are the learners communicating amongst themselves about the solution processes, No Resources: who has the authority over the choice of resources.

TEACHER 1: Yes, Teacher.

Researcher: Were the resources relevant to problem-solving/investigation or conjecture?

Comments:

The conversation indicates several concerns: that there was no cooperative learning; the lesson was not guided by either the investigation or problem to be solved; there was no communication amongst the learners; and the teacher had the authority over resource usage.

5.2.5 Instrument 6 : Analysis Framework for Identifying Teacher Changes

TEACHER 1

The AFITC indicated that this teacher presented the topic inconsistently. Although he presented the topic inconsistently, the main topic progressed from easy to abstract. The overall instructional flow from learning objectives to main activities was not systematic. Evaluation/summary for this lesson was a problem. The teacher tried to focus his lesson on a mathematical concept, but due to lack of mathematical content knowledge, he sometimes failed. He explained a lot but used wrong explanations. The teacher tried to foster learners' mathematical reasoning ability by asking questions. Unfortunately, the questions were of a low order and rhetorical. He did not give learners the task of communicating their solutions amongst themselves; hence, the ability to communicate was not evident from learners. Due to lack of communication, learners seemed to be less interested or had less positive attitude towards the mathematics. The instructional strategy used was telling and explaining for all learners regardless of their differences. There was no instructional material for learners' manipulative activities and exploration. Further, the teacher did not use open-ended questions to provoke learners' thinking. The teacher did not provide feedback timeously to the learners. The teacher dominated the discourse through a question and answer technique and demonstration, but did not solicit learners' multiple ideas. One of the weakest observed actions was that learners' responses were mainly chorused and simple. In addition, the teacher did not provide an opportunity for learners to present their own ideas to their peers, their groups or the whole class. This was because the whole-class arrangement was used throughout the lesson without a chance for group work for learners to discuss their own ideas based on mutual respect.

TEACHER 2

For this teacher, the AFTIC indicated that there were a few criteria of the dimensions that were observed. The teacher presented the main topic progressively from easy to abstract; constructed the lesson in a way that considered the content of the textbook and learners' characteristics; and provided for timely feedback to learners; but the discourse was dominated by the teacher's question/answer pattern and demonstration; learners' responses were mainly chorused and simple; and the teacher used the whole-class organisation throughout the lesson. It was noted that the overall instruction of the lesson did not flow systematically; the lesson did not focus on learners' understanding (though the teacher thought that was his focus); and there was no mathematical concept that the teacher's lesson focused on. Learners were not given a chance to solve a problem, but sat passively watching the teacher doing the demonstration and explanations. It was further identified that the lesson did not focus on fostering learners' mathematical reasoning ability but on procedural or algorithmic fluency. Although procedural fluency is one of the key strands of Kilpatrick and Swafford (2002) for mathematical competency, in this case, this was not fruitful. Procedural fluency becomes meaningful when intertwined with other strands. The lesson did not foster mathematical communication ability, or on fostering learners' positive attitude towards mathematics. Noted also was that the teacher used the instructional strategies that were generic to all learners, regardless of their differences; he did not employ instructional materials for learners' manipulative activities and exploration; and he did not use open-ended questions to provoke learners' thinking. Further, the teacher did not solicit learners' multiple ideas or use them in the lesson, and he did not emphasise the importance of mathematical communication. The learners did not have an opportunity to present their own ideas to the whole class or group; there were no small groups or pairs used to promote communication amongst the learners; and the classroom atmosphere did not encourage learners to discuss their ideas based on mutual respect and trust.

5.2.6 Summary of Practices before Training

The first question of the development and implementation of the framework for EMIPs is: “What are the mathematics teachers’ current instructional practices?”

In summary, the purpose of the question was to identify the current instructional practices of mathematics teachers at schools. The research has indicated that instructional practices of teachers are ineffective and predominantly didactic. The results from the data also confirm what research has identified. The results indicate that both the teachers thought that effective teaching was when the teacher was demonstrating, explaining and demonstrating. In addition, both teachers were asking very low order questions. From the lesson plans of each teacher, the teaching strategy envisaged was telling and explaining or question and answer.

During the lessons, the COI supplemented the observations from the lesson plan. Both teachers dominated the lesson by demonstrating and explaining with some question and answer strategies. Though question and answer strategy could be effective, the type of questions that are asked plays a major role in determining whether the lesson could be effective or not. It emerged that both teachers were asking low order and rhetorical questions which were rather pointless, since whether learners answered or not, both teachers simply continued explaining/demonstrating or answered the questions themselves. With these types of questions being the ones dominating the lesson, it indicates that currently teachers are teaching ineffectively. As indicated, current mathematics teachers’ practices in study are traditional, didactical and ineffective. Both the observations and literature concur. It was these observations that motivated the idea of training of teachers on the framework of EMIPs as envisaged in the study. The following sections outline the observations after the training.

5.3. AFTER TRAINING

5.3.1 Research Question 2: What is the Framework of Effective Mathematics Instructional Practices?

To answer this question, relevant literature and teacher practices were taken into consideration. The following excerpt was an interaction between the researcher and Teacher 1, Teacher 2 and Researcher Assistant after the implementation. It was after the last lessons of both teachers. The researcher used lesson 11 for Teacher 2 as the basis for his questions.

Researcher: I see here, the learners were engaged and asking questions to the answers that the presenters were giving. Do you think the framework assisted these learners to be able to participate especially in explaining and asking questions?

Teacher 2: Yeah, I think this method helped both me and the learners in realising one aspect that we were mostly neglecting in our previous teaching before the research. Learners were not used to question the solutions or present and defend to class their solutions. In most instances, we were happy if a learner gives the correct answer and we could not ask how or why that solution. This method opened our eyes to seek explanations and different solutions to same problems.

Teacher 1: It helped, yes. Especially on the communication part. Our learners were shy to ask or to present their answers. They were mostly, ehh, passive.

Researcher: In your own interpretation based on what happened before and after the implementation of the framework, how could you say what comprises an effective mathematics instructional practices?

Researcher Assistant: I think, it should start with planning the lesson thoroughly. This is because planning includes a lot of things: Objectives, resources and time to be taken in presentation.

Teacher 2: I will say effective mathematics instructional practices starts from proper planning of the lesson.

Researcher: What do you mean by proper planning and Kofi thorough lesson planning?

Teacher 2: Proper planning is the lesson plan that is planned before administration of the lesson which guides the presenter in terms of the objectives, the resources needed, and the teaching and learning methods. The plan should clearly outline the time division in order for the presenter to manage time, the activities to be presented at what time especially those of learners. In addition, it allows learners to have their role which is clearly stipulated.

Researcher: Do you mean effective mathematics instructional practices rely only on planning?

Teacher 2: No, ehh, not only planning, The presentation, meaning the teaching part. When the teacher is able to follow the plan to an extent that, ehh, yeah, the roles of both the teacher and the learners are executed consistently. The teaching should not be teacher dominated rather learners have to take more part. Again, the use of resource on the plan should be taken into consideration.

Researcher: Let me ask you a subjective question. You were watching your own lesson presentations and that of Teacher 1. Based on the two teachers (yourself and Teacher 1) which one's instructions do you think were effective? What features could you identify to support your classification?

Teacher 2: Ehh, eish, I would say teacher 2 (myself). The reasons for my choice are as follows: firstly, I had lesson plans which clearly stated the objectives and there were teacher's activities which corresponded with learners' activities. In, ehh, The teaching methods for different activities were differentiated to allow for differentiated understanding. Assessment was there and ongoing and the role of the teacher was mostly to help and observe the learners where they got problems and pose questions. Very important after the second interview, I realised that the teaching should not deviate from the planned lesson.

Based on the reflective interview, it emerges that the teacher could be able to identify what constitutes EMIPs. Although the teacher could not identify all the components of the framework for effective instructional practices from his practice for the duration of the study, it was noted was that he could identify the two important components: lesson planning and teaching. Again, he was able to identify the important aspects of the lesson plan which a teacher needs to take care of during the planning which might hamper the teaching if not done well. The following were identified: objectives, resources to meet the objectives, the teacher's activities, the learners' activities, the time division based on the duration of the lesson, and the teaching method based on each activity.

The framework for EMIPs is an ongoing teacher development process. The framework is underpinned by theoretical assumptions of constructivism on teaching and learning; and the truth about reality. The framework provides standard operating procedure for teacher PD and implementation. It is aimed at establishing an alignment of operations by teachers, by describing the scope, the timing and procedure for PD and at the same time implementation. It outlines the steps the minimum of two teachers could follow in order for PD during their teaching. Based on literature and data the framework comprises of lesson plan, teaching practices/presentation, Reflective practices and recommendations for next lesson. Figure 5.3 represents the framework:

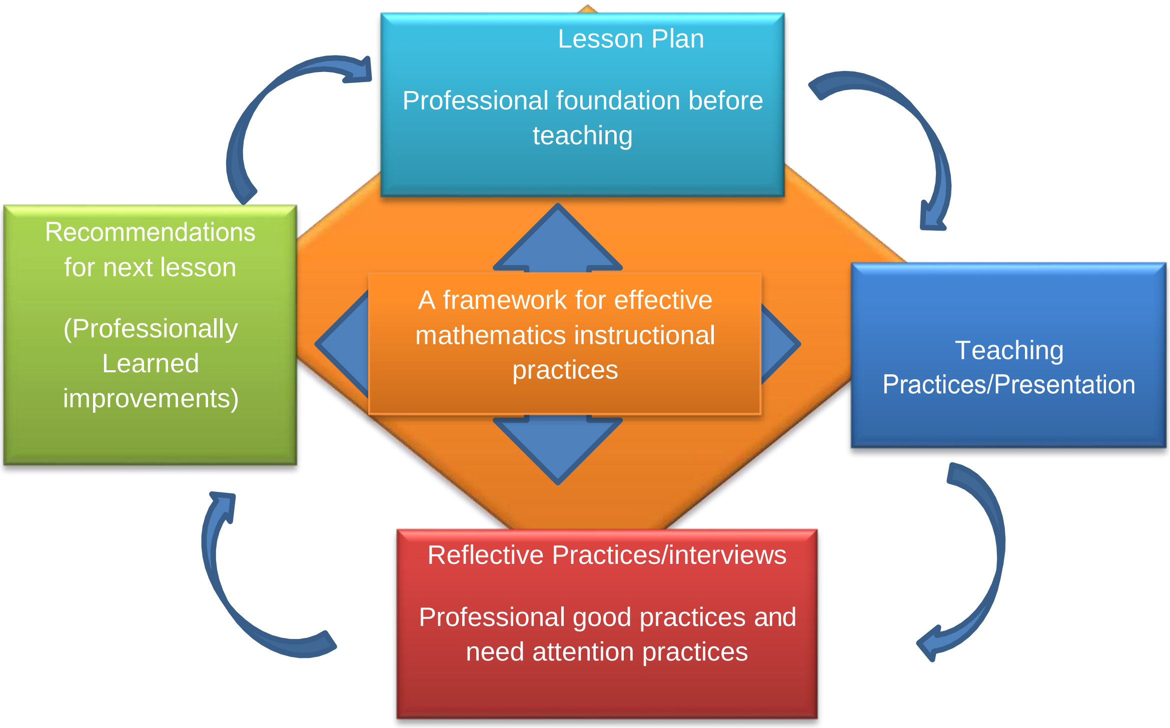


Figure 5.3: *Framework for EMIPs*

5.3.1.1 Lesson Plan

It has emerged that the lesson plan guides the teacher to the intended outcomes and enables the teacher to demarcate the duration into manageable time intervals. This is because on the lesson plan, there should be clear goals for the learners to learn and the goals should accord with the learning progression. Further, the lesson plan guides the teacher before the start of the lesson to identify whether s/he has a problem to be solved/ or an investigation to be followed or a conjecture to be generated in such a way that that learners' inputs are also allocated enough time to understand their meaning during the process. The lesson plan according to this framework should give

the teacher the role of a facilitator who guides the investigation, problem-solving, or conjecturing and question-dependent activities which s/he should assess throughout the lesson. In the same lesson plan, the learners' independence, collaborative and cooperative learning should be catered for. It should stimulate thinking when learners are working alone and when they are with others. This will help in determining the relevant and equal resources for the task. The lesson plan should cater for use of multiple resources to engage the learners.

5.3.1.2 Teaching practices/ presenting

According to this framework, the teaching or presentation practices should link exactly with the lesson and present the established goals in the lesson plan coherently and make sure that it includes tasks that promote reasoning and problem-solving as planned on the lesson plan. The teaching should be responsive to help learners achieve in mathematics with the use of relevant resources to solve problems. The teaching should cover the clearly established goals in the lesson plan for the learners to learn and situate the goals within the learning progression, and uses the goals to guide instructional decisions. During the teaching, the teacher should use and connect mathematical representation to deepen learners' understanding of mathematics concepts and procedures and as a tool for problem-solving, to build shared understanding of mathematical ideas by analysing and comparing learners' approaches and arguments. The teacher needs to pose purposeful questions to assess and advance learners' reasoning and sense-making about important mathematical ideas and relationships. The teacher should provide learners, individually and collectively, with opportunities and support to engage in a productive struggle as they grapple with mathematical ideas and relationships.

5.3.1.3 Reflective practices/ interviews

The use of reflection and reflective practices or interviews is important as a strategy for developing more thoughtful and effective teaching. Two or more teachers of the same subject engage in a professional dialogue by using reflective questioning or interviews on each lesson taught. The teachers engage in an inquiry, reflection and analysis of their own work. They then make modifications for the next lesson based on the observations. By so doing, the teachers would be professionally learning how to make draft future lesson plans.

5.3.2 Research Question 3 How does the development and implementation of the framework of effective mathematics instructional practices change teachers' instructional practices?

In order to answer this question, various instruments were used and excerpts presented. The use of the framework of EMIPs, which was guided by the social constructivist approach during the implementation indicated problems, especially because teachers were used to the telling, explaining and demonstrating teaching method in which they were regarded as the experts as answered in Research question 1. Being the experts, they thought they were supposed to disseminate information to learners through one-way communication, and they were not initially enthusiastic about using the framework, participating actively and contributing to the training. As such, the PD met resistance but eventually positive results were achieved in many instances. In this section, presentation, analysis and discussion is based on individual teacher using LPOI, COI, RVAI and Interviews.

5.3.2.1 Teacher 1

This teacher was observed nine times (nine lessons) including the first lesson Before Training. Representative excerpts of the lessons from Lesson 2 to the last one are used in the presentation, analysis and discussions.

- Lesson plan observation instrument

The teacher entered the classroom with chalks, duster, lesson plan and a worksheet.

- Description of the lesson plan

On the lesson plan, it was envisaged that the first activity would be that of choosing four individual learners to write and explain the solutions of the homework that they had been given the previous day. The previous day's homework dealt with investments and timelines. This activity was aimed at laying the foundation of prior knowledge for the next lesson. It was again envisaged that after the learners had finished writing and explaining their solutions, they would then go on to Activity 2 where it was planned that, in their groups, they would be representing given statements on timelines and solving problems on investments. The topic of the lesson was Financial Mathematics with the subtopic of timelines and investments. It was aimed at grade 11 and the duration of the lesson was aimed to be a period of 45 minutes. The resources that were to be used in the opinion of the teacher were, chalk, duster, calculator, worksheet, textbook and stationery. The first activity was planned to take 15 minutes whereas the second activity was planned to take 20 minutes with a closing assessment of 10 minutes.

- Observation from the LPOI

It was observed from the completed LPOI that the lesson plan had grade, topic, duration, learners' activity, teacher's activity, resources, assessment and time spread for each activity. Further, it was noticed that there were teacher's activities which aligned with the learners' activities and the time spread. The topic was based on a problem to be solved. It was further observed that the objectives arose from the previous lesson which is in agreement with the EMIP framework. The teacher struggled to act as a facilitator. He allocated more time to explaining by individual learners, which indicated that that although there were some changes to his teaching, out of the 45 minutes, almost 30 minutes were spent on learners explaining individually. Although, it was indicated that the second activity was for group work, it was intended that each learner would present their solution to the problem. The learners' activities were mostly individual within a group as planned by the teacher.

- Classroom Observation Instrument

The teacher entered the class with chalks, duster, and a worksheet. The learners were randomly seated in the classroom. The teacher greeted and chose four learners randomly to go to the board to write the solutions to the the homework activities given the previous day. Each learner was asked to explain their solution to the whole class. The teacher pointed to two girls and two boys. They wrote on the board. The two girls were on the left-hand side of the board and the boys on the right-hand side. The teacher was checking, by moving from table to table, whether other seated learners had done the homework. Other seated learners were silent waiting for the teacher to check their work and some were looking at the chalkboard. The four learners in front (of the chalkboard) went there with only the textbook and the calculator. After 9 minutes, the second learner girl had finished writing her solution on the board, followed by the second learner boy after 11 minutes. The first learner girl was writing and rubbing out her solution. She was not sure of what she was writing or doing.

It is observed from the COI that the teacher was asking both high other questions and sometimes reverting back to low order questions like: akere, do you understand. Some of the questions were checking on learner's understanding. For example in the following excerpt the teacher was engaging the solution of the learner by question the learner

TEACHER 1: Alright, A re kwe gore (let's hear) how did you draw the timeline and tell us how did you use the timeline to solve the problem. Felicia: Timeline TEACHER 1: Just explain to us gore, eh on the timeline gore what is happening. Felicia: Ke lebeletše mo godiomo ga statement, ka lebelela go re Sphiwe o butše account, gore o butše account ka R16 000 (I considered the statement which states that Sphiwe opened an account with R16 000). TEACHER 1: Opened an account, go ra go re time e be e le bokae go na moo (what was the time there?), Ge a e bea nako ebe ele bokae? (when he opened what?)

The teacher was checking on the learner's understanding of the solution she wrote. It was also observed that the assessment was meant for understanding and not for grading. The resources (calculator, textbook, and worksheet) that were used were related to the problem that they were solving. It was also noted that the teacher did not follow the plan fully as the lesson ended before he could finish and give them a formative assessment.

Representative excerpt of the lessons from beginning to the last after training is as follows:

(The learners in the classroom are randomly seated. The teacher greets and chose four learners randomly to go on the board to write the solutions of the homework activities given the previous day. And, each learner was to explain his or her solution to the whole class) TEACHER 1: Morning ALL: Morning, Sir TEACHER 1: Alright, I want you to write the solutions of number 1,2,3,4 and 5 on the chalkboard and explain to the class how you solved it. *(The teacher points to two girls and two boys. They write on the board. The two girls were on the left-hand side of the board and the boys on the right-hand side. The teacher was checking on other sitting learners whether they have written the homework by moving from table to*

table. Other sitting learners were silent waiting for the teacher to check their work and some looking on the chalkboard. The four learners in front (of the chalkboard) went there with only the textbook and the calculator. After 9 minutes, the second learner girl has finished writing her solution on the board, followed by the second learner boy after 11 minutes. *First Learner Girl was writing and rubbing her solution. She was not sure of what she was writing or doing.)*

TEACHER 1: Akere o dira number 1 Kgaugelo? Ga o tlo tšea ngwaga moo. O swanetše o fetše (Is it not you are doing number 1 Kgaugelo? You are not going to take long there. You must finish).

(After 11 minutes the teacher stopped the two remaining learners, a boy and a girl and wanted those who were finished to explain their solutions.)

TEACHER 1: A re kwe o hweditšeng (let's hear what did you get)? *(pointing to the second learner girl to come to explain on the board)*, Emang moo. Tla le duleng fase (Stop there, come and sit down) *(Referring to the other two remaining at the board*.) Yeah, read the statement.

Felicia: The question was saying *(she read from the text book verbatim*) Sphiwe wants to buy a motorcycle. The cost of the motorcycle is R55 000. In 1998 Sphiwe opened an account at Sutherland Bank with R16 000. Then in 2003 she added R2 000 more into the account. In 2007 Sphiwe made another change, she took R3500 from the account. If the account pays 6% p.a. compounded half-yearly, will Sphiwe have enough money in the account at the end of 2012 to buy the motorcycle?

TEACHER 1: Alright, A re kwe gore (let's hear) how did you draw the timeline and tell us how did you use the timeline to solve the problem.

Felicia: timeline

TEACHER 1: Just explain to us go re, ehh on the timeline go re what is happening (Just explain to us, ehh what is happening on the timeline).

Felicia: Ke lebeletše mo godimo ga statement, ka lebelela gore Sphiwe o butše account, gore o butše account ka R16 000 (I considered the statement which states that Sphiwe opened an account with R16 000).

TEACHER 1: Opened an account, go ra gore time e be e le bokae gona moo (what was the time there)? Ge a e bea nako e be e le bokae (when he opened what time was it)? Time ye a bulago e ne e le bokae time (The time that she opened the account was how much)?

Felicia: Ke moka ra tla rare o addile R2 000 ka 2003 (Then we said he added R2 000 in 2003).

TEACHER 1: A o so fetše (you didn't finish) that statement.

Felicia: Ba tla bare o addile (They then said he added) R16 000 ka (at) 6% p.a. compounded yearly.

TEACHER 1: Yearly, Is it yearly?

Felicia: Half-yearly.

TEACHER 1: Ee (Yes), you should indicate that during that period it is what….it is half-yearly (The learner writes on the timeline). Alright, yeah, proceed.

Felicia: Akere, o butše account ka R16 000 ka 6% per annum compounded half yearly, kamoka ga tšona o dirile ka compounded half-yearly ka 6% per annum bjalo ka 2003 o addile R2 000, bjalo ka gobane mo bare naa ka 2012 naa o tlabe a nale tšhelete e enough ya go reka motorcycle. Ka tšea 2012 ka minus 1998 (Is it not, she opened an account with R16 000 at 6% per annum compounded half-yearly, she compounded all of them half-yearly at 6% per annum then in 2003 she added R2 000,here they ask whether h she will have enough money to buy motorcycle in 2012. I took 2012 and minus 1998).

TEACHER 1: Ya go fa bokae (How much did get)?

Felicia: Ya mpha fourteen (14) bjale ka tšea tšhelete ka e bea mo(It gave me 14, then I took the money and put it here). *(pointing on the board)*

TEACHER 1: O reng, gabotse nto ya mathomo re nyako go tsebang (Actually what are you saying, firstly what is it that we want to know)? Go re the whole period yang, ya the investment akere (That the whole priod is for what, investment, is it not)? That is the first thing that you must indicate gore (that) the whole period of the investment e tšere bokae, go thoma mo a beago go fihla kae moo e lego (took how much, from the time he invest until where) we don't know gore o tlabe a tšere bokae akere (how much he would have taken, is it not)? Akere mo ke deposit go ra gore kua ro nyakang, if you can tell me akere mo ke eng ye a ebeilego, ke moka ye a tlo ehwetšago mo mafelelong e tloba eng (Is it not, here it is a deposit, it then means here we are looking for what, if you can tell me, is it not here, it is the amount he invested, then the money that is accrued at the end it will be what)? E tloba eng Thabo (What will it be Thabo)?

Thabo: E tloba (it will be an) accumulated amount.

TEACHER 1: E tloba accumulated amount. You can just write go re mo e tloba accumulated amount. Ke eng and ga re e tsebe akere (what is it and we don't know is it not)?. Akere re tlo dirang (is it not we are going to do) calculation, you just put what, question mark? Ke moka ntho yengwe ye bohlokwa o swaneteše o lebele gore naa the whole investment e tšere nako e kae? That is what we want to know you tell us actually e tšere nako e kae?, the whole investment. From zero to what e tlile e fela neng (when did it end)? e thomme ka ngwaga o fe (in which year did it start)?. Bare e thomme neng ngwannyana (when did it start girl)?

Felicia: 1998

TEACHER 1: 1998 akere, e tlile efela neng (In 1998 is it not, when did it end)?

Felicia: 2007

TEACHER 1: 2007, re re the whole investment a re bale eng (we are saying the whole investment without counting what the) withdrawal or e tlile efela neng (when did it end)?

Felicia: 2012

TEACHER 1: E tlile efela ka 2012 (It ended in 2012). Ke moka gore o tsebe gore e tšere nako e kae o tlo reng ga na moo (Then in order to know how long it took, what are you going to say here)? Gore o tsebe the number of years go re o tsebe go re go re naa e tšere nako e kae o tlo reng gona moo (To know the number of years, to know how long it took, what are you going to say here). From 98 to 2012 ke nako ye kae. Ke how many years (From 98 to 2012, how long is it. How many years)? Tšea calculator (Take a calculator) (*all learners respond and the teacher chastises them*) Ae, re bolela le Felicia

Felicia: 14

- Observation from the COI

The teacher was asking productive questions that were scaffolded to lead the learner towards the correct solution. He was questioning the solution the learner was providing and allowing the learner to explain to other learners her solution. There was a positive interaction between the teacher, the learners, the learner and the solution the learner arrive at. The teacher tried to create an environment of rapport in his class. The following emerged from this teacher: teacher’s role, questioning and answering, classroom environment and communication, assessment, classroom arrangement, resources and mathematics concepts.

- Teacher and learners’ role

This teacher found it difficult to be a facilitator even after training. This is because the culture and the way this teacher was taught, either at his secondary school or university was predominantly didactic in most of his subjects and modules. The following excerpt indicates the way the teacher was teaching:

TEACHER 1: Alright, A re kwe gore (let's hear) how did you draw the timeline and tell us how did you use the timeline to solve the problem.

Felicia: timeline

TEACHER 1: Just explain to us go re, ehh on the timeline go re what is happening (Just explain to us, ehh what is happening on the timeline).

Felicia: Ke lebeletše mo godimo ga statement, ka lebelela gore Sphiwe o butše account, gore o butše account ka R16 000 (I considered the statement which states that Sphiwe opened an account with R16 000).

TEACHER 1: Opened an account, go ra gore time e be e le bokae gona moo (what was the time there?), Ge a e bea nako e be e le bokae? (when he opened what time was it?) time ye a bulago e ne e le bokae time?(The time that she opened the account was how much?)

The teacher was often interrupting the learner when the learner was explaining her solution. Instead of letting the learner finish, the teacher went on asking questions from the learner's explanation of the solution. This teacher felt that letting learners to discuss takes a lot of time and was at odds with the CAPS pace setter in order to cover the content given per term and ultimately the year. The researcher indicated to this teacher that he should create more time for content by planning thoroughly so that the problems he was posing to learners were aligned to the content that was scheduled for the term. The teacher changed a little after several interventions by the researcher. Although he tried to be a facilitator, mostly, he was just moving around the learners without checking the discussions but just to check whether the learners had written the solution. This teacher gave learners a chance to present their individual solutions on the chalkboard rather than group solutions. The teacher gave learners homework almost daily, but writing proper solutions to all homework given was difficult to complete. The researcher had to intervene and told the teacher that it would be better to give few purposeful questions which could be discussed during the early part of the next period and be completed with learners understanding the processes.

- Questioning and answering

This teacher struggled throughout the implementation with asking productive questions. Where productive/ challenging questions were asked, their purpose was not realised and there were no follow-ups to guide the learners towards realising what they were expected to do. While it is important to challenge learners through productive struggle as the theory of social constructivism envisions, this teacher was posing incoherent questions to the learners to the extent that learners became confused similar to the before training. Over time, the teacher started using productive questions. For example, in one situation he asked the following questions: “Why do you multiply 5 years by 12?” The learner responded by saying “because it is compounded on a monthly basis”. He further asked: “What happened during that period of years?” All the learners at the chalkboard were able to indicate how they got the solution to the whole class. The teacher asked “How much is the answer?” All learners on the chalkboard responded that it was R19 950.61. There was a problem of place value identified from the learners’ answers. The teacher asked, “Is there anyone who used a different approach?” It was found that one learner – Clement – had a different approach. His approach gave almost the same solution to the same problem. Note again was that this teacher was reverting to the previous ways of questioning like: “is it not, like what.” Although the change was noticeable, reverting to previous ways of questioning even if it was done occasionally indicated that there were still a few problems in terms of the questioning approach.

- Classroom environment and communication

This teacher relied mainly on individuals talking to him or the whole class unlike using cooperative learning. The following indicates the teacher talking to one learner while others were looking on.

TEACHER 1: O reng, gabotse nto ya mathomo re nyako go tsebang?(Actually what are you saying, firstly what is it that we want to know?) go re the whole period yang ya the investment akere? That is the first thing that you must indicate go re the whole period of the investment e tšere bokae, go thoma mo a beago go fihla kae moo e lego we don’t know gore o tlabe a tšere bokae akere? Akere mo ke deposit go ra gore kua ro nyakang, if you can tell me akere mo ke eng ye a ebeilego, ke moka ye a tlo ehwetšago mo mafelelong e tloba eng? E tloba eng Thabo?
Thabo: E tloba (it will be an) accumulated amount.

Further, this teacher relied more on the use of home language than the LoLT. This was very problematic to learners when answering questions on their own without an interpreter. Although the researcher persisted to indicate to the teacher during the reflective interviews that he should use the LoLT, this teacher could not change on this construct. There was communication which was directed at individual learners which was different from the previous lesson before training. Before training, questions were just directed to whole class and even if not answered, the teacher did not care. After training, the teacher was checking that learners (though asked individually) were giving answers to his questions. It was noticed that learners were engaged because they were anticipating that each one could be called to provide the answer to the subsection or solution in total for the problem. That seemed to be a positive move towards EMIPs.

Assessment

This teacher was giving many items of written assessment in the form of classwork or homework. For example, the following indicates an assessment in the form of homework given the previous day to learners.

TEACHER 1: Alright, I want you to write the solutions of number 1,2,3,4 and 5 on the chalkboard and explain to the class how you solved it.

The assessment consisted of five long items. There was a problem when writing and explaining the solutions. Learners were sometimes unable to complete the solutions within one period of 45 minutes. This created a situation where the teacher left some problems unsolved and unmarked. The teacher seemed to use the forms of assessment to meet the required number of written tasks as required by the DBE and school management. It was not effective because the way the exercises are arranged in the text book move from simple to difficult. Both the teacher and learners started with the easiest ones, but when the bell rang, they had not completed the more complicated problems which denied the learners the opportunity to solve sophisticated problems. This was inconsistent with EMIPs which envisions learners engaging in a productive struggle with the teacher scaffolding when needed. The teacher used the slogan “give more work” as prescribed by the DBE. The way the slogan was used did not seem to be effective. Giving more work without proper solutions or marking is meaningless to learning.

- Classroom arrangement

It took this teacher a long time to arrange the class into groups and even after arranging them, there was no cooperative learning. This teacher seems to have been exam-oriented because time and again he was worried about completing the content within the prescribed time saying cooperative learning took time. It took the researcher several interventions during reflective interviews and in the class to indicate that cooperative learning could be used even when one followed the pace setter. The researcher indicated that giving a productive problem which includes a lot of knowledge areas and skills to learners to work collaboratively especially with conjecturing and or investigations, helps learners to learn the same content effectively within the prescribed time. Further the researcher indicated that the group setting could be maintained without having to arrange them every day. It was only after that that the teacher tried to use cooperative learning with a conjecturing problem which required a multi-process approach to solve. That change required the teacher to do thorough planning which was not done previously. The change was positive towards EMIPs.

- Resources

These teachers and the learners all had calculators – Casio FX 85ES Plus. Further, the majority of learners had a Siyabula mathematics textbook. Whether others were given the textbook or just forgot it at home, was not revealed by the teacher. But there were very few (3) who did not have them. The teacher was telling the learners when to use the resources. For example, he was asking learners how long it took for the investment.

TEACHER 1: E tlile efela ka 2012. Ke moka gore o tsebe gore e tšere nako e kae o tlo reng ga na moo? Gore o tsebe the number of years go re o tsebe go re go re naa e tšere nako e kae o tlo reng gona moo. From 98 to 2012 ke nako ye kae. Ke how many years? Tšea calculator *(All learners respond and the teacher chastises them)* Ae, re bolela le Felicia
Felicia: 14

By saying “Tšea calculator” – meaning “taking out the calculator to calculate”, the teacher was instructing the learners when to use resources. The learner herself did not know when to use the resources on her own as that learning culture was not instilled in them. Mostly, the teacher would calculate and tell them the answer while they were watching. As time went on, after reflective interviews with other teachers, the teacher made worksheets for learners to direct them how the lesson would proceed. On the worksheet, he wrote the time to be taken on the problem and when to use the calculator. That changed the normal way of learners waiting for the teacher to come with the problem and teach while they were watching him. It appeared that the most difficult part of being an effective teacher was proper lesson planning. This was because through proper planning, they could identify several important aspects of EMIPs: the method to be used, the time allocation and the use of resources.

- Mathematics concepts

Initially, this teacher and the learners were using wrong mathematics concepts in order to solve problems, especially the concept of dividing or multiplicative inverse when changing the subject of the formula, and used the term ‘cancelling out’ often. The teacher could not explain the difference between depreciating objects and appreciating objects; for example, why a car loses value and a house does not. This teacher left out the clarification of that concept. This suggested training was needed on lesson planning to consider concepts that built up the lesson before it was presented. The researcher indicated that before any lesson, the teacher should identify the key concepts and clarify them himself and ask for assistance if necessary. The next lessons did not have a lot of wrong mathematics concepts or explanations.

5.3.2.2 Teacher 2

The teacher was observed 11 times in different lessons. Excerpts from representative lessons during the development and implementation of the framework for EMIPs are used below to indicate the changes/ improvements observed. One representative lesson is described in detail for the reader to understand what transpired in most of the lesson (Appendix L).

- LPOI

The teacher had a lesson plan. On the lesson plan, many items were observed. There was a space for the school name and the name of the school was recorded; and the grade which the lesson was intended for was indicated as Grade 10. The topic of measurement was planned with the subtopics envisaged to be taught as surface areas and volumes of pyramids. The teacher envisaged that the prior knowledge to his lesson would be knowledge of surface areas for prisms. The date for which the lesson was to be presented was indicated as 11/09/2017 which corresponded with the duration of the period written as 45 minutes. Noted was that there was a time spread for each activity on the lesson plan; for example, the teacher indicated that his first activity was to arrange learners into groups of 4 – 2 boys and 2 girls in each, in which the learners' activity would be to form groups as indicated by the teacher. This activity was planned to take only 2 minutes. Assessment was planned to take place throughout the lesson as indicated for each activity that learners would be doing and in which form (individually or in pairs or in groups). On the part of resources, the following resources were written: chalk, chalkboard, duster and Grade 10 Siyavula textbook. At the end of the lesson there was a planned summative assessment to be given to learners to do as homework on page 429, exercise 12-4, numbers 2 and 3.

- Observations from LPOI

The completed LPOI indicated that there were improvements compared to before the training and the initial stages of after training on the implementation of the framework. On the second activity of the lesson, which was envisaged to take 10 minutes, randomly chosen learners were to come and write their solutions to the homework given to them to calculate the surface area of a prism. That activity was the prior knowledge for the planned lesson. It emerged that the lesson was planned to be based on conjecture (which is the main component of EMIPs) rather than just teaching for the sake of the topic. It was planned that for the third activity, the teacher would draw the base of a pyramid as a square on the chalkboard and request learners to find the surface area of the pyramid in their respective groups and ask for help where they found any difficulty. On the inventory of the observation instrument, it was noted that only a few constructs were not taken care of; for example, the construct of resources was not demarcated for each activity. It was taken as an umbrella term for all activities whereas somewhere learners were not to use the chalkboard and duster. The teacher had a laptop, worksheet and four nets of objects made from milk cartons but did not indicate that under the resources. It was not clear whether he had forgotten or omitted this intentionally. When asked during reflective interviews he responded as follows:

JF: I see on the part of resources there is no line to indicate which resources correspond with what activity. Teacher 2: Ehh, yeah, I think all the resources are for the whole lesson. JF: are you saying that learners would use chalkboard and duster throughout the lesson? Teacher 2: Eish, No… JF: You were having four nets of objects made from cartons of milk, why they were not indicated on this activity (the researcher pointing on the lesson plan) as the resources? Teacher 2: Problem, ke gore I planned and typed the lesson plan and went back to re-plan and forgot to change on the typed lesson plan.

From the interview, it was evident that the teacher had enough time to scrutinise the lesson plan in order to conform to EMIPs. It was noted that the observed lesson plan sample which was similar to the other ones assessed previously had shown improvements as per analysis of change and indicated an important move towards EMIPs.

- Classroom observation Instrument

This teacher presented eleven lessons which were observed. Out of the eleven lessons presented, a representative lesson which showed major improvement according to the EMIP framework is presented, analysed and discussed. Other similar lessons observed are indicated in full in the appendices.

- Description of the presented lesson

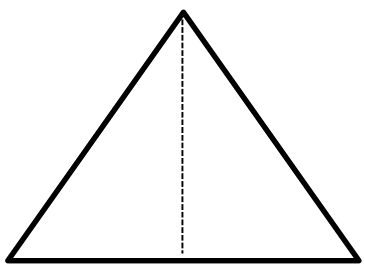
It is in Grade 10 Class, Teacher 2 entered the classroom and found the learners sitting randomly. The teacher greeted the learners. Learners took their bags to take out books. He requested someone to clean the chalkboard and one boy stood up and cleaned the board. The teacher had a duster, chalks, a computer, a worksheet, four nets of object made from milk cartons. After the boy had cleaned the chalkboard, the teacher wrote ‘Surface Areas and Volumes’ on the board. He indicated that “today”, they were going to talk about areas of 3D and 2D objects. He asked if learners knew what 3D objects were and indicated that they were going to be talking about areas of 2D objects and asked learners what 2Ds were. Learners responded in a chorus that 2Ds are objects where they could see two sides. He asked them for an example of 2Ds by pointing at one learner (Enough). It was noted that in this way, the teacher was managing learners and avoiding chorus responses. The learner answered by saying a square. The teacher asked another learner: "Nkwana, what is the area of a square?" The learner responded by saying S^2. Then the teacher asked for another example of a 2D object. All learners answered by saying rectangle. He again asked one learner (Moss) what the area of a rectangle was, and the learner said length times breadth. From that, the teacher asked learners whether there was a difference between a square and a rectangle and what the difference was. It seemed to me that he needed an explanation or description of the difference. All learners responded by saying "yes". He wanted to know what the difference was and all learners said two sides are equal. The teacher then indicated that it was not two sides, but two pairs of opposite sides that were equal.

He further indicated that a square is a rectangle, but a rectangle is not a square. In this case, learners did not have a comment or a question. From this statement, a further explanation could have been required from the learners to explain why a square is rectangle but a rectangle not a square. Instead, the teacher asked learners if they know how an area of a square is calculated, and they responded by saying length times breadth which is (s x s) or S^2. He asked if the answer was correct and all learners responded by "Yes". He continued to ask another example of a 2D object from Pieter. Pieter responded by saying triangle.

The researcher interrupted and asked the learners what makes a square a rectangle and the rectangle not a square. Learners raised their hands and researcher chose one learner (Elvis). Elvis indicated that when calculating the area of the square, it is the same as that of a rectangle. The researcher followed up with Elvis by asking whether the two objects are the same and the learner answered no. The researcher wanted to know what made them different. The learner (Elvis) answered by saying a rectangle is a figure on which two opposite sides are longer than the other ones and that in a square the length and the breadth are equal. The researcher indicated that the learner was correct and that both a square and a rectangle have same dimensions of length by breadth but the two sides of a rectangle are longer whereas for a square all sides are equal. The researcher asked all the learners again about the angles of both a square and a rectangle. All learners responded by saying they are equal. The researcher asked another learner, Puleng, to answer the question. Puleng indicated that the angles are equal and are 90^0 each. The researcher tried indicate to the teacher how to ask clarity-seeking questions which would seek learners' understanding of concepts.

Further, the teacher asked the learners the formula for the area of the triangle. All learners said half base times height $(1/2\square \times h)$. The teacher asked learners what they were talking about. One learner (Enock) responded by going to the chalkboard and drawing an isosceles triangle and divided its bottom base equally by a line to the top of the angle opposite to the side and said he divided into two hence ½ base. The following excerpt indicates the interaction of Enock with other learners and the teacher on the chalkboard

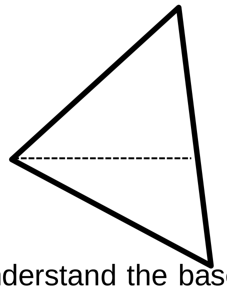
Enoch: Ehh, if we have triangle like this, we ehh, ke gore re kgaola ka bogare with dash line. ke mokana go ra gore line yeo e refera half base. Ke mokana re ripile ka bogare go ra gore ke half (Ehh, if we have a triangle like this, we ehh, I mean we divide it on the middle with a dash line. Then, it means that line is referred as half base).



The teacher then asked the learner what a base is. The teacher drew another triangle different from that of the learner and indicated that he wanted the other learners to understand what a base is. He asked Enoch to indicate the base.

TEACHER 2: Ke nyako kwešiša gore naa ge re bolela ka base re bolela ka eng? (I want to understand when we are speaking about a base what are referring to?) Alright, let me do this, so now

(he drew the following figure)



So now, eh,I want to understand the base, when we are talking about the base what are you meaning when saying a base?

The learner indicated that he understood a base as any side from which a line is drawn dividing it into two equal parts and joining an angle opposite to the line. The teacher asked the class if they understood him. All learners except one said yes.

- Observations from COI

The completed COI indicates that the teacher was asking high-order questions that tested learners' knowledge. For example, the teacher asked learners whether they agreed with Lesedi's solution. He then asked Lesedi to explain why he did not substitute at the second step and further to explain to the learners how he worked out his solution. In addition, the COI indicates that the purpose of assessment was for teaching and learning and not for grading.

- Teacher and learners' role

At the early stages of the development and implementation of the framework, this teacher was particularly still using traditional methods of teaching even after he was trained. The role of the teacher was that of transmitting information to learners. He was talking more than the learners. The following excerpt was from one of the initial lessons after training

Teacher: Ok, ah, surface area and volumes. By the mere look of the name surface area and volumes, today we are going to talk about area of faces. Now, here we will be talking about 3D objects. Do you know what a 3D object is? Surface areas of 2D's? We are going to talk about areas of 2Ds, area of 2Ds are two dimensions. Do you know what

is a two dimension? Alright, the square is one example. Do you know what is a square and how do we find the area of the square? Ge o ka lebelela mo dilo tše dilo tše di a swana, a square is a rectangle but a rectangle is not a square, akere.
All: Yes

- Comments

This conversation indicates that the teacher was dominating the teaching using a lot of questions of which only the last one was answered by learners in a chorus. The purpose of the questions seemed unimportant; rather, the teacher was just asking for the sake of asking. If the questions were important, the teacher could have waited to find the responses to each question from learners in order to understand whether they understood the questions.

Further, he was teaching, explaining and demonstrating. His actions then prompted a supposition that although workshops are currently used as the main source of teacher development in education system towards recent teaching reforms, with few days of workshops, teachers do not change their beliefs, teaching ways and practices. It took several days of lesson observations to move the teacher from his own traditional classroom practices. The researcher had to give him a lot of encouragement and, at times, made use of guiding questions to lead the teacher to a facilitation role. With the establishment of a friendly, encouraging and supportive environment form, the researcher-teacher gradually became more able to change the role of the teacher to the role to a facilitator. After he tried out what for him was a novel teaching approach, he became more enthusiastic about being a facilitator. This teacher had many difficulties in the lessons – particularly with respect to class and time management and helping learners to participate meaningfully in the mathematics activities. With the intervention of the researcher in his classroom to initiate the facilitation role and engage learners, the teacher recognised his common problems and his need to solve them. The discussions after every lesson led to some constructive suggestions and the process became self-reinforcing to the teacher. With further guidance and support from the researcher, this teacher came to accept the value of the role of the teacher in a social-constructivist approach as used in the framework. The teacher was able to promote an approach of reflective dialogue to the learners which ultimately improved the learners' beliefs about critical discussions. This teacher structured situations such that the learners become actively involved with the 2D and 3D objects through manipulation of the materials that he created by using milk cartons. He made sure that learners generated the conjecture for calculating the area of a triangle from that of a rectangle without just giving the formula. Learners were taught to take chances and were actively involved in trying to solve problems to find the solution. It seemed to the researcher that these learners had moved beyond their normal way of learning which was happening before the implementation of the framework. This prompted the researcher to believe that when learners are met with a situation, like the implementation of the framework, learners tend to respond to the situation; in other words, situated learning, which is one form of constructivism.

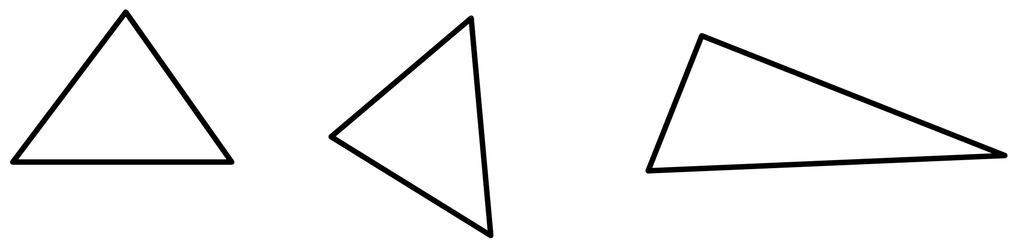
- Questioning and answering

The teacher was trained on questioning techniques during the reflective interviews. According to the observations, the concept of questioning seemed to be more problematic to the teacher than it was explained during training. At the beginning, the teacher was still concentrating on asking very low-order or rhetorical questions. Most of the questions were like “ akere”; “do you understand”; “is it not” and others such as “like what?”. Here learners had to complete the statement or the teacher himself would complete the question. The answering of questions also seemed problematic. This was because even though he was trained and shown that the chorus response does not help in tracking learners’ understanding or reasoning behind their solutions, chorus responses dominated the initial lessons. This made it difficult for the teacher to cater for individual learners’ needs since he could not identify who answered them. This pointed out a very important aspect, that though training helps in improving practices, it should be noted that once-off and/ or few days training does not produce the required or desired outcomes quickly since according to the study, training was done for only three days. At this stage, it was expected that the teacher could have differentiated the teaching from the one done before training. The observations indicated that, in the early stages, there were no significant differences or changes between the lessons presentations before training and after training in terms of questioning, answering and the level of the questions.

It took some discussion, until this teacher managed to change the way questions were asked.

JF: Mnr, here you were asking learners what the difference is between the square and the rectangle. All learners responded by saying "yes". This seemed for me, that you needed an explanation or description for the difference. Teacher 2: Yes, I wanted them to describe or explain the difference. JF: But you continued without giving them enough attention to explain the difference. I think you should have also drawn the two for them to look on and bring the descriptions and/ or explanation.

From these deliberations, the teacher realised that questioning should serve a purpose and it should not assumed that learners understand. After the deliberations, the teacher began asking challenging questions to probe learners' understanding and to challenge their solutions provided. For example, when the teacher heard the learners talking about a base, he wanted to check thoroughly whether learners understood what a base was by drawing different triangles on the board. The following were the different triangles drawn and learners were supposed to indicate the base.



What was interesting here was that the teacher did not impose what the base was but rather wanted different perceptions of the base based on learners' beliefs and experience in these situations. The questioning helped learners in generating the concept that a base is the side of a triangle in which a perpendicular line is drawn from it to the apex of the other two sides. This helped in clarifying a misconception that a base of triangle is always the bottom side of the triangle. Learners were involved in their learning and they were provided with a challenge to their thinking of what a base is, which forced them to rearrange their beliefs. There were a lot of changes that happened in questioning by this teacher to indicate that he had moved towards productive questioning. The teacher was able to create a cognitive conflict to the learners' held beliefs by creating a mismatch with reality. Since this teacher often created cognitive conflict, learning took place because learners were engaged in assimilating or accommodating in order to change their internal mental structures. This way of challenging learners aligned well with the EMIPs.

- Classroom environment and communication

The classroom environment changed although it took time to happen. At the beginning after training, the teacher paired the learners into two – a boy and a girl. There was an instance where one paired worked individually and the teacher did not notice it until the researcher brought it to his attention. Eventually, as time passed, the teacher used group work with other lessons. This was after the reflective interviews were carried out. This teacher managed to move from chorus response by learners to cooperative learning where from each group, representative learners would present the group solution to the whole class. This was because, in their respective groups, learners were assigned tasks. There was a scriber, presenter and so on. Apart from content engagement, the learners were physically engaged in their learning and interacting. The communication was also systematic in that learners were exchanging their views amongst their respective groups and eventually with the whole class. Furthermore, learners from different groups were able to ask their presenting peers how they came up to a certain step. The teacher tried to avoid dominating the talking by allowing learners time to discuss and present to others. The classroom climate changed from that of a boring to an engaged and interesting environment since learners were on their own making observations, reciting/recalling facts, measuring, comparing and contrasting and interpreting and analysing information.

- Assessment

Assessment is divided into two parts according to CAPS policy document: formal assessment and informal assessment. Before the training, the teacher relied more on the formal assessment. His teaching was specifically aimed at formal assessment since it is the what the DBE recognises more for progression and promotion. He took informal assessment for granted and regarded it as of no value. After the training, the teacher realised that informal assessment especially the informal writing in groups and oral presentations were of importance to determine the knowledge and understanding of the learners' progress in terms of intended outcomes. The teacher was now giving more discussion problems for the learners to solve and explain to each other, in their groups and the whole class, how they approached the problem. That helped the teacher to assess which learners were struggling with conceptualising the solutions to the problems in order to use the conceptual understanding for procedural fluency. Assessment was used mainly for checking learners' progress on the envisaged outcomes compared to the perception before the training. By probing the diferent solutions of the learners the teacher was able to determine whether they understood the problem or got to the solution by chance. It was a form of continuous assessment which the DBE and the CAPS advocate.

- Classroom arrangement

From the training, this teacher managed to change the classroom setting to group settings. Apart from the arrangement, the teacher was using the groups, not just arrangement. The learners were given a problem and the teacher let them discuss the possible solutions in their respective groups and come up with one agreed solution in that group. From the group solutions, they had to present to the whole class, but each group member sitting down could also answer any question that was posed to their presenter.

- Resources

Initially, the teacher seemed not to see the value of resources for teaching and learning. But as time went on, the teacher realised the importance of the resources, be they bought or improvised. During the teaching of 3D shapes, this teacher used the cartons of milk to create the 3D objects of a tetrahedron, a cube and a pentagonal prism for the learner to be able to identify the vertices, edges and faces. That helped the learners a lot because they were able to touch and turn the shapes and, at the same time, understand what happens when you view the object from the front, back, bottom or top. Improvised resources made the lesson more interesting to the learners. Apart from that, the teacher prepared the hand-outs before going to the class and that was important for both the teacher and the learners in the sense that it saved time especially for the groups that were excelling at finding the solutions. They were able to move easily to the next problem. Furthermore, learners were now getting used to the textbook in order to check the similar problems to that given on the hand-outs.

- Mathematics concepts

After the first lesson after the training, this teacher showed an improvement in explaining mathematics concepts. He was able to define the concepts which he asked learners correctly. He was further able to explain the concepts correctly using the correct mathematical language. This was evident when learners used wrong explanations, he followed up on their explanations. There was one learner who wrote the following:

$SA = 2\pi r^2 + \pi dh$
$SA = 2\pi(5^2) + \pi(10)(15)$
$SA = 50\pi + 10\pi \times 15$
SA= 200π
SA= 628.32cm^2

The following conversation was recorded when the teacher was asking the learner based on the presentation where he used wrong mathematics explanation:

TEACHER 2: Why do you continue using π instead of substituting t?
Learner: In order to understand/ ke kgone go kwešiša gabotse.
TEACHER 2: Ga ke gane gore o nyako kwešiša gabotse, ke ra gore, alrigth okay, ge o ka substitude ka o ka se kwešiše. Question yeo ke nalego le yona ke mo go step se sa $SA = 50\pi + 10\pi \times 15$ re ka di adda ka moka, ke bona o sa dira justice ka polelo ye ya go di adda. O wa nkwešiša. Did you add or multiplied?
Learner: Ok, I multiplied π, 10 and 15 first ka hwetša 150 π. Ke moka ka tšea 150 π ka hlakanya le 50 π ka hwetša 200π.Then ka simplifier ka hwetsa 628.32cm^2.

- Comments

This conversation indicated that the teacher had spotted that the learner was using the wrong mathematical explanation. He challenged the learner with guiding questions until the learner was able to explain the concept correctly. There were other cases where the teacher was scaffolding the concepts so that the learners could use correct concepts and procedures.

In order to answer this question, several aspects were taken into considerations: the time which the teachers were giving learners during solving the problems and discussing as either peers, or groups or class presentation; the type of the questions that the teachers were asking; the flow of the lesson; teaching for conceptual understanding and the resources that were used in the class.

Teachers' instructional practices were seen to change but very slowly and sometimes retrogressed towards didactic practices. Teachers often returned to their traditional teaching ways regardless of the training and reflective interviews they had with the researcher. This was because they were used to their old practices and the fact that their learners were regarded as knowing nothing, and the teacher had to give them the information. After some time of four to five days, teachers were getting used to the new framework and no longer panicked about the telling and explaining information to learners, the covering of the pace setter, teaching towards examinations and the time factor. They were following effective instructional practices wherein they were able to give learners enough time to allow them to solve problems in their own way. Learners were able to exchange their solutions as peers, as groups and lastly present their solutions to the whole class on the chalkboard. This took a lot of dedication and needed time. Teachers were questioning learners, questions that sought understanding other than the rhetorical questions that they were used to. Although they were asking those questions, it was clear that Teacher 2 had moved further away from his previous practices as compared to Teacher 1. This teacher was not teaching in the traditional sense of delivering instruction to a group of learners; rather, he structured situations for learners to become more actively involved with the content through conjecturing and social interactions. For example, in one question, Teacher 2 was asking, "What is the area of a triangle?" Learners responded by saying, "half base times height". The teacher posed a challenging follow-up question: "When we are talking about half base what are we referring to? Can somebody come and explain to us on the board. I want to understand the base. When we are talking about the base, what are you meaning when saying base?" In this case, he drew two different triangles for the learner to come and indicate the base of the triangle to make sense of learners' understanding of the base. Learners were challenged on every solution they were providing and this also prompted learners to challenge each other's solutions.

5.3.3 Research Question 4 What is the impact of effective mathematical instructional practices on learners' questioning skills and the teacher's instructional practices?

In order to answer this question, different elements of impacts on learners and the teacher are captured from different instruments and presented, analysed and discussed. The following elements were observed from learners: questioning culture by learners; motivation and participation; conceptual understanding; and confidence. The following elements emerged from the teachers: high-order question skills; ability to use group work; and proper planning of lessons.

5.3.3.1 Questioning Culture by Learners

Learners were able to question every answer or solution that was presented to them either by the teacher or their peer learners from individual to group presentations. The framework instilled a classroom culture in which learners were free and participating in learning and critically questioning the how part of the solution presented rather than just giving the correct answer.

5.3.3.2 Motivation and Participation by Learners

It was noted that learners were motivated to try to question almost if not all solutions presented. That culture made other learner presenters anticipate questions when finding and presenting solutions. This, afforded learners with the chance of questioning their solutions first in their respective groups or as individuals before presenting to the whole class. Learners were motivated to answer any question posed based on their respective solutions. The motivation led learners to engage in solving and discussing tasks that promoted mathematical reasoning and allowed multiple and varied solution strategies. In both cases, learners were able to question freely and were eager to answer posed questions.

5.3.3.3 Conceptual understanding

When learners were questioning solutions given to them by either their peers or the teacher, it provided them with effective learning practices. Learners changed from being recipients without questioning solutions to critical thinkers, which is envisaged by the CAPS policy document. The EMIPs framework fostered an effective culture of learning which was not there previously before the development and implementation. The questioning also developed learners' conceptual understanding of the mathematics they were dealing with. Learners, especially presenters, were able to explain, describe and apply the same concept in different ways and in different situations.

TEACHER 2: why do you continue using □ instead of substituting t?
Learner: Ke kgone go kwešiša gabotse (In order to understand).
TEACHER 2: Ga ke gane gore o nyako kwešiša gabotse (I am not refueing that you want to understand better), ke ra go re, alrigth okay, ge o ka substitude ka o ka se kwešiše (I mean, alright okay, if you substitute will you not understand?). Question yeo ke nalego le yona ke mo go step se sa: SA = 50π + 10π × 15 re ka di add ka moka (I am having a question on the step : SA = 50π + 10π × 15 we can add them all), ke bona o sa dira justice ka polelo ye ya go di adda (I think you did not do justice with what you said). O a nkwešiša (do you understand)? Did you add or multiply?
Learner: Ok, I multiplied π, 10 and 15 first ka hwetša 150 π (Ok, I multiplied π, 10 and 15 then I got 150 π). Ke moka ka tšea 150 π ka hlakanya le 50 π ka hwetša 200π (Then I added 150 π with 50π then got 200 π).Then ka simplifier ka hwetša 628.32cm^2 (I then simplified and got 628.32cm^2).

In this section, the learner was requested to present the solution of the problem to the whole class, and he was asked further questions after presenting. The learner was able to present and explain exactly what he did. Again, some learners were able to use the learned problem solutions to solve other problems from the book and be able to explain their solution. The following excerpt is an indication:

Learner: Mnr, on page 149 of the textbook, I solved this problem: "The problem was saying calculate the expression for the formula of the surface area of a cylinder".
Teacher: where is your solution? Can you explain this to the classroom?
Learner: Here (pointing to the solution he wrote:
Surface Area = Area of circle 1 + area of circle 2 + area of rectangle
= πr^2+ πr^2+ l x b
= 2 πr^2 + πd $x\,h$
Surface Area= 2πr^2 + πdh
Go nale (There are) two circles le (and a) rectangle, ke moka area ya circle ke (then the area of a circle is) πr^2 and mo go nale (here there are) two circles ra hlakanya ra

hwetša (then added and got) $2\pi r^2$, so I multiplied on the rectangle $\pi d \; times \; h$ and got the following: Surface Area= $2\pi r^2$ + πdh

Here the learner took another problem different from what was given on the worksheet that he had finished and solved. This shows that learners gained conceptual understanding because they were able to use and represent the same information to solve other problems in other situations. These are alluded to the intervention of the framework.

5.3.3.4 Confidence

It takes confidence for a learner to ask a teacher a question or to question another peer learner in the presence of the teacher. Before the implementation of the framework, learners were not used to the culture of questioning. They were shy and not ready to question for the process of the solution or even to ask the teacher where they did not understand the solution. This confidence allowed them the freedom to communicate their solutions and to interrogate others' solutions and processes.

5.3.3.5 High-order questioning skills

The following is an excerpt from a reflective interview with the two teachers to indicate how the assessed the questions the teacher was asking.

JMNF There we go, let us start. What kind of questions is the teacher asking? Teacher 1:I think must,.. they are high-order questions. **(The questions were HOQ and intended to determine learners' understanding)** Researcher: They were high-order questions. How is the quality of the questions the teacher is asking? Teacher 2: I think the.., most questions they needed the learner to express their knowledge **(Learners were able to express their opinions)** Researcher: Were there questions checking on learners' knowledge? Kofi Teacher 1: Hmmm, I think yeah, they were Researcher: They were, for example: he wanted to check, they were somewhere the learners were having two numbers 7 and 9 were they were even (they wanted to get the number in between which is even). They wanted to get the number in between which is 8 and there were somewhere where he introduced what if there were 10

and something here in between, how will you get the number there? Now are learners talking to each other?

Teacher 2: YES. They were interacting

Researcher: they were interacting. Are they discussing their solutions in the group? We are basing on what we have seen, they were showing each other, you can write it like this

Teacher 2: yeah; yeah.

Researcher: alright, what words and action is the teacher doing and saying to learners?

Teacher 2: what's an action?

Researcher: yeah. What did you see? What was happening to the teacher during that time?

Teacher 1: eh he was busy intervening where the learners they….

Researcher: okay. He was moving around the groups neh? Questioning their answers, their solutions, ke gore (it means) he was doing probing questions. How did you come. Why did you write this one? ok eh, are the learners explaining their solutions to whole class?

Based on the reflective interview, it emerges that the teacher was able to pose questions that are of high order and purposed to check learners' understanding. This means that the framework changed the teacher's questioning techniques from that of low order as observed before the training to that of useful and which check understanding of the learners. Effective instructional practices stress a point that teacher questioning should serve two purposes: to assess and advance learners' reasoning and sense making about important mathematical ideas and relationships.

5.3.3.6 Teacher Usage of Resources for Learning

The framework helped teachers to be able to improvise and take relevant resources to help in EMIPs. The following figure indicates one of the resources used where the teacher wanted to teach the learners about surface area and volume.

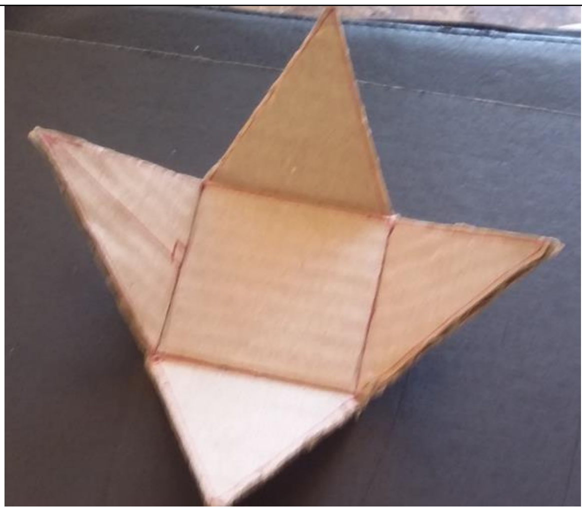


Figure 5.4: Example of use of resources

This means that the framework had developed the teachers towards the two purposes. Learners were given freedom to communicate their solutions and processes which is a major component of the EMIPs framework. For the teachers, posing high-order questions fostered and catered for conceptual understanding since the activities applied were conceptual to problem-solving. Furthermore, teachers were able to identify resources that enhanced learners' conceptual understanding.

5.3.4 Research Question 5: How do effective mathematics instructional practices affect learners' resources choice and resource usage?

To answer this question, excerpts from different instruments used are presented. The following subthemes also were observed from the data: calculator usage, textbook usage, carrying textbooks to school and solving complex problems.

5.3.4.1 Calculator Usage

Before the implementation of the framework, learners were not using the calculator until the teacher told them to take out the calculator and calculate. The framework helped learners to be able to know when to use a calculator on their own with the worksheet. Learners were able to identify when to use a calculator, and when to use their own developed nets to form shapes in order to solve problems. This catered for conceptual understanding in problem-solving.

5.3.4.2 Textbook Usage

The following excerpt indicate the usage of textbook by learners

The following excerpt indicate the usage of textbook by learners Teacher 1: A re kwe o hweditšeng (let's hear what did you get) *(pointing to the second learner girl to come to explain on the board)*, Emang moo. Tla le duleng fase (Stop there, come and sit down) *(Referring to the other two remaining on the board*.) Felicia: The question was saying *(she read from the text book verbatim*) Sphiwe wants to buy a motorcycle. The cost of the motorcycle is R55 000. In 1998 Sphiwe opened an account at Sutherland Bank with R16 000. Then in 2003 she added R2 000 more into the account. In 2007 Sphiwe made another change, she took R3500 from the account. If the account pays 6% p.a. compounded half-yearly, will Sphiwe have enough money in the account at the end of 2012 to buy the motorcycle?

This learner opened the textbook and read the question before she was told to. Although the teacher had prepared the handouts for the learners, before the teacher could ask them to look in the text book for similar problems, learners were able to detect on their own that these problems were taken from their book and that there were similar problems they could work through if they needed to. This was different from the initial approach before the use of the EMIPs framework.

- Carrying textbooks to school

One important thing that emerged was that although learners used to leave textbooks at home and come to school and watch the teacher writing on the chalkboard when teaching, and then copying the answer, the framework encouraged learners to come with their textbooks every day in order to use them.

- Solving complex problems

Learners were observed to solve similar and more complex problems in the textbook than those the teacher had prepared for them. This happened especially when others were still working on the worksheets. Those who had completed eventually moved to the textbook without been being reminded.

Learner: Mnr, on page 149 of the textbook, I solved this problem: "The problem was saying calculate the expression for the formula of the surface area of a cylinder".

Teacher 2: Where is your solution? Can you explain this to the classroom?

Learner: Here (pointing to the solution he wrote)

Go nale (There are) two circles le (and a) rectangle, ke moka area ya circle ke (then the area of a circle is) πr^2 and mo go nale (here there are) two circles ra hlakanya ra hwetsa (then added and got) $2\pi r^2$, so I multiplied on the rectangle $\pi d\ times\ h$ and got the following:

Surface Area= $2\pi r^2 + \pi dh$

The above excerpt is a representative example that indicates that learners were able to solve complex problems without being instructed by the teacher. Here the learner just took a problem of a cylinder from a textbook different from the worksheet given and solved it before even the teacher referred them to it. Even in the other grade, it was observed that some could go beyond the types of problems on the worksheet. The framework helped the learners to know and understand the use of resources, especially the textbook which was neglected and often left at home. Effective teaching and learning occur when resources are integrated into investigations, problem-solving or conjecturing which were observed in this case.

5.4 CHAPTER SUMMARY

This chapter presented the findings to establish mathematics teachers' current instructional practices before training and experiences during professional development and implementation process after training. The data collected through lesson plan observation, classroom observation, video recording, interviews and analytic framework for identifying teacher change instruments were used to answer the questions of this study. It was noted that teachers' practices were initially didactic and teacher-centred. When given sufficient training, teachers could change towards EMIPs as shown in the analysis.

The following chapter presents conclusions, the limitations of the study, and recommendations.

CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The study intended to explore, develop and implement a framework of EMIPs. In Chapter 5, the findings of the study were discussed. The purpose of this chapter is to present a summary of the findings of the study, draw conclusions and make recommendations and suggestions for improvement of mathematics teaching. This study was prompted out of the realisation that very few teachers are moving beyond their didactical approach in teaching. The summary of the findings is presented under the following five research questions:

- What are the current mathematics teachers' instructional practices?
- What is the framework of effective mathematics instructional practices?
- How does the development and implementation of effective mathematical instructional practices framework change teachers' instructional practices?
- What is the impact of effective mathematical instructional practices on learners' questioning skills and the teacher's instructional practices?
- How do effective mathematics instructional practices affect learners' resources choice and usage?

6.2. SUMMARY OF FINDINGS

The summary of findings of the study are presented under the five research questions. For each research question, results are presented under categories and themes. The study was purposed to explore the mathematics teachers' practices by developing and implementing a framework for EMIPs.

6.2.1 Research Question 1: What are the current mathematics teachers' instructional practices?

From the LPOI, COI and reflective interviews, data revealed the mathematics teachers' current instructional practices. Teachers were found overwhelmingly to use the didactic method under the categories: teaching method, lesson planning, classroom interactions and resource usage.

6.2.1.1 Teaching method – overwhelmingly didactic

The study found that teachers were overwhelmingly using the didactic, traditional teaching methods (explaining, telling and textbook bound) which were of no help to learners' mathematics understanding and mathematics achievement (See Section 5.2.1). Before the training, throughout the lessons of both teachers, it was observed that both teachers were only using explaining and telling as the teaching method. According to Serra (2015), EMIPs are responsive practices envisaged to help learners achieve in mathematics and have mathematical understanding with the use of relevant resources for the problem being solved. It is further argued that teaching practices as defined in section 2.3.2 of the literature review is not only aimed at teaching and/ or explaining to learners only, but also improving the process of teaching itself in order to identify good instructional practices. The observed teaching was also consistent with the findings by other researchers (Khalid & Azeem, 2012; Ngoepe, 2014; Wachira et al, 2013) that it is very common and dominates mathematics education.

6.2.1.2 Planning lessons

From the results of this study, it was found from the initial lesson plans of each teacher, that the teaching strategy envisaged was telling and explaining or question-and-answer. On the lesson plans, there was no opportunity given for the learners to speak, share ideas and or present their solutions. It emerged that although teachers were planning their lessons, the reasons that they were doing this were to impress government officials or for policy's sake other than for EMIPs. The results indicate that teachers planned lessons as one of the prerequisites other than a guide to what they were going to do to improve their mathematics learners' conceptual understanding and their own mathematics skills. Thus, the teachers in the study had limited knowledge of how to plan an effective mathematical instructional lesson. Teachers' lesson planning is therefore of no use in effective teaching other than for compliance since it missed a lot of concepts for attainment of the objectives of the instructional unit. Lesson plans impact the development of the lesson. Shellard and Moyers (2002) argue that once teachers plan lessons effectively, they are empowered, would have a clear understanding of the learning expectations for their learners, and be able to identify how and where these expectations fitted into the larger instructional unit.

6.2.1.3 Classroom Interactions: One way of information transmission

In analysing whether the classroom interactions conformed to EMIPs during the teaching and learning, data revealed similarities in the two teachers' approaches. One-way information transmission to learners was common, from the teacher speaking alone while learners received the information quietly. It was noted that learners were not exchanging their solutions and not questioning the solutions from the teacher or their peers. Mostly, chorus responses dominated the answering of the questions posed by the teacher. EMIPs is backed by social constructivism which espouses that learners should socially interact, communicate and engage in problem-solving, conjecturing and investigating. The aspects of social interaction between the learners as pairs or groups were missing. There was little communication either between the teacher and learners or between learner and learner.

6.2.1.4 Resource usage

In examining how the resources were used by both learners and teachers; and who dictated the use of the resources, it was discovered that the only resources both teachers used were chalk, the chalkboard, dusters and textbooks; and that the only resources learners used were classwork books and pens. It was found that the school had laptops and one teacher had one but using a laptop as a teaching aid was never tried by both the teachers. They used them for typing question papers only. It was noted that learners had Casio Scientific calculators in their bags. It emerged that those calculators were used only if the teacher asked them to calculate. Other than that, learners did not use the calculators.

6.2.2 Research Question 2: What is the framework for effective mathematics instructional practices?

In order to identify the framework for EMIPs, literature and reflective interviews were analysed. From the data, when asked what EMIPs entails, it emerged that the teachers were able to identify what EMIPs constituted. It was noted that teachers recognised two important components of EMIPs: lesson planning and teaching method.

Although the teachers could identify the two components, they did not recognise other components (classroom interactions, resource usage, and assessment) of the framework for EMIPs which are important to their practices. However, one of the teachers was able to identify the important aspects as part or a subset of the lesson plan which a teacher needed to take care of during the planning which might hamper effective teaching if not done well. The following were identified: objectives, resources to meet the objectives, the teacher's activities, the learners' activities, the time division based on the duration of the lesson, and the teaching method based on each activity.

It further emerged that the framework for EMIPs is an ongoing teacher development process. The framework is underpinned by theoretical assumptions of social constructivism and the truth about reality. The framework provides standard operating procedures for teacher PD and implementation. It could be aimed at establishing an alignment of operations by teachers, by describing the scope, the timing and procedure for PD and implementation of the framework. It outlines the steps the teachers could follow in order for PD during their planning and teaching.

From the literature and data, it therefore emerged that the framework comprises of the lesson plan, teaching method, reflective practices and recommendations for the next lesson. The following figure represents the framework:

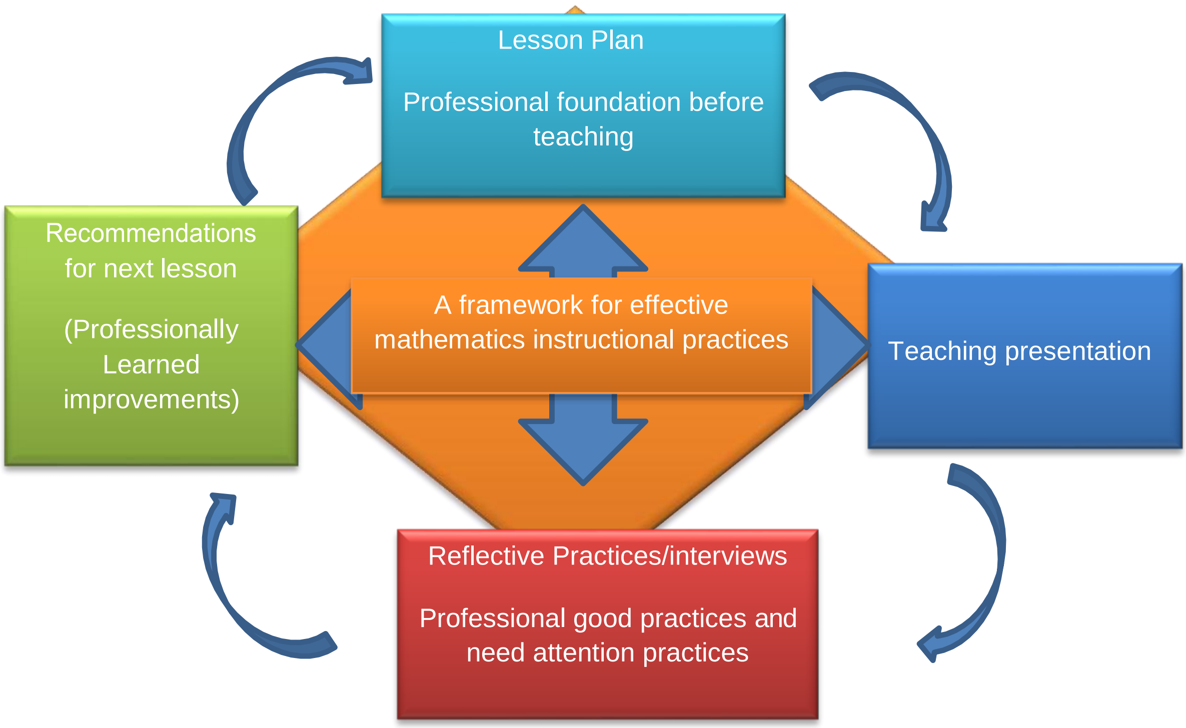


Figure 6.1: *Framework for EMIPs*

The framework for EMIPs as depicted on the figure is a cyclical process, starting from the lesson plan, followed by the teaching practice, then reflective practice and then recommendations for the next lesson plan.

6.2.2.1 Lesson plan

It emerged that lesson plan guides the teacher to the intended outcomes and enables the teacher to demarcate the lesson into manageable time intervals as indicated. The data indicate that the lesson plan should set clear goals for the learners to learn and the goals should be progressive. Further, the lesson plan should guide the teacher before the start of the lesson to identify whether s/he has a problem to be solved or an investigation to be followed or a conjecture to be generated in such a way that that learners' inputs are also allocated enough time to understand their meaning during the process. According to this framework it was established that the lesson plan could give the teacher the role of a facilitator who guides the investigation, problem-solving or conjecturing and creates question-dependent activities which they should assess throughout the lesson if planned properly. Further, the learners' freedom to work on their own, to collaborate and to learn cooperatively should be catered for. It should stimulate learners when working alone and with others. This will help in determining the relevant resources needed for the task. The lesson plan should cater for use of multiple resources to engage the learners.

6.2.2.2 Teaching presentation

According to this framework, the teaching or presentation practices should link exactly with the lesson, present the established goals in the lesson plan coherently and make sure that it implements the tasks that promote reasoning and problem-solving as planned on the lesson plan. The teaching should be responsive to help learners achieve in mathematics with the use of relevant resources to solve problems. The teachers should consider the clearly established goals in the lesson plan, ensure that the goals lead to progress, and use the goals to guide instructional decisions. During the teaching, the teacher should use correct mathematical representations to deepen learners' understanding of mathematics concepts and procedures and as a tool for problem-solving, and to build shared understanding of mathematical ideas by analysing and comparing learners' approaches and arguments. The teacher needs to pose purposeful questions to assess and advance learners' reasoning and sense-making about important mathematical ideas and relationships. The teacher should provide learners, individually and collectively, with opportunities and support to engage in a productive struggle as they grapple with mathematical ideas and relationships.

6.2.2.3 Reflective practices/ interviews

The use of reflection and reflective practices or interviews is important as a strategy for developing more thoughtful and effective teaching. Two or more teachers of the same subject engage in a professional dialogue by using reflective questioning or interviews on each lesson taught. The teachers engage in an inquiry, reflection and analysis about their own work. Once they have reflected on and analysed the lesson, they make modifications for the next lesson based on their observations. By so doing, the teachers would be professionally learning how to make draft future lesson plans.

6.2.3 Research Question 3: How the development and implementation of effective mathematical instructional practices framework changes teachers' instructional practices?

The findings indicated that both teachers were seen changing their instructional practices under the following themes: planning the lesson, asking productive questions, ability to scaffold to lead learners towards a solution, being the main source of information in every lesson and classroom interactions. Although there were changes, Teacher 2 changed significantly more than Teacher 1.

6.2.3.1 Planning the lesson

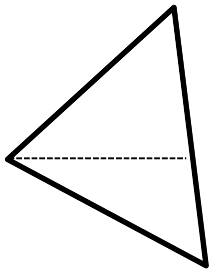
After the training and implementation of the framework, the data revealed that both teachers were able to plan purposive lessons which were timed, with clear objectives, with teacher's activities corresponding to learner's activities, with assessment included and improvisation on resources. Teachers were able to improvise and to draft worksheets which they were not doing before the development and implementation of the framework. Their lesson plans were able to capture the concepts of time division, learner's activities, teacher's activities, assessment and resources needed which are consistent with the social constructivist theory.

6.2.3.2 Asking productive questions

After the training and implementation of the framework, it emerged that teachers were able to ask productive questions. For example

TEACHER 2: Ke nyako kwešiša gore naa ge re bolela ka base re bolela ka eng? (I want to understand when we are speaking about a base what are referring to?) Alright, let me do this, so now (he draws the following figure)

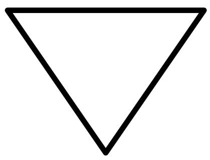
So now, eh,I want to understand the base, when we are talking about the base what are you meaning when saying a base?



The teacher was trying to ask a learner what a base is, based on the response that learners gave. Learners said that a base is the bottom line of the triangle, which is a misconception. The question that the teacher posed was productive in the sense that the teacher wanted the learner to explain how one could identify a base of a triangle. Asking productive questions help in encouraging learners' reasoning during learning (Dengler, 2009).

6.2.3.3 Ability to scaffold to solution

It was established that Teacher 2 was able to give learners the opportunity to come up with their own solution to problems. Often, learners got stuck. The teacher was able to scaffold through asking helping questions. For example: learners were thinking that a base is any bottom line of a triangle. The teacher drew three different triangles in which he requested learners to identify the base instead of explaining what a base is. One of the triangles did not having a line at the bottom of the triangle. The following is one of the triangles drawn:



Learners were unable to use their operational definition of the base being the bottom line of a triangle, hence they got stuck with identifying what the base is on this triangle. The teacher asked them whether the triangle had a base and a height. The learners were able to indicate the height. From the height, they were able to identify what the base of this triangle was and eventually derived an operational definition of a base through scaffolding. The questioning helped learners in understanding that a base is a side of a triangle in which a perpendicular line is drawn from it to the apex of the other two sides. This helped in clarifying a misconception that a base of triangle is always at the bottom of the triangle. Scaffolding allows learners to build confidence that helps them tackle difficult tasks.

6.2.3.4 Being the main source of information

During the implementation, the teachers (especially, Teacher 2) realised that learners are also a source of solutions to the problems when given a chance to solve and let them brainstorm and share their solutions. The teacher was able to give learners a problem without teaching them an algorithm and learners were able to come up with solutions. The solutions learners provided the teachers with proof that they were not the only source of information, and that they should not use the telling method only. They should rather plan the lesson challenge learners and let learners come up with solution.

6.2.3.5 Classroom interactions

It was established that eventually both teachers were able to interact with learners (individually and as a class) and allowed interaction between learners as peers, in groups and with the whole class. The phenomenon of interaction was one-sided before the implementation of the framework.

It was also noted that posing and directing productive questions were improved by the teachers, although when not answered by learners, teachers felt that they were not teaching and reverted to their traditional, didactic methods. It was noted that, initially, teachers often used incorrect mathematical terminology or explanations. After the implementation, they were at least able to use correct terms like dividing instead of cancelling or additive inverse instead of ‘raka (chase)’ and other mathematical terms.

6.2.4 Research Question 4: What is the impact of effective mathematical instructional practices on learners’ questioning skills and the teacher’s instructional practices?

The results indicate that the framework impacted both the learners and teachers in terms of learners questioning their peers, learners questioning their teacher and the teacher’s questioning skills.

6.2.4.1 Learners Questioning Peers and Defending solutions

Data showed that learners were able to question their peers on their solutions presented on the board or during group discussions. Before the training on the framework, the questioning was not done. In addition, learners were able to present, explain and defend their solutions. This is one of the required outcomes by DBE and the framework of EMIPs. It was also found that learners were motivated to pose questions with confidence either to their teacher or peers.

6.2.4.2 The teachers questioning skills

It was established that the teachers seemed to have changed their instructional practices in terms of questioning. They were able to direct questions, pause and wait for an answer from one learner and no longer in a chorus response. Further, the teachers were able to time the questioning. Initially, teachers posed a question and whether learners answered it or not, the teacher would continue or would answer the question himself. The other important feature that was impacted on the side of the teachers was purposeful lesson planning. Before the framework was implemented, teachers had very scanty lesson plans which did not direct the teaching and learning. It was observed that after the implementation that teachers were able to plan a lesson, time it and follow it during the presentation. The lesson plans catered for concepts required by the EMIP which was consistent with the DBE CAPS document.

It was also noted that progress was made in reducing the use of Sepedi in the class and eventually the LoLT was used more.

6.2.5 Research Question 5: How do effective mathematics instructional practices affect learners' resources choice and usage?

It was established that the framework affected learners in terms of the use of resources. With the implementation of the EMIPs, learners brought their textbooks to class and used calculator even when not directed to do so.

6.2.5.1 Learners able to bring textbooks

It was very interesting to see learners being able to work out similar problems in the textbook to those given on the worksheet even though they were not told to do so. They were taking out calculators on their own to verify some of their peers' solutions on the board and used the calculator also for their own solutions. Thus, the EMIP framework had an effect on the learners.

Before the implementation of the EMIP framework, it was observed as a norm that learners did not bringing textbooks to school, were not solving problems on their own, but rather waited for the teacher to solve the problem on the chalkboard which they then copied. The only resource that learners were using was a pen and a classwork book.

6.2.5.2 Use of calculator even when not asked

Data indicated that after training with the framework, learners were bringing resources like calculators, and they were using them. This was unlike before the training where learners (those who brought them) would use the resources only when told to by the teacher. Many did not bring the resources. When learners use a calculator on their own, it means awareness of when to use it independently and that 21st century skills are being achieved as envisaged by the framework.

6.3 IMPLICATIONS

- This study implies that when given proper support and development, teacher could move beyond their technical, cultural and or political barriers towards EMIPs.
- Furthermore, the study implies that for conceptual understanding to be achieved there is a need to move beyond our traditional teaching method and embrace current teaching reforms like this study which is similar to a modern education reforms such as lesson study.
- It is also noted that subject advisers could use the framework for EMIPs as a PD programme to train other teachers on effective mathematical teaching techniques.
- The framework could be a valuable tool for teachers to use in their own teaching for evaluating and improving their teaching if used correctly. Teachers can identify the teaching practices that they are not using which are consistent with CAPS and that have been shown to improve learning.
- At the level of the department (circuit, district and province), the framework reveals that there are teachers whose practices are at odds with the CAPS policy document which is envisaged and guided by the social constructivist theory of teaching and learning.
- Further, the findings indicate that learners could learn effectively if they were given enough time to brainstorm solutions either as pairs or within a group. Giving learners enough time benefited the teachers in understanding the explanations or

the solutions which learners were giving and helped them to realise the understanding the learners had of a concept. Although, this was in contradiction with the pace setters as they prescribe when to do what, it benefited both the teacher and the learners because the learners were able to understand complex concepts like formulating a conjecture or general formula other than being given it the learn by rote. This has increased the conceptual understanding of the content the teachers were busy with. It should be said that Teacher 2 indicated many changes based on the framework compared to Teacher 1. The learners in Grade 10 mathematics class were fully engaged and able to create their own meaning which were consistent with the real-life mathematics and able to reason why they went to such a solution. Differently, although there were changes in the Grade 11 mathematics class, where both the learners and the teacher found it difficult to works towards the framework.

6.4 LIMITATIONS

The study took place in one school with two mathematics teachers with their learners. There were no quantitative data collected to measure the significance of the learner achievement and performance in mathematics tests or exams, because the study focused on qualitative data collection wherein teacher practices were the focus.

The study could have taken a longer period and included the quantitative research approach by analysing learner performance for the quarter in order to to explorewhat the framework could change if followed consistently over a long time. In addition, the researcher could visit the school even after the study to track progress, help and motivate the teachers to continuously follow the PD of EMIPs.

Supplementary to the above, limitations of the study may include associated potential problems with the large amount of data collected to make concise interpretations and meaning of the individual items, especially, because much of the time both the teachers and learners reverted to their Home Language when trying to express themselves. However, because the researcher is a native Sepedi speaker, it was easier to transcribe, translate and derive the themes. The transcriptions were also taken to a Sepedi and English teacher to minimise errors.

Again, other questions like whether the availability of instruments like a video and audio recorder hindered the smooth running of the process especially to participants; and what the effect of teaching and learning in the presence of the researcher and researcher assistant was. This could have made participants avoid sharing actual practice to protect themselves. However, the researcher assured the participants otheir anonymity and confidentiality and that any recordings would not be shown to anybody except for the purposes of the research.

6.5 CONTRIBUTION TO KNOWLEDGE

The study contributes to knowledge in various ways. Firstly, the EMIPs framework could be used to track teacher changes.

- The study indicates that continuous support is needed for teachers in order to remove their technical, cultural and/ or political barriers to implement effective instructional mathematics practices. It was found that irrespective of the value and extent of a PD programme, teachers will continue to come across technical, cultural or political barriers when implementing a new instructional approach and tend to revert to old practices if they cannot find a way out.
- Further, the study contributes to knowledge that reflective practices seem beneficial especially when done for improvement and not for supervising.
- Given enough time to review their planning, teachers could improve their planning and introduce constructive assessment practices.
- Lastly, this study contributes by laying a foundation for improving the Professional Learning Communities which the DBE introduced as a policy in their Integrated Strategic Planning Framework for Teacher Development in South Africa 2011-2025 (DBE; 2011) for teacher development which should be classroom- and curriculum-focused.

6.6 CONCLUSIONS

This is a qualitative case study design and it explored current mathematics teachers' practices. It developed and implemented a framework for EMIPs with its focus on lesson plans, teaching methods, classroom interactions, resource usage and classroom rapport. The main tools for data collection were LPOI, COI, RVAI, AFITC and reflective interviews targeting the topics which teacher would be busy teaching.

Based on this study's findings, a number of conclusions can be realised. Use of effective mathematic instructional practices could help in updating teachers' ways of teaching. However, teachers are not ready to change from using traditional ineffective teaching practices even after the workshop on recent curriculum changes in their mathematics classrooms. Further, the study showed that when given enough support and time, teachers were able to move beyond their traditional practice to EMIPs.

In view of this, this thesis concludes that the current teaching practices of teachers need to be improved if the education system is to improve learners' conceptual understanding and mathematics achievement. As mentioned, the thesis posits that the framework could be beneficial for PD for both pre- and in-service mathematics teachers. Teaching and learning in South Africa largely follows the traditional (didactic) way. As observed from the two teacher there is a need for PD in terms of modern ways of teaching.

It is hoped that the present study of the development and implementation of EMIPs will make an important contribution to the field of teaching, learning and PD research. The research findings of this study should complement those of other classroom practices studies in South Africa aimed at improving learners' mathematical understanding and achievement. The researcher envisions that stakeholders and mathematics teachers could enhance and guide improvements in mathematical understanding and mathematics achievement through the use of this study.

It has emerged that there are EMIPs. These practices begin with lesson planning, teaching and presentation and reflective interviews with peers or with an expert practitioner.

Using the framework of EMIPs indicated some positive changes in teachers' practices. It was found that when teachers were given enough mentoring, persistent guidance and monitoring, they changed their ineffective mathematics instructional practices towards EMIPs. The EMIP framework could aid teachers and the DBE in reflecting, developing and improving mathematics teaching and learning. It has been tested on two mathematics teachers and indicated improved mathematics instructional practices. This framework could be used to gauge the extent of effective teaching practices and to track teacher changes in the use of the research-based teaching practices.

6.7 RECOMMENDATIONS

Despite the limitations indicated, the study has provided some possible new directions for PD and EMIPs for improving learning and hence mathematics understanding and achievement.

- It is recommended that teachers could use this framework for their own development and improvement over a longer period.
- As a form of development, it is further recommended that curriculum advisers could use the EMIPS framework for PD with many teachers as this study has shown that its use is beneficial.

6.8 RECOMMENDATIONS FOR FURTHER RESEARCH

- It is recommended that further studies could use this framework for a longer duration, like a school term with more teachers or schools to make a significant change in learner performance analysis.
- It is further recommended that other studies could use this framework in other contexts for example, subjects and/or learning areas.

REFERENCES

Abu-Tineh, A.M. & Sadiq, H. M. (2018). Characteristics and models of effective professional development: the case of school teachers in Qatar, Professional Development in Education, 44:2, 311-322, DOI: 10.1080/19415257.2017.1306788

Adams, P. E., & Krockover, G. H. (1999). Beginning Science Teacher Cognition and its Origins in The Preservice Secondary Science Teacher Program. *Journal of Research in Science Teaching*, *34*(6), 633-653.

Adler, J., & Sfard, A. (Eds.). (2016). *Research for educational change: Transforming researchers' insights into improvement in mathematics teaching and learning*. London, Enland: Routledge.

Ahmed, A. K. (2013). Teacher-centered versus learner-centered teaching style. *Journal of Global Business Management*, *9*(1), 22.

Allen, L. B., & Crowley, K. (2013). Moving beyond scientific knowledge: Leveraging participation, relevance, and interconnectedness for climate of education. *International Journal of Global Warming*, *12*(3-4), 299-312.

Alsharif, K., & Atweh, B. (2010). Gaps in understanding and implementing connectedness in mathematics teaching by Saudi student teachers. In *AARE 2010 Conference Proceedings*. Retrieved from https://eprints.qut.edu.au/view/publication/AARE_2010_Conference_Proceedings.html

Education Alliance. (2006). *Closing the achievement gap: Best practices in teaching mathematics.* Charleston, WV: The Education Alliance.

An, S., Kulm, G., & Wu, Z. (2004). The PCK of middle school mathematics teachers in China and the US. *Journal of Mathematics Teacher Education*, *7*(2), 145-172.

Andrawis, M. (2011). *Using active learning in teaching electromagnetics.* Washington, DC: American Society for Engineering Education.

Anthony, G., & Walshaw, M. (2007). *Characteristics of effective teaching of mathematics: An evidential synthesis.* Chicago, IL: American Educational Research Association.

Baker, E., McGaw, B., & Peterson, P. (Eds.). (2007). *Teaching constructivist science, K-8: Nurturing natural investigations in the standards-based classroom.* Thousand Oaks, CA: Sage.

Baker, T.T. (2019). Transforming Teachers: A Global Training Initiative in a Community-Based school Program. Un published Manuscript. Graduate School of Education and Psychology. Pepperdine University. Los Angeles, CA.

Baker, S., Gersten, R., & Lee, D. S. (2002). A synthesis of empirical research on teaching mathematics to low-achieving students. *The Elementary School Journal*, *103*(1), 51-73.

British Educational Communications and Technology Agency (BECTA). (2003). *What the research says about barriers to the use of ICT in teaching.* Retrieved from http://www.becta.org.uk/research/ictrn/

Bekhet, A. K., & Zauszniewski, J. A. (2012). Methodological triangulation: An approach to understanding data. *Nurse Researcher*, *20*(2), 40-43.

Bentley, M. L. (2003, October). Introducing critical constructivism. Critical consciousness through a critical constructivist pedagogy. *Paper presented at Annual Meeting*, American Educational Studies Association, Mexico City, Mexico. Retrieved from: http://web.utk.edu/~mbentle1/Crit_Constrc_AESA_03.pdf

Birman, B. F., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing professional development that works. *Educational Leadership*, *57*(8), 28-33.

Boote, D. N., & Beile, P. (2005). Scholars before researchers: On the centrality of the dissertation literature review in research preparation. *Educational Researcher*, *34*(6), 3-15.

Bransford, J.D., Brown, A.L., & Cocking, R.R. (2000). *How do people learn?* Washington, DC: National Academy Press.

Brenner, M. E. (1998). Development of mathematical communication in problem solving groups by language minority students. *Bilingual Research Journal*, *22*(2-4), 149-174.

Brown, B. L. (2002). *Improving teaching practices through action research.* Doctoral dissertation. Retrieved from:

https://vtechworks.lib.vt.edu/bitstream/handle/10919/26869/BethBrownDissertation.pdf?sequence=1&isAllowed=y

Bruce, C. D. (2007). *Student interaction in mathematics classroom: Stealing ideas or building understanding. what works?* Retrieved from: http://www.edu.gov.on.ca/eng/literacynumeracy/inspire/research/bruce.pdf

Brunner, J. (1960). *The process of education*. Cambridge, MA: Harvard University Press.

Bubb, S. (2005). *Helping teachers develop.* Thousand Oaks, CA: SAGE.

Business Dictionary. (2016.) *Definition: Professional development*. Retrieved from: www.businessdictionary.com

Buysse, V., Winton, P. J., & Rous, B. (2009). Reaching consensus on a definition of professional development for the early childhood field. *Topics in Early Childhood Special Education*, *28*(4), 235-243.

Cai, J., Perry, B., Wong, N. Y., & Wang, T. (2009). What is effective teaching? A study of experienced mathematics teachers from Australia, the Mainland China, Hong Kong-China, and the United States. In *Effective Mathematics Teaching from Teachers' Perspectives: National and Cross-National Studies*, 1-36.

Centre for Development and Enterprise. (2015). South Africa's Education Crisis: The Quality of Education in South Africa 1994-2011

Century Dictionary. (1889). *An encyclopedic lexicon of the English language.* Toronto, Canada: University of Toronto – Robarts Library..

Chindanya, A. (2011). *Parental involvement in primary schools: A case study of the Zaka District of Zimbabwe.* Doctoral dissertation. University of South Africa, Pretoria, RSA.

Clements, D. H. (2000). From exercises and tasks to problems and projects: Unique contributions of computers to innovative mathematics education. *The Journal of Mathematical Behavior*, *19*(1), 9-47.

Clements, D. H., Agodini, R., & Harris, B. (2013). Instructional practices and student mathematics achievement: Correlations from a study of mathematics curricula. *NCEE Evaluation Brief. NCEE 2013-4020.* Washington, D.C.: National Center for Education Evaluation and Regional Assistance.

Cobb, P. (1994). An exchange: Constructivism in mathematics and science education. *Educational Researcher*, *23*(7), 4.

Coetzee, S. A., Van Niekerk, E. J., Wydeman, J. L., & Mokoena, S. P. (2015). *An educator's guide to effective classroom management*. Pretoria, RSA: Van Schaik.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education.* (6th ed.). London, England: Routledge Falmer.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education.* (7th ed.). London, England: Routledge Falmer.

Cooper, H. (2006). Research questions and research designs. In P. Alexander & P. Winne (Eds.), *Handbook of educational psychology* (2nd ed.). Mahwah, NJ: Erlbaum.

Corbin, J. M. & Strauss, A. L. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Thousand Oaks, CA: Sage.

Creswell, J.W. (2009). *Qualitative inquiry and research design*: *Choosing among five approaches.* (2nd ed.). Thousand Oaks, CA: Sage.

Creswell, J.W. (2014). *Research design: Qualitative, quantitative and mixed methods approaches.* (4th ed.). Thousand Oaks, CA: Sage.

Crotty, K. (2012). *Educational theory*. Waterford, Ireland: Waterford Women's Centre.

Danielson, C. (1996). *Enhancing professional practice: A framework for teaching.* Alexandria, VA: Association for Supervision and Curriculum Development.

Danielson, Charlotte. "Evaluations that help teachers learn." *Educational leadership* 68, no. 4 (2011): 35-39.

Danielson, C. (2013). *The framework for teaching: Evaluation instrument*. Princeton, NJ: Danielson Group.

Darch, C., Carnine, D. W., & Gersten, R. (1984). Explicit instruction in mathematics problem solving. *Journal of Education Research, 77*(6), 351-359.

Dengler, R.A. (2009). *The use of productive questions in the early childhood classroom.* Retrieved from: https://scholarworks.uni.edu/cgi/viewcontent.cgi?article=1060&context=hpt

Department of Basic Education (DBE). (2011). *National curriculum statement: CAPS FET content grades 10-12.* Pretoria, RSA: Government Printers.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, *38*(3), 181-199.

Dewey, J. (2011). *Democracy and education.* Hollywood, FL: Simon & Brown.

Even, R., & Tirosh, D. (2008). Teacher knowledge and understanding of students' mathematical learning and thinking. In L.D English (Ed.), *Handbook of international research in mathematics education* (2nd ed.), (pp. 202-222). New York, NY: Routledge.

Felder, R. M., & Brent, R. (2010). The National Effective Teaching Institute: Assessment of impact and implications for faculty development. *Journal of Engineering Education*, *99*(2), 121-134.

Forrest-Pressely, D. L.; MacKinnon, K. E., & Waller, T. G. (1985). Metacognition, cognition and human performance. In: *Instructional Practices*. *Volume 2.* New York, NY: Academic Press.

Fourie, M., & Deacon, E. (2015). Meaning in work of secondary school teachers: A qualitative study. *South African Journal of Education*, *35*(3), 1-8.

Fraser, B. J. (1998). Classroom environment instruments: Development, validity and applications. *Learning Environments Research*, *1*(1), 7-34.

Fuchs, L. S., Fuchs, D., Finelli, R., Courey, S. J., Hamlett, C. L., Sones, E. M., & Hope, S. K. (2006). Teaching third graders about real-life mathematical problem solving: A randomized controlled study. *The Elementary School Journal*, *106*(4), 293-311.

Fung, Y. (2000). A Constructivis Strategy for Developing Teachers for Change: A Hong Kong Experience. *Journal of In-Service Education,* 26(1), pp.

153-167.DOI:10.1080/13674580000200108

Gall, M. D. (1970). The use of questions in teaching. *Review of Educational Research*, *40*(5), 707-721.

Gallagher, J., & Parker, J. (1995). Secondary science teacher analysis matrix (STAM). East Lansing, MI: Department of Teacher Education, Michigan State University.

Garret, T. (2008). Student-centered and teacher-centered classroom management: A case study of three elementary teachers*. Journal of Classroom Interaction, 43*(1), 34–47

Garet, M. S., Porter, A. C., Desimone, L., Birman, B.F., & Yoon, K.S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915-945.

Gersten, R. (1996). The double demands of teaching English language learners. *Educational Leadership*, *53*(5), 18-22.

Gersten, R., Ferrini-Mundy, J., Benbow, C., Clements, D., Loveless, T., Williams, V., Banfield, M. (2012). *Report of the task group on instructional practices* Washington, DC.: National Mathematics Advisory Panel, US Department of. Education.

Gleason, J., Livers, S.D., & Zelkowski, J. (2015). Mathematics classroom observation protocol for practices: Descriptors manual. Retrieved from http://jgleason.people.ua.edu/mcop2.html

Goldkuhl, G. (2012). Pragmatism vs interpretivism in qualitative information systems research. *European journal of information systems*, *21*(2), 135-146.

Goodell, J. (2000). Learning to teach mathematics for understanding: The role of reflection. *Mathematics Teacher Education and Development*, *2*, 48-60.

Grossman, R (1986). *A finger on mathematics*. Selby, RSA: RL Esson & Co.

Grouws, D. A. (2004). Mathematics.‖ In G. Cawelti. *Handbook of Research on Improving Student Achievement,*, 162-181.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In *Handbook of qualitative research*, *Vol*. *2* (pp. 163-194). Thousand Oaks, CA: Sage.

Guion, L. A., Diehl, D. C., & MacDonald, D. (2011). *Triangulation: Establishing the validity of qualitative studies*. Retrieved from: http://edis.ifas.ufl.edu/fy394

Haas, M. S. (2002). *The Influence of teaching methods on student achievement on Virginia's end of course standards of learning test for algebra I.* Doctoral dissertation. Retrieved from: https://vtechworks.lib.vt.edu/bitstream/handle/10919/29203/HAASDISSERTATION.PDF?sequence=1

Habermas, J. (1972). *Knowledge and human interest* (2nd ed.). (Translated by J.J Shapiro). London, England: Heinemann.

Hannah, R. (2013). The effect of classroom environment on student learning. Retrieved from http://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=3380&context=honors_theses

Harwell, S. H. (2003). *Teacher professional development: It's not an event, it'sa process*. Waco, TX: CORD.

Hidden Curriculum. (2014). Definition: Professional development. In S. Abbolt (Ed), *The glossary of education reform*. Retrieved from: http://edglossary.org/idden-curriculum.

Hiebert, J. (1999). Relationships between research and the NCTM standards. *Journal for Research in Mathematics Education*, *30*(1), 3-19.

Hogue, R. J. (2011). *Developing an appreciative understanding of epistemologies in educational research – One blogger's journey*. Retrieved from: https://www.academia.edu/12235888/Developing_an_Appreciative_Understanding_of_Epistemologies_in_Educational_Research_One_Bloggers_Journey

Hora, M. T., & Ferrare, J. J. (2013). Instructional systems of practice: A multidimensional analysis of mathematics and science undergraduate course planning and classroom teaching. *Journal of the Learning Sciences*, *22*(2), 212-257.

Horizon Research. (2000). Inside the classroom: teacher interview protocol Retrieved from: http://www.horizon-research.com/inside-the-classroom-interview-protocol, Accessed 16/02/2017.

Imenda, S.N. and Muyangwa, M.M. (2006). Introduction to Research in Educational and Behavioural Sciences. *Publication and Design Services. Tswhane University of Technology.*

IOWA Department of Education. (2011). *The Iowa core.* Retrieved from: https://www.educateiowa.gov/index.php?option=com_content&view=article&id=2485&itemid=4602

International Society for Technology in Education (2008). *ISTE Classroom Observation Tool (ICOT*®). Retrieved from: www.iste.org › docs › excel-files › icot

Jansen, D., & Warren, K.(2020). What (Exactly) is Research Methodology. A Plain Language Explanation & Definition (With Examples), GradCoach.

Jia, Q. (2010). A brief study on the implication of constructivism teaching theory on classroom teaching reform in basic education. *International Education Studies,* 3(2), 197-199.

Johnson, E., Ellis, J., & Rasmussen, C. (2016). It's about time: the relationships between coverage and instructional practices in college calculus. *International Journal of Mathematical Education in Science and Technology*, *47*(4), 491-504.

Jojo, Z. M., Dhlamini, J. J., Phoshoko, M. M., & Ngoepe, M. G.(2014). *Exploring the mathematical proficiency of grade 6 teachers: A case of Gauteng Tshwane East.* Retrieved from: http://www.amesa.org.za/AMESA2014/Proceedings/papers/Long%20Papers/Exploring%20Mathematics%20Teachers'%20proficiency%20(3).pdf

Jonassen, D. H. (1994). Thinking technology: Toward a constructivist design model. *Educational technology*, *34*(4), 34-37.

Jung, H. Y., & Reifel, S. (2011). Promoting children's communication: a kindergarten teacher's conception and practice of effective mathematics instruction. *Journal of Research in Childhood Education*, *25*(2), 194-210.

Khalid, A., & Azeem, M. (2012). Constructivist vs traditional: effective instructional approach in teacher education. *International Journal of Humanities and Social Science*, *2*(5), 170-177.

Kameeniu, K. J., Darch, C. B., Carnine, D. W., & Stein, M. L. (1986). Two approaches to the developmental phase of mathematics instruction. *The Elementary School of Journal, 86*(5), 633-650

Kilpatrick, J., & Swafford, J. (2002). *Helping children learn mathematics*. Washington, D.C.: National Academy Press.

Kincheloe, J. L. (2005). *Critical constructivism primer (Vol. 2).* New York, NY: Peter Lang.

Koehler, M., & Mishra, P. (2009). What is technological PCK (TPACK)?. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60-70.

Kropiewnicki, M. (2006). *An investigation of effective instructional methods to train preservice teachers in reading comprehension strategies.* Retrieved from: https://files.eric.ed.gov/fulltext/ED492002.pdf

Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago, IL: University of Chicago Press.

Kuhn, T. S. (1977). *The Essential tension.* Chicago, IL: University of Chicago Press.

Lancaster, G. (2005). *Research methods in management. A concise introduction to research in management and business consultancy*. Oxford, England: Jordan Hill.

Larson, M. (2002). Essential characteristics of effective mathematics instruction. Retrieved from: https://www.eduplace.com/state/pdf/author/larson1.pdf

Lee, G. V., & Barnett, B. G. (1994). Using reflective questioning to promote collaborative dialogue. *Journal of Staff Development*, *15*(1), 16-21.

Leedy, P.D. & Ormrod, J.E. (2010). *Practical research: Planning and design*. (9th ed.), Boston, MA: Pearson.

Lerman, S. (Ed.). (2014). *Encyclopedia of mathematics education* (pp. 579-582). Dordrecht: Springer.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry* (*Vol. 75*). Thousand Oaks, CA: Sage.

Lindvall, J. (2017). *Critical features and impacts of mathematics teacher professional development programs: Comparing and characterizing programs implemented at scale* (Doctoral dissertation, Mälardalen University).

Little, J. W. (1987). Teachers as colleagues. In V. Richardson-Koehler (Ed.), *Educators' handbook: A research perspecti*ve (pp. 491-518). New York, NY: Longman.

Liu, C. H., & Matthews, R. (2005). Vygotsky's philosophy: Constructivism and Its criticisms examined. *International Education Journal*, *6*(3), 386-399.

Mabrouk, P.A. (Ed.) (2007). Active learning: Models from the analytical sciences. *ACS Symposium Series 970, Chapter 4*, (pp. 34–53). Washington, DC: American Chemical Society.

MacSuga-Gage, A. S., Simonsen, B., & Briere, D. E. (2012). Effective teaching practices: Effective teaching practices that promote a positive classroom environment. *Beyond Behavior*, *22*(1), 14-22.

Maddux, C. D., Johnson, D. L., & Willis, J. W. (1997). *Educational computing: Learning with tomorrow's technologies.* Boston, MA: Pearson.

Major, T. E., & Mangope, B. (2012). The constructivist theory in mathematics: The case of Botswana Primary Schools. *International Review of Social Sciences and Humanities*, *3*(2), 139-147.

Marlowe, B. A. and Page, M. L. (1998). Creating and sustaining the constructivist classroom. Thousand Oaks, CA: Corwin. 10.

Marlowe, B. A. , Mathur, S. R., & Schoenfeld, N. (2010). Effective instructional practices in juvenile justice facilities. *Behavioral Disorders*, *36*(1), 20-27.

Mativandlela, P. M. (2009). Analysing Learner Perception of interpersonal teacher behaviour and achievement in grade 10 mathematics classes.(M.Ed). University of Limpopo.

McMillan, J. H., & Schumacher, S. (2001). *Research in education A conceptual introduction.* (5th ed.). Bostaon, MA: Addison Wesley, Longman.

McMillan, J. H., & Schumacher, S. (2014). *Research in education: Evidence-based inquiry*. Boston, MA: Pearson Higher Ed.

McRobbie, C. J., & Fraser, B. J. (1993). Associations between student outcomes and psychosocial science environment. *The Journal of Educational Research*, *87*(2), 78-85.

Dictionary, M. W. (2002). Merriam-webster. *On-line at http://www. mw. com/home. htm*.

Mertler, C.A. & Charles, C. M. (2011). *Introduction to educational research*. (7th ed.). Boston, MA: Pearson Education.

Miller, R., & Pedro, J. (2006). Creating respectful classroom environments. *Early Childhood Education Journal*, *33*(5), 293-299.

Milondzo, K.S. (2006). The role of power in school leadership*. Paper Delivered at Principals' Conference*, Manyeleti Game Reserves, 15-17 October, 2006.

Mok, A. C. I. (2012, July). Research on mathematics classroom practice: An international perspective. *Paper presented at the 12th International Congress on Mathematical Education*. 8–15 July 2012. COEX, Seoul, Korea.

Moser, A. & Korstjens, I. (2018). Series: Practical guidance to qualitative research. Part 3: Sampling, data collection and analysis, European Journal of General Practice, (24)1, 9-18, DOI: 10.1080/13814788.2017.1375091

Mosala, O. L. (2011). *Problems encountered by educators regarding the implementation of the national curriculum statement in mathematics.* Doctoral dissertation. Bloemfontein, RSA: Central University of Technology.

Mouton, J. (2004). *How to succeed in your master's & doctoral studies: A South African guide and resource book*. Pretoria: Van Schaik.

Mudavanhu, Y. (2017). Quality of Literature Review and Discussion of Findings in Selected Papers on Integration of ICT in Teaching, Role of Mentors, and Teaching Science through Science, Technology, Engineering, and

Mathematics (STEM). *Educational Research and Reviews*, *12*(4), 189-201.

Munroe, L. (2015). The Open-Ended Approach Framework. *European Journal of Educational Research, 4(3), 97-104.*

National Center for Education Evaluation. (2013). *Instructional practices and student mathematics achievement: Correlations from a study of mathematics curricula.* Retrieved from: https://files.eric.ed.gov/fulltext/ED544189.pdf

National Center for Research in Mathematics. (1992). *Mathematics classroom observation protocol.* Madison, WI: Wisconsin Center for Educational Research, University of Wisconsin-Madison.

National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all*. Reston, VA: NCTM.

National Research Council. (2001). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Neuman, W. L. (1997). Social research methods: qualitative and quantitative approaches. Allyn & Bacon. *Needham Heights, USA*.

Newton, D.P. (2000). *Teaching for understanding: What it is and how to do it.* London, England: Routledge Falmer.

Ngoepe, M.G. & Treagust, D. (2003). Investigating the classroom practices of secondary mathematics teachers in the township schools of South Africa. *Paper presented at the Joint AARE/NZARE Conference*, Auckland, pp. 1-10.

Ngoepe, M.G. (2003). A glance into interaction in some South African township mathematics classrooms. *Mediterranean Journal of Social S*cience, *4*(13), 435-439.

Ngoepe. M.G. (2013, December). Investigating the classroom practices of secondary mathematics teachers in the township schools of South Africa. *Paper presented at the joint AARE/NZARE Conference,* University of Aucklamd, Auckland. 29 November – 3 December.

Ngoepe, M.G. (2014). An examination of some instructional practices in selected rural secondary schools. *Mediterranean Journal of Social Sciences.* MCSER Publishing, *5*(9), 464-469.

Nørreklit, H. (2011). Actor-reality construction – A pragmatic constructivist approach to management and accounting. *Proceedings of Pragmatic Constructivism*, *1*(1), 5-6.

Okeke, C., & van Wyk, M. (2016). *Educational research: An African approach.* Capetown, RSA: Oxford University Press.

Owusu, J. (2015). *The impact of constructivist-based teaching method on secondary school learners' errors in algebra*. Doctoral dissertation. Pretoria, RSA: University of South Africa.

Özden, M. (2008). The effect of content knowledge on pedagogical content knowledge: The case of teaching phases of matters. *Educational Sciences: Theory and Practice*, *8*(2), 633-645.

Pang, J. S. (2012). Changing teaching practices toward effective mathematics instruction in the Korean Context: Characteristics and implications. *ZDM Mathematics Education*, *44*, 137-148.

Patel, S. (2015). *Research methods: The research paradigm-methodology, epistemology and ontology – explained in simple language*. Retrieved from: http://salmapatel.co.uk/academia/the-research-paradigm-methodology-epistemology-and-ontology-explained-in-simple-language

Pausigere, P. (2014). *Primary maths teacher learning and identity within a numeracy in-service community of practice*. Doctoral dissertation. Grahamstown, RSA: Rhodes University.

Piaget, J. (1970). *Structuralism*. New York, NY: Basic Books.

Pitsoe, V. J. (2008). *A conceptual analyisis of constructivist classroom management.* Doctoral dissertation. Pretoria, RSA: University of Pretoria.

Pournara, C., Hodgen, J., Adler, J., & Pillay, V. (2015). Can Improving teachers' knowledge of mathematics lead to gains in learners' attainment in mathematics? *South African Journal of Education*, *35*(3), 01-10.

Pretorius, E. J. (2000). *Inference generation in the reading of expository texts by university students*. Doctoral dissertation. Pretoria, RSA: University of South Africa).

Pretorius, S.G. (2013). Teacher effectiveness in South African context: First steps towards a comprehensive definition. *Journal of Social Sciences, 36*(3), 235-246.

Ramey, K. E., Champion, D. N., Dyer, E. B., Keifert, D. T., Krist, C., Meyerhoff, P., ... & Hilppö, J. (2016). Qualitative analysis of video data: Standards and heuristics. Singapore: International Society of the Learning Sciences.

Rittle-Johnson, B. (2006). Promoting transfer: Effects of Self –Explanation and Direct Instruction. *Child Development*, *77*(1), 1-15.

Roberts, J. (2016). *Language teacher education*. London, England: Routledge.

Rowland, T., Turner, F., Thwaites, A. & Huckstep, P. (2009). *Developing primary mathematics teaching: Reflecting on practice with the knowledge quartet*. London, England: Sage.

Schneidmiller. J. (2008). *International society for technology in education (ISTE) Classroom observation tool.* Retrieved from: http://www.iste.org/icot.

Scott, D. (2014). Knowledge and curriculum. *The Curriculum Journal*, *25*(1), 14-28.

Serra, R., & Marco, Q. (2015). What Is reflective teaching and why is it important.

Sepeng, P. (2013). Exploring mathematics classroom practices in South African multilingual setting. *Mediterranean Journal of Social Sciences, 4(*6), 627- 638

Shepherd, D. L. (2011, June). The impact of teacher subject knowledge on learner performance in South Africa: A within-pupil across-subject approach. *2nd International Workshop on Applied Economics of Education.* Cantanzaro, Italy*.* 20–21 June 2011. (pp. 1-32).

Shellard, E., & Moyer, P. S. (2002). *What principals need to know about teaching math*. Alexandria, VA: National Association of Elementary School Principals,

Shulman, L.S. (1986). Those who understand: *Knowledge growth in teaching. Educational Researcher*, 15(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations for the new reform. *Harvard Educational Review*, 57 (1), 1-22.

Shulman, L.S. (1995). Those who understand: Knowledge growth in teaching. In B.

Moon & A.S. Mayes (Eds.), *Teaching and* learning in the secondary school London, England: Routledge.

Simmons, R.W. & Kamlay, M. (1999). *Action research in urban science classroom: Inquiry teaching and African American youth*. Detroit, MI: Lawrence Technological University.

Slavin, R. E. (2008). Perspectives on evidence-based research in education—What works? Issues in synthesizing educational program evaluations. *Educational researcher*, *37*(1), 5-14.

Spaull, N. (2013). *South Africa's education crisis: The quality of education in South Africa 1994- 2011*. Johannesburg, RSA: The Centre for Development and Enterprise.

Steedly, K., Dragoo, K., Arafeh, S & Luke, S. D.(2008). Effective mathematics instruction. *Evidence for Education*, *1*(3),1-11.

Stepanek, J. (2000). *Mathematics and science classrooms: Building a community of learners. It's just good teaching*. Portland, OR.: Northwest Regional Educational Laboratory.

Tashakkori, A., & Teddlie, C. (2003). Handbook on mixed methods in the behavioral and social sciences.

TIMMS. (2004). *Trends in international mathematics and science study (TIMMS).* Botson, MA: Lynch School of Education, Boston College: TIMMS Centre.

Tracey, D. H., & Morrow, L. M. (2012). *Lenses on reading: An introduction to theories and models* (2nd ed.). New York, NY: Guilford Press.

Turnuklu, E.B., & Yesildere, S. (2007). The PCK in mathematics: Pre- Service Primary mathematics Teachers' perspectives in Turkey. *IUMPST: The Journal,* (1), 1-13.

Van de Walle, J.A; Karp, K.S.; & Bay-Williams, J.M. (2016). *Elementary and middle school mathematics. Teaching developmentally*. Boston, MA: Pearson Global Edition.

Verinikina, I. (2008). Scaffolding and learning: Its role in nurturing new learners. In P. Kell, W. Vialle; D. Konza & G. Vogl. (Eds.), *Learning and the learner:*

Exploring learning for new times. Wollongong, Australia: University of Wollongong.

Von Glaserfeld, E. (1995). *Radical constructivism: A way of knowing and Learning*. London, England: The Falmer.

Vygotsky, L.V. (1978). Interaction between learning and development. In *Mind and Society*, (pp. 79-91). Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1987). Thinking and speech. In R.W. Rieber & A.S. Carton (Eds.), *The collected works of L.S. Vygotsky, Volume 1: Problems of general psychology* (pp. 39–285). New York: Plenum Press. (Original work published 1934.)

Wachira, P., Pourdavood, R.G., & Skitzki, R. (2013). Mathematics teachers' role in promoting classroom discourse. *International Journal for Mathematics Teaching and Learning, 13*(1), 1-38.

Walliman, N. (2011). *Your research project: Designing and planning your work*. Thousand Oaks, CA: Sage.

Warin, P. (2009). A pragmatic constructivism. In S. Narath & F. Varone (Eds.). *Rediscovering public law and public administration in comparative policy analysis: Tribute to Peter Knoepfel*. Presses polytechniques et universitaires romandes / Haupt Verlag, pp.319-332.

Weiss, I. R., Banilower, E. R., McMahon, K. C., & Smith, P. S. (2001). *National survey of science and mathematics education.* Retrieved from: http://www.horizon-research.com/712-2

Wells, G. (1999). *Dialogic inquiry: Towards a sociocultural practice and theory in education*. New York, NY: Cambridge University Press.

Wieman, C., & Gilbert, S. (2014). The teaching practices inventory: A new tool for characterizing college and university teaching in mathematics and science. *CBE – Life Sciences Education*, *13*(3), 552-569.

Williams, K. (2015). *The effects of computer-assisted instructions on the mathematics achievement of students with emotional and behavioural disorders.* Richmond, VA: Virginia Commonwealth University.

WNET Education. (2004). *Concept to classroom: Constructivism as a paradigm for teaching and learning.* Retrieved from: http://www.thirteen.org/edonline/concept2class/constructivism/index.html

Woods, T., & Sellers, P. (1997). Deepening the analysis: Longitudinal assessment of a problem-centered mathematics program. *Journal for Research in Mathematics Education*, *28*(2), 163–186.

Woods, M. (2011). *Interviewing for research and analysing qualitative data: An overview.* Palmerston North, New Zealand: Massey University, 67-80.

Wu, L. (2008). On the different social scripts of teaching and learning between Chinese and Westeners. *Intercultural Communication Studies XVI*(1), 115-125.

Yackel, E., & Cobb, P. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education*, 27, 458-477.

APPENDICES

APPENDIX A: ETHICS CLEARANCE CERTIFICATE

UNISA university of south africa

COLLEGE OF EDUCATION RESEARCH ETHICS REVIEW COMMITTEE

16 November 2016

Ref : **2016/11/16/34385711/59/MC**
Student : Mr JF Malatjie
Student Number : 34385711

Dear Mr Malatjie,

Decision: Approved

Researcher: Mr JF Malatjie
Tel: +2782 511 7179
Email: jmnfourrie.malatjie7@gmail.com

Supervisor: Prof MG Ngoepe
College of Education
Department of Mathematics Education
Tel: +2712 429 8375
Email: ngoepmg@unisa.ac.za

Proposal: A framework for the development of effective instructional teaching practices of Mathematics. A case of selected rural schools in Limpopo

Qualification: D Ed in Curriculum and Instructional Studies

Thank you for the application for research ethics clearance by the College of Education Research Ethics Review Committee for the above mentioned research. Final approval is granted for the duration of the research.

The application was reviewed in compliance with the Unisa Policy on Research Ethics by the College of Education Research Ethics Review Committee on 16 November 2016.

The proposed research may now commence with the proviso that:

1) *The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the College of Education Ethics Review Committee. An amended application could be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for*

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

the research participants.

3) *The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.*

Note:

The reference number **2016/11/16/34385711/59/MC** *should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] with the intended research participants, as well as with the College of Education RERC.*

Kind regards,

Dr M Claassens
CHAIRPERSON: CEDU RERC
mcdtc@netactive.co.za

Prof VI McKay
EXECUTIVE DEAN

APPENDIX B: LETTER TO DISTRICT

"A FRAMEWORK FOR THE DEVELOPMENT AND IMPLEMENTATION OF EFFECTIVE INSTRUCTIONAL TEACHING PRACTICES OF MATHEMATICS. A CASE OF A SELECTED RURAL SCHOOL IN LIMPOPO"

UNISA | college of education

13 July 2017

Malatie Jeffrey Fourrie

Department ofMathematics Education

malatjf@unisa.ac.za/jmnfourrie.malatjie7@gmail.com -0825117179

Dear District Senior Manager- Mr T G Nkadimeng

Request for permission to conduct research in Sekhukhune District

I, Malatjie Jeffrey Fourrie am doing research with Prof Ngoepe Mapula, a Professor in the Department of Mathematics Education towards a PhD at the University of South Africa. We are inviting you to participate in a study entitled "**A framework for the development and implementation of effective instructional teaching practices of mathematics. A case of a selected rural school in Limpopo".**

The aim of the study is to explore the classroom instructional practices of mathematics teachers through classroom-based research and professional development that could lead to improved mathematics instructional practices (Effective mathematics instructional practices).

Your district has been selected because the circuit and schools that are selected fall in and that the problem area was identified in the same district. The request will also be sent to the Circuit Manager later this year after your respond. Your response letter will be attached to the circuit manage.

The study will entail classroom-based research on two schools (one being a pilot and the other study) in Malokela Circuit where in Grades 9, 10 and 11 mathematics teachers will participate.

Teachers will be trained on effective mathematics instructional practices, be allowed to implement in their own mathematics classrooms respectively, observed and video-recorded while implementing and after every lesson reflective interviews will be conducted and voice recorded.

The benefits of this study are teacher's instructional practices could be improved and learners' mathematical understanding and mathematical achievement could be improved.

There are no potential risks in connection with the study. Feedback procedure will entail the findings and report on the findings from the study. The circuit and the teachers will be given the written report to read to see if it gives exact information that was recorded and captured.

Yours sincerely,

Malatjie Jeffrey Fourrie

Student- Researcher

APPENDIX C: LETTER FROM DISTRICT

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

SEKHUKHUNE DISTRICT

Enq: Thoka RP
Tel: 015 633 2902
Date: 10/02/2017

To: Malatjie Jeffrey Fourrie
Department of Mathematics
University of South Africa (UNISA)

From: District Director
Sekhukhune District

SUBJECT: GRANTED PERMISSION TO CONDUCT RESEARCH

1. The above matter refers.

2. Kindly be informed that your research application to conduct research in Malokela Circuit ,Limpopo Province, focusing on the title **" a framework for the development of effective instructional teaching practices of mathematics a case of selected rural school in Limpopo,** is approved.

3. Please note you should conduct your research in line with research ethics as prescribed by your institution and international norms and standards for research.

4. The district wishes you well in your research and awaits your findings with great interest.

Nkadimeng

Nkadimeng T.G
DISTRICT SENIOR MANAGER

10.02.2017
DATE

APPENDIX D: LETTER TO CIRCUIT

"A FRAMEWORK FOR THE DEVELOPMENT AND IMPLEMENTATION OF EFFECTIVE INSTRUCTIONAL TEACHING PRACTICES OF MATHEMATICS. A CASE OF SELECTED RURAL SCHOOL IN LIMPOPO"

UNISA college of education

13 July 2017

Malatjie Jeffrey Fourrie

Department ofMathematics Education

malatjf@unisa.ac.za/jmnfourrie.malatjie7@gmail.com -0825117179

Dear Circuit Manager- Mrs M TD Monyela,

Request for permission to conduct research at Malokela Education Circuit

I, Malatjie Jeffrey Fourrie am doing research with Prof Ngoepe Mapula, a Professor in the Department of Mathematics Education towards a PhD at the University of South Africa. We are inviting you to participate in a study entitled "**A framework for the development of effective instructional teaching practices of mathematics. A case of selected rural school in Limpopo".**

The aim of the study is to study is to explore the classroom instructional practices of mathematics teachers through classroom-based research and professional development that could lead to improved mathematics instructional practices (Effective mathematics instructional practices).

Your circuit has been selected because the schools that are selected fall in and that the problem area was established in the same circuit. The request was also sent to the Sekhukhune District Senior Manager (DSM) earlier this year and was responded to. See the attached DSM letter.

The study will entail classroom-based research on two schools (one being a pilot and the other study) in Malokela Circuit where in Grades 9, 10 and 11 mathematics teachers will participate. Teachers will be trained on effective mathematics instructional practices, be allowed to implement in their own mathematics classrooms respectively, observed and video-recorded while implementing and after every lesson reflective interviews will be conducted and voice recorded.

The benefits of this study are teacher's instructional practices could be improved and learners' mathematical understanding and mathematical achievement could be improved.

There are no potential risks in connection with the study. Feedback procedure will entail the findings and report on the findings from the study. The circuit and the teachers will be given the written report to read to see if it gives exact information that was recorded and captured.

Yours sincerely,

Malatjie Jeffrey Fourrie

Student- Researcher

APPENDIX E: LETTER TO SCHOOL

Malatjie Jeffrey Fourrie

malatjf@unisa.ac.za/jmnfourrie.malatjie7@gmail.com- 0825117179

Department of Mathematics Education (DME)

College of Education

University of South Africa

24 August 2016

Dear Principal and SGB

I, Malatjie Jeffrey Fourrie am doing research with Prof Ngoepe Mapula, a Professor in the Department of Mathematics Education towards a PhD in Education at the university of South Africa. We are inviting you to participate in the study entitled “A Framework for the development and implementaionof effective mathematics instructional practices. A Case of a selected rural school in Limpopo”. The aim of the study is to explore the classroom instructional practices of mathematics teachers through classroom-based research and professional development which could lead to improved mathematics instructional practices (Effective mathematic instructional practices).

Your school has been selected because it falls within the circuit and that the problem area was established in the same circuit and because you are experts for the study.

The study will entail classroom-based research on two mathematics teachers and their Grade 10 and 11 mathematics learners respectively. Teachers will be trained on the framework for effective mathematics instructional practices. The teachers will be given an opportunity to implement the framework in their own mathematics classrooms. Both teachers and learners classes will be observed and video-recorded while teachers are teaching and learners are learning. After every lesson, reflective interviews will be done with each teacher in the presence of the other.

The benefits of this study are teacher's instructional practices could be improved and learners'mathematical understanding and mathematics achievement could be improved. There are no potential risks to the study.

Feedback procedure will entail findings and report on the findings from the study. The district, circuit, school and teachers will be given written report to read and see if it gives exact information of what took place.

Yours sincerely

____

Malatjie Jeffrey Fourrie

Student-Researcher

______________________	______________________	______________
Principal's name (print)	Principal' signature	Date
______________________	______________________	______________
SGB Chairperson's name (print)	SGB Chairperson's signature	Date

APPENDIX F: LETTER FROM SCHOOL

"A FRAMEWORK FOR THE DEVELOPMENT OF EFFECTIVE INSTRUCTIONAL TEACHING PRACTICES OF MATHEMATICS. A CASE OF SELECTED RURAL SCHOOLS IN LIMPOPO"

UNISA college of education

Malatjie Jeffrey Fourrie

malatjf@unisa.ac.za/jmnfourrie.malatjie7@gmail.com -0825117179

Department of Mathematics Education (DME)

Colleges of Education

University of South Africa

24 August 2016

Dear Principal and SGB,

I, Malatjie Jeffrey Fourrie am doing research with Prof Ngoepe Mapula, a Professor in the Department of Mathematics Education towards a PhD in Education at the University of South Africa. We are inviting you to participate in a study entitled **"A framework for the development of effective instructional teaching practices of mathematics. A case of selected rural schools in Limpopo".**

The aim of the study is to study is to explore the classroom instructional practices of mathematics teachers through classroom-based research and professional development which could lead to improved mathematics instructional practices (Effective mathematics instructional practices).

Your school has been selected because the schools that are selected fall within the circuit and that the problem area was established in the same schools and because they are experts for the study.

The study will entail classroom-based research on three schools in Malokela Circuit. Three classes (Grade 9, 10 and 11) Mathematics Teachers will be trained on the framework for effective mathematics instructional practices. The teachers will be given an opportunity to implement the framework in their own mathematics classrooms. Both the teachers and learners in Grade 9, 10 and 11 Mathematics classes for each school will be observed and video recorded whilst teachers are implementing and learners are learning. After eve lesson reflective interviews will be done with each teacher.

The benefits of this study are teacher's instructional practices could be improved and learners' mathematic understanding and mathematical achievement could be improved. There are no potential risks on the study.

Feedback procedure will entail the findings and report on the findings from the study. The district, th circuit and the teachers will be given the written report to read and see if it gives exact informatio what was took place.

Yours sincerely

Malatjie Jeffrey Fourrie

Student- Researcher

MOHLALA MJ

Principal's name (print) Principal's signature: Date: 24·07·2017

LEKUBU MJ

SGB Chairperson's name (print) SGB Chairperson's signature: Date: 24/07/201

DEPARTMENT OF EDUCATION
POTOKO SECONDARY SCHOOL
22 SEP 2017
P.O. BOX 2354 MOROKE 1154
LIMPOPO PROVINCE

APPENDIX G: LETTER TO PARTICIPANT TEACHERS

24 August 2016

Title: "**A FRAMEWORK FOR THE DEVELOPMENT OF EFFECTIVE INSTRUCTIONAL TEACHING PRACTICES OF MATHEMATICS. A CASE OF SELECTED RURAL SCHOOLS IN LIMPOPO"**

Dear Prospective Participant

My name is Malatjie Jeffrey Fourrie and I am doing research with Prof Ngoepe Mapula, a Professor in the Department of Mathematics Education towards a PhD, at the University of South Africa. We are inviting you to participate in a study entitled "a framework for the development of effective instructional teaching practices of mathematics. a case of selected rural school in Limpopo"

I am conducting this research to find out current teachers instructional practices, develop and implement a framework for effective mathematics instructional practices. The study will help you in identifying your current practices and been trained on recent teaching developments and hence improve learners' mathematics understanding and achievement.

You are chosen because the focus of the study problem is the area were you are located and further that you will provide accurate and relevant information pertaining to the identified problem Grade 10 and 11 mathematics teachers and their learners from one secondary school will form part of the study.

The study involves lesson planning observation, classroom observation, video taping and unstructured reflective interviews. And the questions to be asked on the reflective interviews will be based mainly on the lesson plans observed, classroom observations and the video tape would help in reviewing what happened. You are expected to participate in the study for twelve days in total each. The first two days of the first week will be evaluating your current practices, training on the effective instructional practices on the same point being two and from there each will be required to implement for remaining days on different times. The other activities will be done at your own subject period. The individual reflective interviews will take for 30minutes after every lesson for all lessons.

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason. Your identification will not be revealed during reporting-pseudo codes will be used instead of your identity and the video recording will not form part of the submission and will be kept

You have the right to insist that your name will not be recorded anywhere and that no one, apart from the researcher and identified members of the research team, will know about your involvement in this research *(this measure refers to confidentiality)* OR your name will not be recorded anywhere and no one will be able to connect you to the answers you give (*this measure refers to anonymity)*. Your answers will be given a code number or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings *(this measure refers to confidentiality).*

The transcriber, external coder and research assistant will have access to the data will maintain confidentiality *by signing a confidentiality agreement.* Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Review Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

While every effort will be made by the researcher to ensure that you will not be connected to the information that you share during the focus group, I cannot guarantee that other participants in the focus group will treat information confidentially. I shall, however, encourage all participants to do so. For this reason I advise you not to disclose personally sensitive information in the focus group.

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet *of the researcher's home* for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. After the required time, *hard copies will be shredded and electronic copies will be permanently deleted from the hard drive of the computer through the use of a relevant software programme.*

There will be no payment for taking part in this research study. This study has received written approval from the Research Ethics Review Committee of the *CEDU ERC,* Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

If you would like to be informed of the final research findings, please contact Malatjie Jeffrey Fourrie on 0825117179/ 0124292220 or email:malatjf@unisa.ac.za or jmnfourrie.malatjie7@gmail.com or website: http//:www.unisa.ac.za. The findings are accessible for two years.

Should you require any further information or want to contact the researcher about any aspect of this study, please contact: Prof Ngoepe M.G, email: ngoepmg@unisa.ac.za, cell: 082 9633 706 or 012 429 8375

Should you have concerns about the way in which the research has been conducted, you may contact: Prof Ngoepe M.G, email: ngoepmg@unisa.ac.za, cell: 082 9633706 or 012 429 8375

Alternatively, contact the research ethics chairperson of the CEDU ERC, Dr Claasens and email: classa@unisa.ac.za, 012 429

Thank you for taking time to read this information sheet and for participating in this study.

Thank you.

____

Malatjie Jeffrey Fourrie

APPENDIX H: LETTER TO PARENTS

"A FRAMEWORK FOR THE DEVELOPMENT AND IMPLEMENTATION OF EFFECTIVE INSTRUCTIONAL TEACHING PRACTICES OF MATHEMATICS. A CASE OF SELECTED RURAL SCHOOL IN LIMPOPO"

UNISA | college of education

13 July 2017

Malatjie Jeffrey Fourrie

Department of Mathematics Education

jmnfourrie.malatjie7@gmail.com - 0825117179

Dear Parent

Your child is invited to participate in a study entitled "A framework for the development of effective instructional teaching practices of mathematics. A case of selected rural school in Limpopo". I am undertaking this study as part of my doctoral research at the University of South Africa. The purpose of the study is to train teachers on effective instruction and allow them to present to their learners and the possible benefits of the study are the improvement of mathematics performance and mathematical understanding. I am asking permission to include your child in this study because she is doing Grade 10/11 mathematics classroom. I expect to have all the Grade 10/11 learners of mathematics participating in the study.

If you allow your child to participate, I shall request him/her to

- Take part in a classroom observation

Any information that is obtained in connection with this study and can be identified with your child will remain confidential and will only be disclosed with your permission. His or her responses will not be linked to his or her name or your name or the school's name in any written or verbal report based on this study. Such a report will be used for research purposes only.

There are no foreseeable risks to your child by participating in the study. Your child will receive no direct benefit from participating in the study; however, the possible benefits to education are solution to poor mathematics performance and lack of mathematical understanding. Neither your child nor you will receive any type of payment for participating in this study.

Your child's participation in this study is voluntary. Your child may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly, you can agree to allow your child to be in the study now and change your mind later without any penalty.

The study will take place during regular classroom activities with the prior approval of the school and your child's teacher. However, if you do not want your child to participate, an alternative activity will be available.

In addition to your permission, your child must agree to participate in the study and you and your child will also be asked to sign the assent form which accompanies this letter. If your child does not wish to participate in the study, he or she will not be included and there will be no penalty. The information gathered from the study and your child's participation in the study will be stored securely on a password locked computer in my locked office for five years after the study. Thereafter, records will be erased.

If you have questions about this study please ask me or my study supervisor, Prof Ngoepe, Department of Mathematics Education, College of Education, University of South Africa. My contact number is 0825117179 and my e-mail is malatjf@unisa.ac.za/ jmnfourrie.malatjie7@gmail.com. The e-mail of my supervisor is ngoepmg@unisa.ac.za. Permission for the study has already been given by the Ethics Committee of the College of Education, UNISA.

You are making a decision about allowing your child to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow him or her to participate in the study. You may keep a copy of this letter.

Name of child:________________________

Sincerely

______________________ ________________________ ___________

Parent/guardian's name (print) Parent/guardian's signature: Date:

Malatjie Jeffrey Fourrie ________________________ _____________

Researcher's name (print) Researcher's signature Date:

APPENDIX I: LETTER TO LEARNERS AND ACCENT FORM FROM LEARNERS

Appendix K: Assent form for learners

UNISA college of education

Malatjie Jeffrey Fourrie

malatjf@unisa.ac.za/jmnfourrie.malatjie7@gmail.com -0825117179

Department of Mathematics Education (DME)

Colleges of Education

University of South Africa

24 August 2016

WRITTEN ASSENT

I have read this letter which asks me to be part of a study at my school. I have understood the information about my study and I know what I will be asked to do. I am willing to be in the study.

MOROPANA ANTHONY	M.A.T	05 September 2017
Learner's name (print):	Learner's signature:	Date:
MORABA RUTH	M.R	05 septembe 2017
Witness's name (print)	Witness's signature	Date:

(The witness is over 18 years old and present when signed.)

Moropana M.R	M.A Moropana	05september 2017
Parent/guardian's name (print)	Parent/guardian's signature:	Date:
MALATJIE J FOURRIE	[signature]	24/08/2016
Researcher's name (print)	Researcher's signature:	Date:

APPENDIX J: CLASSROOM OBSERVATION INSTRUMENT

Date of the lesson:________________Topic:___________________________

Time:____________Duration:______________Teacher:______________

	What to be observed	What is observed
A. Teacher's question in the classroom	1. What kind of questions is the teacher asking	
	2. How is the quality of the questions that the teacher asks?	
	3. Are the questions checking on learners' knowledge?	
B. Creating Environment of respect and rapport	1. Are learners talking to each other	
	2. Are learners in each group discussing their solutions	
	3. What words and actions is the teacher saying and doing to learners	
	4. What actions and words are learners saying to each other	
	5. Are learners explaining their solution to whole class	
C. Assessment	1. Is assessment meant for understanding or for grading?	
	2. Is assessment based on the problem conjecture/ investigation?	
	3. What type of assessments are used in the lesson	

D. Resources	1. What kind of resources are present/used	
	2. Are the resources related to the content/ problem/ conjecture or investigation?	
	3. Are the resources accessible to learners	
	4. Who direct the use of resources	
	5. Is there an inclusion of ICT on the resources?	
E. Mathematics Concepts	1. Is the teacher using correct mathematics concepts	
	2. Are learners using correct mathematics concepts in their discussion or explanation of their solutions	

APPENDIX K: LESSON PLAN OBSERVATION INSTRUMENT

Lesson Plan Observation Instrument (LPOI)

Teacher:______________ Date:__________Duration:______________

Items on the plan	**Description**	**Comments**
Topic	Is the topic based on problem/ conjecture to be solved?	
	Is it investigative/does it includes investigation?	
	It there a chance of formulating conjecture or a general rule?	
Time division	is the time spread evenly to allow learners input?	
	is there a time for group work?	
	is there a time for individual learner?	
Objectives	Are objectives generated by teacher and learners?	
	Did learners had an input on the objectives?	
	Are the objectives based on investigation?	

	Are objectives arising from previous lesson?	
Content	Does the nature of the content focus on investigation dominates	
	Is the content constructed from learners' prior knowledge and background?	
	Is the content question dependent?	
	As part of problem-solving	
Teacher activities	Is the teacher acting as facilitator?	
	Is the teacher guiding investigations	
	Is the teacher's activities question dependent?	
	Does the teacher's activities includes assessment?	
	Are learners allowed to communicate their solutions and processes?	

Learner Activities	Is Cooperative learning included in the lesson?	
	Are individuals working alone and with others?	
	Conceptual, applied to investigation	
	Are they communicating amongst themselves about the solution processes?	
Resources	Who has authority on the choice of resources?	
	Are the resources relevant to the problem/conjecture/ investigation	
	Are multiple resources used?	
	Is there any inclusion of ICT in the lesson?	
Environment	Does the environment cater for learning	
	Does the environment cater for investigation/ problem-solving?	
	Is there enough space for discussion among learners?	

Assessment	Is assessment included in the whole lesson	
	Is assessment continuous and based on investigation or problem-solving or conjecturing?	
	Are multiple forms of assessment used?	
	Is the purpose of assessment for planning the lesson and instructional practices?	

APPENDIX L: RESEARCH VIDEO ANALYSIS INSTRUMENT

Research Video Analysis Instrument

Teacher___________________Level/Class________Number of Students ______

1. Physical Setting/Classroom Environment (Mark all that apply.)

A. Classroom Facility

- Classroom adequate size for student number
- Adequate storage for resources/materials/equipment
- Furnishings allow for inquiry-based instruction
- Student Seating_____rows_____pairs______small groups_____other ______________
- Room size will accommodate activities
- Flat top surfaces are sufficient for investigations, projects, displays, etc.

B. Classroom Environment

- Mathematics manipulatives/tools evident
- Mathematics displays/posters promote learning
- Core curriculum materials evident
- Mathematics student work displayed
- Adequate resources available for hands-on lesson (as appropriate)

C. 21st Century Tools

- Class set of calculators available - type _________________________
- Interactive Whiteboard
- Number of computers available to students_____teacher _____

- Projection system
- Document camera

2. Lesson Effectiveness (Mark all that apply.)

A. Major Instructional Resources Used

- Textbook ☐ Manipulatives ☐ Computer to access Internet
- Other print materials ☐ Calculators ☐ Computer to collect/analyze data
- Overhead ☐ Overhead Calculator ☐ Computer to practice a skill
- CD/DVD ☐ 21st Century Tools ☐ Mathematics tools (rulers, compass, protractor, etc.)
- Document Camera ☐ TI-Navigator ☐ Palms
- GPS ☐ Software like Sketchpad, Tinkperplots, or Fathom

B. Content Focus

- Number/computation
- Algebra/pre-calculus/calculus
- Geometry
- Measurement
- Data/Probability

C. Content Delivery

- Instructional resources used appropriately and effectively
- Content presented is accurate
- Use of real-world context

- Focus on problem-solving
- Students solved one or more non-routine, or open-ended problems

D. Inquiry-Based Lesson Design

- Launch
- Investigation
- Summary/Closure

E. Grouping Arrangement(s) Used

- Whole Group
- Small groups working on same task
- Small groups working on different tasks
- Individuals working on same task
- Individuals working on different tasks
- Grouping arrangements were appropriate for the instructional goal and activity

F. Teacher and Student Behaviours Observed

Teacher Behaviours

- Setting up and guiding students through meaningful real-world problems
- Moving around the room monitoring/questioning
- Encouraging students to consider multiple ways to solve problems/test solutions
- Guiding students in the use of manipulatives/technology
- Promoting student use of inquiry/creativity through questioning/collaboration

- Facilitating discussions about problem-solving processes/ efficiency/effectiveness
- Leading students through discussions/journaling of their understanding

Student Behaviours

- Interacting with others
- Working alone
- Working in groups to test solutions
- Working in teams to challenge and defend solutions
- Applying mathematics to real-world problems

21st Century Information and Communication Skills

- Sharing solution processes and listening to others share their thinking
- Defending solution processes' efficiency and usefulness
- Communicating mathematics ideas: demonstrations, models, drawings, and arguments
- Helping to clarify each other's learning through discussion/modeling

G. Instructional Strategies

- Connection to prior knowledge
- Provides differentiated instruction
- Teacher modeling
- Collaborative grouping
- Opportunities for students to justify solutions
- Incorporate varied assessments

3. Questioning Strategies (Mark all that apply.)

- Wait Time I Wait Time II No/limited wait time
- Questions were higher-order and stimulated broad student responses
- Questions were lower-cognitive and stimulated narrow student responses
- No questions were asked by the teacher or posed through the activity being conducted
- Teacher used strategy to ensure all students had opportunity to respond
- Teacher asked probing follow-up questions based on students' understanding (individuals, small group, whole class)
- Students are encouraged to ask questions of each other and of the teacher
- Teacher provided specific praise
- Teacher provided general praise
- Teacher provided no praise
- The questioning strategies checked for student understanding of apparent instructional goal Yes No

4. Classroom Climate

A. Student Involvement

- Majority of students demonstrated interest/were engaged and on task
- Most students take initiative in classroom discussions
- Majority of students uninterested or apathetic
- Majority of students were frequently off task

B. Classroom Management

- Classroom orderly, no disruptions that impaired learning environment

- Classroom generally orderly, but some disruptions impaired learning environment
- Classroom disorderly, frequent student disruptions seriously impaired the learning environment
- The climate was generally positive
- The climate enhanced learning opportunities for students

5. Development of Higher-Order Thinking Skills

A. Check all skills that were introduced and/or developed in the observed lesson.

- Making observations
- Reciting/recalling facts
- Classifying
- Estimating
- Choosing appropriate strategies
- Measuring
- Collecting/recording data
- Comparing/contrasting
- Organising and displaying data
- Drawing conclusions
- Interpreting and analysing data
- Making predictions
- Selecting problem-solving strategy
- Creating/formulating patterns/equations

- Justifying/verifying solutions/strategies

B. Learner Attitudes Demonstrated

- Dependent on others
- Cooperation
- Persistence
- Responsibility
- Confidence
- Enthusiasm
- Objectivity
- Accuracy
- Critical thinking
- Self-directed
- Curiosity

APPENDIX M: ANALYTIC FRAMEWORK FOR IDENTIFYING TEACHER CHANGE

Dimensions	Criteria	Week 1		Week 2		Week 3	
		Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
1. Overall characteristics							
1.1 Consistent	Is the main topic presented consistently throughout the lesson?						
1.2 Progressive	Is the main topic presented progressively (from easy/concrete to difficult/abstract)?						
1.3 Systematic	Is the overall instructional flow systematic? (learning motivation? learning objectives? main activities? practice? evaluation/summary						
2. Learning objectives							

2.1 Conceptual understanding	Does the lesson focus on students' understanding of a mathematical concept, principle, or law?						
2.2 Mathematical process							
2.2.1 Problem-solving	Does the lesson focus on solving a given problem?						
2.2.2 Reasoning	Does the lesson focus on fostering students' mathematical reasoning ability?						
2.2.3 Communication	Does the lesson focus on fostering students' mathematical communication ability?						
2.3 Positive disposition	Does the lesson focus on fostering students' positive attitude toward mathematics?						
3. Instructional strategies							

3.1 Considering content	Does the teacher use instructional strategies sensitive to the content to be taught?						
3.2 Considering students	Does the teacher use instructional strategies tailored to students' differences?						
3.3 Instructional materials							
3.3.1 Manipulatives	Does the teacher employ instructional materials for students' manipulative activities and exploration?						
3.3.2 Reconstructio n	Does the teacher reconstruct the textbook in a way that considers the content and student characteristics?						

4. Mathematical discourse							
4.1 Questioning	Does the teacher use open-ended questions to provoke students' thinking?						
4.2 Feedback	Does the teacher provide timely feedback sensitive to students' understanding?						
4.3 Teacher role							
4.3.1 Question/ answer and demonstration	Is the discourse dominated by the teacher's question/answer pattern and demonstration?						
4.3.2 Emphasising communicatio n	Does the teacher emphasise the importance of mathematical communication?						
4.3.3 Soliciting and using students' ideas	Does the teacher solicit students' multiple ideas and						

	use them in the lesson?						
4.4 Student role							
4.4.1 Chorused and simple responses	Are students' responses mainly chorused and simple?						
4.4.2 Presenting one's own ideas	Do students have an opportunity to present their own ideas to the whole class?						
4.4.3 Peer communicatio n	Do students have an opportunity to communicate their ideas directly with peers?						
5. Learning environment							
5.1 Group organisation							
5.1.1 Whole-class	Is the whole-class organisation used mostly throughout the lesson?						

5.1.2 Small-group or individual activity	Are small-group or individual activities used appropriately given the characteristics of content and students?						
5.2 Classroom atmosphere							
5.2.1 Permissive	Does the classroom atmosphere allow all students to participate actively through shared norms?						
5.2.2 Mutual respect	Does the classroom atmosphere encourage students to discuss their ideas based on mutual respect and trust?						

APPENDIX N: INTERVIEW RESPONSES

(After watching the video, the researcher interviewed the two teachers)

Researcher: There we go, let us start. What kind of questions is the teacher asking?

Teacher 1:I think must,.. they are high-order questions. **(The Questioning were HOQ and purposed to find learners' understanding)**

Researcher: They were high order questions. How is the quality of the questions the teacher is asking?

Teacher 2: I think the.., most questions they needed the learner to express their knowledge **(Learners were able to express their opinions)**

Researcher: Were there questions checking on learners' knowledge? Kofi

Teacher 1: Hmmm, I think yeah, they were **(Teacher confirms the questions were checking on learners' knowledge)**

Researcher: They were, for example: he wanted to check, they were somewhere the learners were having two numbers 7 and 9 were they were even (they wanted to get the number in between which is even). They wanted to get the number in between which is 8 and there were somewhere where he introduced what if there were 10 and something here in between, how will you get the number there? Now are learners talking to each other?

Teacher 2: YES. They were interacting

Researcher: they were interacting. Are they discussing their solutions in the group? We are basing on what we have seen, they were showing each other, you can write it like this

Teacher 2: yeah; yeah.

Researcher: alright, what words and action is the teacher doing and saying to learners?

Teacher 2: what's an actions?

Researcher: yeah. What did you see? What was happening to the teacher during that time?

Teacher 1: eh he was busy intervening where the learners they….

Researcher: okay. He was moving around the groups neh? Questioning their answers, their solutions, kegore he was doing probing questions. How did you come. Why did you write this one? ohk eh, are the learners explaining their solutions to whole class?

Teacher 2 **|** Teacher 1: yes

Researcher: yes: they were presenting the. Now is there the assessment in the whole? i want to check from you both did you see any assessment?

Teacher 1: from my perspective, I think they were.

Researcher: they was. What type of assessment was it?

Teacher 1: informal

Researcher: it was formative assessment, (formative assessment) The assessment that we are doing while we are teaching (akere) we want to check this one, we are not interested in summative, it was a formative hence informal, we wanted to check whether they are able to do this one. Okay.

Researcher: then was the assessment based on the problem or on the conjecture or on the investigation, what was that?

Teacher 2: it was problem-solving

Researcher: is it? For me it's not a problem-solving because a problem-solving is when we pick up statement that will not have a specific solution, will not have a specific way of solving it, everybody will come with his own way of solving it. That was a conjecturing because they were following a certain routine, eh general state….. (Teacher 1: formula) yeah formula

Researcher: e ya kwala akere? (is it clear)

Teacher 1 & Teacher 2: Eee

Researcher: it was based on the conjecture. What kind of resources are present in there?

Teacher 1: chalk and duster

Researcher: chalk and duster

Teacher 2: aaaaaaaahhhhh

Researcher: pen, calculator and eh text book. You need to look on those resources when you are looking on that one. Are the resources related to the content to the problem to the conjecture or to the investigation? They are, calculator is related to the data handling, to solve the data you use this one, a pen is also related to that one, the chalk also was used to. We want check whether the resources that were there, were they used fruitfully or they were just there for the sake of being there, it is possible that a teacher could carry a calculator and a meter stick and a protractor put them on a table, and then teach,teach and the siren is ringing and then go with them out.

Teacher 2: without them?

Researcher: yes

Teacher 1: so they were not fruitful

Researcher: yes: so are the resources accessible to all learners?

Teacher 2: yes

Researcher: who direct the use of the resources? the learners on their own, you didn't tell them, use the calculator they just decided here now we need what, a calculator. Now is the teacher using the correct mathematics concepts, are the learners also use the correct mathematics concept or explanations of their solutions

Teacher 2: yes, they were using it, and also the teacher was using the

Researcher: I will say yes and I will say no because there is an argument that we still going to talk about here

Teacher 2: that one of eh (laughing)

Researcher: three comma seven five and three comma seventy five which one is correct, why do we say it is correct? Three comma seven five and three comma seventy five, what says the CAPS document because there is a way of speaking on the decimals, internationally and in South Africa they will say ok we specify this is what we talk. What says our caps

Teacher 1: our caps says seven five

Researcher: seven five

Teacher 2: mhhh

Researcher: are you sure?

Teacher 1: yes

Teacher 2: in actual facts it should be seven five not seventy-five

Teacher 1: seven five

Researcher: what makes you believe that? That.

Teacher 2: I think I have seen it somewhere, somewhere somehow.

Researcher: because, let's look at this one: this is what we have. How do you call it? while you still thinking.yeah it was interesting when I was looking at it I say ok, which one is the correct one because the caps will tell us, this is what we, numbers and number what what. You need to look on those things

Teacher 2: ge e šetše ele tše three ka mo tše three ka kua ore one hundred and seventy one thousand comma seven hundred and fifty

Teacher 1: if ke seventy five ka mo ke seventy five o tlore ke seventy five comma seventy five?

Teacher 2: Ga ye fe sense nthwewe (*it does not give sense*)

Teacher 1: Wa e bona gore

Researcher: this are the things that you need to emphasise them when you are in the class

Teacher 1: because ngwana a ka nore why mara meneer why, why, why?

Researcher: number, number patterns, ok millimetre, centimetre, measuring, because I remember somewhere, there should talk about this comma. How do we write it, the other thing is it should we write three like this or three like this. It should specify. Which one is the correct one?

Teacher 2: between this two

Researcher: mhm

Teacher 1: three comma, three comma. Ye ga se ya ge gole. ye ke ya towards the

cents Researcher: towards the?

Teacher 1: kera ye, o kare ke ya go divider which ones?

Teacher 2: ye e divider ka dithousands

Researcher: what is it that you are teaching the kids?

Teacher 2: yona keng mara? Which is the correct one?

Researcher: laughing what are you teaching them?

Teacher 1: free country

Researcher: ah ah, its not a free country, because you cant. That's the distortion because once you teach them in grade 08, grade 10, grade, they come with this kind of a comma.

Teacher 2: which is, wrong

Teacher 1: which is wrong this one

Researcher: Which is wrong, then you get them in grade 12 you want to change them while they heard grade 11, grade 10, grade 9, four years it in the memory, then you want to change at the later stage, do you think that you are going to change it? Because that argument, I am saying this becausethat argument is there somewhere in the caps where it shows how we should write this comma, how should we talk about it. Because it is very very important. If we don't see it will

Teacher 2: multiples of

Researcher: multiple of 10, multiple……Now, let's look on this one, the learners were seated in small groups akere, there were no material or equipment, the room size will accommodate the activities, there were no maths manipulative tools akere, there were no posters, the core curriculum material was evident that is students work was played on the board, there were no resources for hands on akere

Teacher 2: mhm

Researcher: eh, here we have class set of calculators, no interative white board, no computer no projector, no whatever, I saw text book, nothing here akere? The topic was data handling

Teacher 2: mhm

Researcher: Did they use the calculator, and the chalk board and the chalk effectively?

Teacher 2: yes

Researcher: yes. Was the content that they were presenting accurate?

Teacher 2: yes

Researcher: yes. Was it of a real-world context?

Researcher & Teacher 2: no

Researcher: were they focusing on problem-solving? No. did the student solve one or more non- routine? No, they were solving routine, tša go tlwaelega akere

Teacher 2: mhm

Researcher: finding what what. Right. grouping arrangement, eh what type of grouping was there, there were having a small group working on same

Teacher 2: task

Researcher: task akere. now let’s look at the teacher behaviour, because there were no real-world problems we can’t tick, setting up and guiding throughout meaningful real world problems, he was moving around the room monitoring and questioning, did you see it?

Teacher 1: mhm

Researcher: moving around monitoring and questioning. he was encouraging the students to consider multi to solve or to test what, solutions, like that one of saying what if it is like this

Teacher 2: how did you

Researcher: how would you solve it, akere? Asanka a ba ruta go šomiša calculator or whatever, he didn’t even mind to check on that one. Was he promoting student use of enquiry or creativity through questioning or collaborating?

Teacher 2: yes

Researcher: yes, akere, facilitating discussion about problem-solving processes? no, he was leading students through discussion. But this part is not there. akere?

Teacher 2: mhm

Researcher: students’ behaviour, they were interacting with each other? They were working in group to test solution? They were working in teams to challenge and defend solutions? They were defending akere?

Teacher 1: mhm

Researcher: now the twenty first centuries

Teacher 2: wasn’t this one applicable at the beginning of the

lesson? Researcher: working alone neh?

Teacher 2: yeah

Researcher: ok, there at least. There is a problem of applying maths to the real world. I even talked to that in the classroom, do you remember?

Teacher 2: mhm

Researcher: taking one question paper, which was saying consider the following data, it doesn't show what types of data. What was the data for what?

Teacher 1: e foba di nomoro

Researcher: e foba dinomoro. We are saying this is useless, if I was the one that demonstrating I will take.

Teacher 2: e nyaka o no bafa di scripts tsa bona o no re tseya ngwala, o hwetsane bokae, 10, eng eng eng

Researcher: 10 ee. Ehe. I even gave that particular example, u are saying.

Teacher 2: ka maths

Researcher: ka maths test, say the maths test. Right let's look at, the twenty first century and communication, this is very important.

- Sharing solutions processes and listening to others. Yes

Teacher 2: yes

Researcher: defending solutions: yes

Researcher: communicating maths ideas. Demonstration akere? Yes

Teacher 2: yes

Researcher: but there were no models

Teacher 2: drawings yes, arguments yes

Researcher: yes: there were no models akere

Teacher 2: mmm

Researcher: helping to clarify each other through discussion or mmm. This was out, this was there. now do u see whats going on now?

Teacher 2: yes

Teacher 1: yes

Researcher: Ok, instructional strategy. Did you connect to prior knowledge? yes.

Did you model? No

Collaborative? there

Students were justifying

Varied assessments? Yes, there is somewhere where they were explaining, somewhere where they were writing, it was varied.

Now let's go to this one and check. Was he asking question and waiting? Yes

Teacher 2: yes

Researcher: what type of the questions were asked? they were high order and stimulate student's responses akere?

Teacher 2: mhm

Researcher: were questions of lower order? No we can't take this one

: no questions were asked? They were asked

: teacher used strategy

: all students had the opportunity to responds

- Let's look at this one. did all of them respond?

Teacher 2: no Researcher: no

Teacher 1: some

Researcher: some akere? Ok, students are encouraged to ask questions, did we hear that? Do we have question or comment or clarity?

Teacher 2: yes

Researcher : did he praise anybody who wrote? no. in this class you didn’t, but in another class you did

Teacher 2: give him a round of applause

Researcher: no, even saying that good one, you are praising akere? You are encouraging them

Teacher 2: yeah

Researcher: mhm: ohk

the questioning strategy were checking for students understanding akere? Now lets look at this one;eh

Teacher 2: eh! dilo tše ke tše ntšhi

Researcher: yes these are the things that, these are the things that, when you are, you will see that we are ticking, ticking them akere?

Teacher 1: mhm

Researcher: majority of the students demonstrated interest, they were engaged is not it?

Teacher 1: yes

Teacher 2: yes

Researcher: most students takes initiative in classroom discussions, boEnoch I saw him, so these two were not there. They were all on task not off task, we tick this one akere?

Teacher 2: mhm

Researcher: classroom management, the classroom was orderly, no disruption that impaired learning akere?

Teacher 2: mhm

Researcher: the classroom generally was orderly but some no. class dis.. no. the climate was generally positive, the climate enhances learning opportunities

Teacher 1: mhm

Researcher: now let’s look on this one. The development of high order thinking skills, we want to check what is it, that we are doing. Were learners making observations? No, they were residing and recalling facts akere, the formula, that’s the first thing. Were they classifying?

Teacher 1: no

Researcher: No. were they estimating?

Teacher 1: mm

Researcher: no, estimating they must not use a calculator, they must think that, if ok, if the square roots of 49 is 7, the square root of 64 is 8, what will be the square root of 55. Must be between those values

Teacher 1: the percentile:

Researcher: eee, somewhere there they estimate, but when they press the calculator. They are not estimating, they are getting th exact value of it, they are calculating. OK, were they choosing appropriate strategy?

Teacher 1: mmm

Researcher: mmm, were they measuring?

Teacher 1: no

Teacher 2: no

Researcher: no, they didn’t collect a data on their own. Were they collecting or recording data?

Teacher 2: no

Researcher: no, were they comparing and constructing?

Teacher 2: no

Researcher: no, they were organising and displaying data. I saw one of them those who put them in an array. Arranging from smallest to the biggest, that's why I ticked.

Teacher 1: mmm

Researcher: were they drawing conclusion?

Teacher 2: no

Researcher: no, that data were just useless it was just numbers. That you cannot even say, what does this data help you in. Were they interpreting the data? Yes, they were calculating the percentage, they were checking on the percentile. Did they make the predictions? No

Teacher 2: no

Researcher: selecting? No

Formulating patterns or equations? no

Teacher 2: no

Researcher: justifying solutions or strategies, I will say this for solution I will say, but justifying that's another thing. What happened learner attitude, they were in corporation, they were not depending on others akere?,

Teacher 2: mm

Researcher: they were responsible, they were confident, they were critically thinking, self-directed. Accuracy, were they accurate? I could say yes because they got correct answers. Curiosity? I am not sure, were they curious?

Teacher 2: I am not sure

Researcher: not sure

: Ok now lets comment on this lesson

: Kofi, I need your comment now

Teacher 1: I think the lesson was learner centred

Researcher: mhh

Teacher 1: it was learner centered, eh most of the learners were engaged, eh even though they were engaged, I think eh, what you could have done is that, you could have at least used the activity which is more, in an everyday life

Researcher: context?

Teacher 1: Ee, so It should have been in a more in a real life context and eh.

Researcher: now lets check on, I want your view on the first lesson, lets look on this, the first lesson and this lesson, is there any improvement?

Teacher 1: yes there is improvement.

Researcher: what is it that you think has improved on Teacher 2, when we looking generally on the first. This one we analysed we were together, me and you and Teacher 2*, you remember it, on the sixth

Teacher 2: Ka kowa

Researcher: ka kowa class roomong yela

Teacher 1: mhh

Researcher: now this is another one I want you to compare looking at this, do you remember where I say I put a small tick I put, now look at it look at other one, or just use your intuitive, how do you compare the lesson and the previous one?

Teacher 2: I myself I can say that, ahh, I have

improved. Researcher: mhh

Teacher 2: because, remembering those lessons I used to have, learners were not engaged, I will do too much talking where by at some point I will just confuse the learners, so but I saw myself now engaging the learners and seeing them being interested in working together, seeing that they are even interested in going to the chalk board, presenting their solutions to the others, just seeing them being active

Researcher: now one thing that I like about is, remember at the beginning when we started? Learners were responding in chorus

Teacher 2: yeah

Teacher 1: mhh in chorus

Researcher: now the chorus is no more there,

Teacher 1: mhh its gone

Researcher: again your learners were using mother tongue to respond to the questions, now that is gone they are speaking in English, the language of learning and teaching, so that they are able to understand the question paper. And now they understand what is it that it is needed from them. They have a confident to go to defend their own answers to the whole class, and were able to question on their own without being told to question

Teacher 2: mhh

Researcher: what else can you comment of Kofi?

Teacher 1: and before they used to work in

isolation.

Researcher: mhh, you see, individual one by one and hiding the work from each other

Teacher 2: mhhh

Teacher 1: so now they have that

Researcher: and, and, remember one of the CAPS, I want to show you, one of the CAPS requirements is this, we must produce learners that are able, just a bit, we must produce learners that are able to communicate, the curriculum, ehhh let me show you, here, we want the learners who work effectively as individuals and with others as members of a team

Teacher 2: of a team

Researcher: that is the key, if you are if now you are still teaching learners to work individually, you are breaking one of the aims of curriculum

Teacher 2: yoh

Researcher: yes, again we want learners to organise and manage themselves and their activity responsively and effectively that's why at the end here we were checking whether, eh where is it, at the end we were checking last page, we were checking whether there is corporation, lerner attitude neh

Teacher 2 and Teacher 1: mhhh

Researcher: there is responsibility there is what what. it comes from here responsibly and ehhhh

Teacher 2: effectively

Researcher: effectively, are they able to collect, analyse, organise and critically evaluate information akere?

Teacher 2 and Teacher 1:

Researcher: are they able to communicate effectively? language skills, this what we are saying you are teaching our children, you must teach them this,

Teacher 2: eh

Researcher: mara ge o di bona dile mo gadi Nape di bonala gabotse gore ke tsela di tšwago mola, this instrument, when I was designing this instrument I was looking on this

Teacher 2 & Teacher 1 :mhhhh

Researcher: I used this, what is it that is required by our curriculum, naa when we say the teacher is effective, must make sure that he is doing this things, then re sure gore ngwana wag ago ge a tšere 80, we don't look at 80 as a number gore this kid is, wa kgona, a palelwa kego presenter, a palelwa kego reason gore why ke e hweditše. that is an accident

Teacher 1: laughing Researcher: wa e

kwešiša? Teacher 1 & Teacher 2: yeah

Researcher: this is what happening ge bana ba etšwa kwa Mbilo ba fihla Wits ba feila, ba sa kgone the same thing that they were doing kowa. Gora gore somebody came with the question paper and memorised a question paper and memorised and they got hundred, we say this kids are intelligent, ge re fihla kwa University rere ohk, what is the formula to calculate the perimeter? A Grade 7 of a rectangle, the learner doesn't know. This is what we are looking at. Any other comment. Mhhmm, Kofi, any other comment

Teacher 1: mhhh any comment that I have seen from there is that, mhh when that learner just wrote 3, 75

Researcher: mmm

Teacher 1: then he said three comma seven five

Researcher: he didn't make a follow up

Teacher 1: eee, then the learner become surprised because the majority said three comma seven five, then he also just said three comma seven five

Researcher: without knowing why

Teacher 1: without knowing why, then he just joined the majority

Researcher: another thing that I have seen very negatively on lesson at the beginning, he asked the learners the formula for calculating the percentile in groups, they went there in groups, he went there to see the, the individual learners' groups percentile, he eventually wrote the correct, there was one which started with P.

Teacher 1: laughing

Researcher: he didn't one that other to see that there is a formula of who started with P, so that, that misconception, we want to see what happened to that particular misconception, did you see it Mr Masina?

Teacher 2: this one I did not see it, I just saw it right now in the, in the.

Researcher: but you were in that particular group

Teacher 2: I don't know what happened I didn't see, if I saw it I could have asked learners to come and present, because most of the time if I see different thing in the classroom I need them to be presented, so lets say if I see three,or,let me say three to four

Researcher: mhh, common

Teacher 2: similar things, and then there happens to be another one that is different to the, those three, so I would ask one from those three similar, and the other one which is different to thiers, so that we could see what went wrong there

Researcher: ohk, what can you, Masina, what can you keep from that lesson and what can you discard from that lesson?

Teacher 2: from that lesson what I will keep, let me start with the positive ones, I will keep this thing of eh, group discussion, and then I will minimise as much as I can, this too much teacher talking, and the also I will always encourage learners to present their solution and as much as explain their solutions using mathematics language effectively and then what I will discard.

Researcher: mhh

Teacher 2: from the lesson, of which I saw myself doing it, I did not eh check all the groups work very well, I happened to have been so fast in checking their work, such that I visited small groups, or let me say

Researcher: few

Teacher 2: few groups and the others I let them out, that's why now I did not see this one, I could have seen it

Researcher: ohk Kofi. What can you take from his lesson, what can you not take from his lesson?

Teacher 1: mhh whsat could take from his lesson is that, ehh the way in which he engages the learners, the learners they feel free to participate, they not afraid, so and something which I cannot take is ehh, is wasting time writing something on the board which I could just prepare

Researcher: with a worksheet

Teacher 1: worksheet, so that I can just give them

Teacher 2: I will also discard that one

Researcher: so does, did this help you in a way?

Teacher 2: yes, I see a very critical eh, improvement that I have and from, during eh, this study

Researcher: now what I would say, which I see is still difficult for you to add on you, the issue of planning the lesson,

Teacher 2: yeah

Researcher: you seem not, though you were planning, but you seem not enjoying to plan it

Teacher 2: laughing

Researcher: I am being honest with you, because somewhere I could see that, you see that I didnt plan the lesson and then you say no I am going to use that oone of yesterday

Teacher 2: yeah

Researcher: but in essence, the yesterday lesson should tell us what is going to happen today

Teacher 1: today

Researcher: do you see it and if we were, we were very much positive on that, I am sure now you were going to have all the lessons now, for next year is just to make corrections and change the date, and now you are having them, you will eventually have all of the lessons on your own

Teacher 2: oh that one one I need to upgrade on

Researcher: because I am saying this because if you prepare lesson for this year. Next year it is easy

Teacher 1: you just modify

Researcher: you just modify, and when you are going to class, classes you start now seeing, ohk this is the lesson that I presented now I can add this

Teacher 1: mhh

Researcher: with this lesson I found this misconception, now I can add this, now that experience now is coming, now you become an experience teacher who can anticipate what the learners might not know, and I could solve it like this one

Teacher 2: you see on

that one Researcher: mhh

Teacher 2: yeah I can agree with you, because I have seen something that I did which was wrong, more especially with that oned of ehh, the voluMES and surface area

Researcher: surface areas

Teacher 2: of the prisms, last year I did this models and I taught using them, but

Researcher: this year you just went

Teacher 2: this year just gone to the class

Researcher: just gone to class and without them, and there was a confusion of that rectangular prism you remember that?

Teacher 2: yeah, so I could say that is the problem with arose from not planning very well

Researcher: and the next thing that I want you to look on eh, Hans and Teacher 1 &Teacher 2: mhh

Researcher: here at school, I don't know, but it's not difficult for you, for example, you were teaching probability, it was not difficult for you to bring dice, to bring coin, to bring a pack of cards, those are the manipulatives we are talking about, you might think, all the people they know cards, some they don't even know the cards, because ka gabo bona ka kuwa gae baba botša gore a ke nyake, re tsena kereke a ke nyake go bona ngwana a swere karata or eng eng, so when we are talking about di dice di nale dipalo tše kae, so ngwanola o tšea nnoto, because ga tsebe gonale tše six.

Teacher 1: laughing

Teacher 2: yeah, ke ebone gase kgale

Researcher: wa e bona. Okano e tšea for granted, wa re ae ba tseba gore ma dice a nale bokaka, that activity is favouring boys

Teacher 1:mhh

Researcher: and boys will excel, so you are sexualy, you are what, you are not gender insensitive, wa e bona?

Teacher 2: mhh

Researcher: wena o ka no e bona o kare its

Teacher 2: you’re sexist

Researcher: yes you are sexist, unaware, wa e kwešiša, unaware, o sare keng. That’s why nowadays kamo di pukung tsabo physical science, we are discouraging that a man pushes this, we rather say a lady is pushing a kid on what what, so that we are encouraging that, ba thoma go bona gore oh, le rena physics ye key arena, it is ours ya kwala

Teacher 1: mhh

Researcher: yes those are the things, ge o eya go dira kadi Financial Mathematics, o nale di tšhalete, you start kago inter linker le economics what is repo rate, what is what what, because we want to know when we say interest is gone, what is gdp, those smallanyana things, bathoma go bona gore, oh, ge bare Lesetša Kganyago o increase repo rate, bara gore ketlo amega so,

Teacher 1: those things,

Researcher: kegore I am bringing that thing of real world, like ke laeletša Masina kere, roundavel e swere di prism tsela tša gagwe

Teacher 2: eh

Researcher: I wanted to show you in one of the material that I am writing, I took a picture of a rondavel put it here

Teacher 2: issue of projector comes in

Researcher: I took ehh lee, lee bana ba le tseba, what type of shape is this one, I took a football kae beya, ka tšea netball kae beya, ba thoma go bona gore ohh, this is a sphere, this is a circle, this is an oval.

Teacher 1: motho ga atsebe sphere, re bothata

Teacher 1: ice cream

Researcher: cone, ice cream cone, if you don't want to, go fota ice cream, take the phage like this, fold it for them to se the cone, wa e bona then it goes, then ba thoma go tseba gore oh, cone gabotse e former ke, it's a three dimention, e former ke a circle and a triangle. Those are the things that you need to, kemoka maths wo wa gago ba fela bare ge a sepela mo strateng, o thoma go nyaka go bona dilo tsa ka kua classing tsa maths

Teacher 1: oh

Teacher 2: yeh bjalo o phela thuto bjalo

Researcher: ee, k, do you have any other comment? For this lesson, kamoswane retlo, re tsena ga a gago Kofi, re tlo e hlaramolla ka mokgo, no comment

Teacher 2: mhh no so far eh eh

Researcher: again one issue that I want you to look on is the content, both of you akere?

Teacher 2 & Teacher 1: mhh

Researcher: the content because, once a teacher doesn't know the content, kegore give yourself, time kwa gae, o di dire di problems tše, o be o kgone lego bona, before o eya ka kua classeng, sit together, even with Hebert akere, interpret e make sense, so that you anticipate, because current teaching reforms on your, we are encouraging collaborating teaching, we go into the class as three like this, e le gore we are free, I teach this section, whenever I make explanation that the learner do not understand, you just come in, you explain it in another way, he comes in and explain in another way, all of you, you benefit, while you looking at him, you see, how he teaches, while he is looking at you, he sees, ok, this one ebe e mpalela because of this, this one gabotse-botse nka e beya ka mokgo, ke team teaching.

Teacher 1: mhhh

Researcher: wa kwa re sa boetse kae? Working in a team

Teacher 1: bjalo nako yee

Researcher: when you are/ have time, akere agona nako e, nako tše dingwa le hwetša lese free, nako tše dingwe le hwetša lele di classeng kamoka ga lena, ye le boneng gore ye period ye, reka kgona goba ka classeng ya ye mongwe.

VOICE CLIP: 170829 0027

JFM: what is it that you are picking up there?

Teacher 1: Oh, Gabotse e ke laetša, e ke nyako laetša gore gabotse ntho ge sala rere e a depreciaotor ke diquality dife tšeo re di lebelelago ge re sala rere e a appreciator reba relebeletse which qualitiesso that isn why ke be ke compara the house and the car.

Research: But what comes out from that thing that you were doing, before I say something

Teacher 1: answering ke gore making the learners that was not understanding gore maybe rere be ke try gabotse go araba yena on this, eh..

JFM: Boa Masete, come, come, when you were in the lesson, Masina, What do you get from there

Teacher 2: Yeah eh, ka eh, introduction e be e le good and then ge re e tla mo ga explanation ya

JFM: Just hold on, what is it that you are picking there (showing the video)

(Teacher 2 reflective interviews)

JFM: Learners were comparing and

Teacher 3: comparing and conjecture

JFM: Where do you see it

Teacher 3: and predictions

What did they predict?

Teacher 3: No they were conclusion

Researcher: Now let's on it we will come and

Researcher: Okay let us look on what was happening (playing the video). E akere. Le mo kwele e reng?

Teacher 3: 3D

Teacher 1

JFM: O re here we will be talking about 3D objects, surface area and volume. Now there was something that I wrote here what is a surface area? Although ge a tswelela pele o a e definer ge a thoma a saka a e definer. (Monna yo o be a thiba mike and le maabane re be re sa kwe Hans ge a bolela.)

Teacher 2 (o e swara bjang)

MHL: (ke e swara so gabotse showing)

JFM: (e a kwala gore o tšama o ethiba, kganthe ge o ka e swara so, wa mokwa ga re mokwe. Ro mo analyser bjang re sa mo kwe. Maabane le gona o sepetše ra sala rebolela gore o thibile Makofane somewhere and mola problem ya gagwe a dula ko morago kgole leyena mola Masina a se na lentšu. That is a problem). Now let's look on, there is a lesson plan that Masina brought that he is trying to follow, he said the teacher's activity: introduction of surface area and volume can help us determine material needed to build an object as well as the number of quantity, but remember the learners do not know what is surface area and volume? That is why kere ga wa thoma ka go definer mara mo go ya le ka wena o introducer tšona. What is it that you were introducing? hmm

Teacher 2: oh, le a botsisa, ke theeleditse ka mo

JFM: We can stop it that one is not a problem. You are saying the first activity you are going to introduce the surface area and volume? Now the question what is it that you are introducing on surface area and volume. When you are saying we are going to deal with surface area and volume are you introducing it? Or ge rere re introducer something re ra gore eng?

Teacher 2: ke ra ke ra Go introducer? other than defining engwe gape ke bolela ka di basics, ke gore is as if you can summarise the whole story and then o tlo re ge o etla mo go body then you explainthat thing in detail

JFM: Let's take it this way. What is this? This is not prior knowledge? Why do we start with prior knowledge after introduction.

Teacher 2: ke yona

MHL: e swanetše go tla prior knowledge before introduction
JFM: we want to put the learners where they are and then move to the next section a kere.

Teacher 2: Mmm

JFM: Let’s say I am going to teach, eh, BODMAS rule suppose. When I am teaching BODMAS rule is the mixture of all operations signs. It means therefore the prior knowledge is that learners must be able to add alone, subtract alone, divide alone and multiply alone. So when I enter into the class I will a simple problem of addition, subtraction, division and or multiplication just to see if learners are able to do those. It means as a prior knowledge I will give the learners problems that

APPENDIX O: LESSONS PRESENTED

Lesson 1 Before Training

Teacher 1: Dumelang, ah, if I remember very well, last time we did, eh, simple and compound, a kere (is it not), I am just repeating for you for what we did last time, simple and, and eh, compound. So, I just want you to find the link between the two a kere and the last time we said that these two they use them to calculate eh, the future values, that if you invest, for example if you invest they are using these two methods akere and not only when you invest, even when they are calculating the depreciation value of an asset, a kere eh like what dilo tša go depreciator re boletše gore di swana le eng? Ae, you just raise up your hand and tell us gore naa re bolela ka dilo tša go swana le eng? Eh dilo tša go depreciator, dilo tša go swana le dikoloi akere, dilo tša go swana le dikoloi dia depreciator, tša go swana le eng gape Aletta?

Aletta: Ntlo

Teacher 1: Le ntlo? Ntlo e ya depreciator? Wa mo supporter

Lincoln? Lincoln: (silent)

Teacher 1: Kganthe ge o reka ntlo wa investor or eng, Lincoln. Let’s just take a simple example. O reka ntlo ngwago ka bokae, ka R800 000 a kere,therefore after eh, if o rekile R800000, after eh 4years, ge o rekiša, o rekiša kang the less price or what? E swana le eng,Same thing applies to the car. O reka koloi ka R800 000, after 4years yo so lekana ka the price? Difference ke eng mo? What is the difference? Pauline!

Pauline: Koloi e lusa value (A car looses value).

Teacher 1: why, e lusa value, e lusa value in terms of what. ge re šala rere e lusitše value re ba re lebeletše eng? Keitumetše (*calling another learner and no response)*.

Ketumetše: Tšhelete ya yona

Teacher 1MHN: Tšhelete ya yona. Alright, eh, let's check mo ntlo wa kgona go dira a kere, as we have said that eh inflation rate each and every year e dirang eng? it can change! Gore re fele re e ba le different change in price of eh quantities its because of what? the inflation rate, so if eh it happens that for ngwako a kere, price ya ditena e no dula e le ka etee e noba sale o reka R5.00, so e dirang ya oketsega akere ke moka price ya ditenaya mafastere e ya oketsega, e nob aka e tee. Koloi e dirang, ya hlagala a kere, that is the difference e depreciator go ya le ka ang? Interest rate. We said again that in terms of investments which best method can be used for investments. when we are dealing with the investments Delicia which methods we said is was better to use.

Delicia: compound.

Teacher 1: It's a Compound, why do you say compound is the best method to use?

Delecia: Ka lebaka la gore ge re calculator the accumulated amount, the amount ye ba re felego ka mafelelong a kere ba re fele 4 years of the term, ka ngwaga wa mathomo ntong, tšhelete ye re e hwetšago bo thoma ka yona ka ngwaga wa bobedi, mola ele gore ka ga simple ba ilo re yona amount yela ya mathomo bo thoma ka yona ka ngwaga wa bobedi.

Teacher 1: go ra gore in a simple interest the initial amount always e tlo no dula e le the initial amount in every year. If o thomile ka R400 as you said go ra gore ngwaga o mongwe le o mongwe ba tlo no dula ba dira ka eng? R400 But in a compound interest the initial amount eh o hwetša eng. Let's say in the first year ke moka o hwetša eng the accumulated amount for the first year. Ke moka the accumulated value for the first year yoba eng the initial amount for the second year so gana ka mokgwa woo. That is why we say it is best for investment. So that is why rere it is best for for investments. Now, again what we said that is that in terms of depreciation, now there is a change the story now in terms of depreciation we said what Kamogelo? we said what. Which best method can be used to calculate depreciation. O nyako rekiša koloi bafana a kere. So we want to sell a car ba faihla kaTherefore, they say in order to sell your car, you are given this two options. Which option would you use for selling your car?

Kamogelo: Simple

Teacher 1: Simple! Why did you choose simple instead of compound?

Kamogelo: ka gore depreciation ya simple interest ke e nnyane go fetiša ya compound interest.

Teacher 1: Ke e nnyane, bonnyane o ra bjang what do you mean? A kere ke nyako go kwišiša bonnyane bjoo. Ke nyaka go kwa gore ke e nnyane bjang. Gore ke e nnyane in terms of ga rere ga le e depreciator ka bokae ba go fele percentage bare depreciation ya tšona ke 8% kamoka ga tšona, so wene o e rekile bokae? Let’s say R150 000, ke nyako kwešiša bonnyane bjoo bja gago o bolelago ka bjona. A kere, ba ilo šomiša 8% kamoka ga tšona.Ka bokae, R1500 000 a kere. Wene o e rekile R150 000 ke moka bare o e rekiša ka after 3 years ka interest rate ya 8%, ke moka which one will you use Kamogelo

Kamogelo: Simple interest a kere ka compound interest o hwetsa gore koloi o ilo e pataela tšhelete e ntši go fetiša ka simple interest

Teacher 1: go patela! O patelang bafana ka gore o a rekiša.

Kamogelo: Kera ge o e rekiša mo, ka compound interest kera ka simple interest ke mo o hwetšago ke mmmm, *(silent*)

Teacher 1: O hwetšang, fine a re direng simple. Ga a simple a kere, go na le yoo a mo supporting gore why a kgethile simple. Mohaswa o šomiša simple, if o mo supporter why oilo šomiša simple?

Mohaswa: because when the difference between the simple interest and compound when they depreciate is that, compound interest depreciate by the high amount

Teacher 1: Compound depreciate by the high amount

Mohaswa: While simple interest depreciate by lower amount than compound

Teacher 1: Se se dirang gore simple interest e depreciate ka lower amount e dira ke eng? E dira ke eng, why e depreciator ka lower amount?

Mohaswa: Because eh when calculating the accumulated amount they just take that initial amount

Teacher 1: Yeah! Ke yona nthwe re be go re bolela ka yona rere simple e no swana le a straight line depreciation.Ra ba ra draw graph go go laetša gore ke straight line. E ra gore e depreciatorat a what? at constant amount. For this one we said, let’s compare them (he draws a table for comparison). Gore ka mo e yoba simple kamo compound. Again, we said after 3 years, now ntho ye re e boletšeng mo ke gore, which means we are selling the what, the car after 3 years, a kere and then reboletše rare the depreciation interest rate ke bokae 8% and then reboletše rare ge re bolela ka depreciation re bolela ka eng, go ra gore e dirang, ea fokotšega a kere, so now let's us use the formula for simple interest A=P(1+in), Oh now because we are talking about depreciation the middle sign e yoba minus A=P(1- in), now ka mo eh, $A=P(1-i)^n$. Okay, now let's check here, kana ba go boditše gore you bought this car ka bokae R150 000.A kere, and ge o ka hwetša karabo ya gago e feta R15000 mola re bolela ka depreciation, go ra gore you did some miscalculation. Go ra gore koloi e we le eng e wele value. Go ra gore tšhelete yo ba less than present amount. So, eh yo ba if we can write the data we have what, this will be your principle amount (*pointing at R150 000*) and this will be your what the interest rate (*pointing at 8%)* which is your I and your n is 3. go ra gore ro ba le (*substituting on the simple interest formula*)

$A = P(1 - in)$

$A = 150000(1 - 0.008x3)$

$A = R114000.00$

Now for this one, gora gore mo roba le R150 000 and then 1 minus I, value ya i and as we have said that interest rate we always do what with the interest rate. We always do what, we divide by 100, what is the value of I 8 over what 100 which is 0,08 over and then eh, there is something, so here they never said the depreciation is compounded monthly or what, so our depreciation is per annum, so go ra gore it is 0,08 over 1. So the answer is R114 000

$A = P(1 - i)^n$

$A = 150000(1 - 0.008)^3$ So are tle ka mo, P =R15000 in to 1 – 0.08 over 1 close brackets

$A = R116803$

and n=3 (*substituting on the compound formula*). Because it is per annum go no ra gore re divider ka one. So the answer is R116803.

So at the end go ra gore, eh, option 1 (*pointing at simple interest formula*) eh go ra gore e depreciator ka kudu ke efe?

All: Yes

Teacher 1: go ra gore o tlo reng? O tlore R150000 wa minus R116 803 and R114 000. Ke R36 000 and then ke for eng? Ka eng, ka Simple, ka compound ke R33197.So yeah, So which means the right option is what 1 or 2? So what is the value of the car after 3 years? It is R36000 for simple interest and R33197 for compound interest.

We are now going to do the timeline. (*Writing the word Timeline on the board*) you cannot know the timeline if you don't know the relationship between the two simple interest and compound interest. In timeline eh, you can do what, you can add another money, a kere mo motho o no tšea

APPENDIX P: COMPLETED INSTRUMENTS

Improvement!!

Classroom Observation Instrument (COI) Grade 10

Date of the lesson: 11/09/2017 **Topic:** ____________

Time: ____________ **Duration:** 45 mins **Teacher:** DMES

	What to be observed	What is observed
A. Teacher's question in the classroom	1. What kind of questions is the teacher asking	Do you agree with the solution of hesed / why didn't you substitute → PTO
	2. How is the quality of the questions that the teacher asks?	High order questions
	3. Are the questions checking on learners' knowledge?	yes checking on learners kn.
B. Creating Environment of respect and rapport	1. Are learners talking to each other	yes in groups then whole
	2. Are learners in each group discussing their solutions	yes
	3. What words and actions is the teacher saying and doing to learners (asic qu... to →)	explain how they got the answer; ask for their question while learners pres.
	4. What actions and words are learners saying to each other	explain how the got their answer; we I multiplied to get
	5. Are learners explaining their solution to whole class	yes
C. Assessment	1. Is assessment meant for understanding or for grading?	understanding
	2. Is assessment based on the problem/ conjecture/ investigation?	problem
	3. What type of assessments are used in the lesson	Summative, formative
D. Resources	1. What kind of resources are present/used	chalk/chalkboard, calculator, worksheet
	2. Are the resources related to the content/ problem/ conjecture or investigation?	yes
	3. Are the resources accessible to learners	yes, calculator, worksheet
	4. Who direct the use of resources	learners on their own
	5. Is there an inclusion of ICT on the resources?	calculator only
E. Mathematics Concepts	1. Is the teacher using correct mathematics concepts	yes
	2. Are learners using correct mathematics concepts in their discussion or explanation of their solutions	NO check the bottom of (BODMAS rule) was not used

LOLT not used often by both learners and teacher.

$200\pi = 628,32$ → rounded! wrong language / substitution

$\pi(5)^2 \times 15$ → 375π — 1178 cm^3 → round off

Add all

COI- Classroom Observation Instrument Data Analysis

	Descriptions	**On the 01/08 Before training.**	**On the 03/08: After Training**	**On the 04/08: After Training**
A. Teacher's question in the classroom	A1. What kind of questions us the teacher asking?	The teacher was asking low order questions that were not meant to probe understanding. The questions that were mainly asked were as follows: Isn't , are we together, do you remember? And learners were responding in chorus while the teacher was mainly focussing on the chalk board.	There were still an element of low order questions, and unproductive questions like isn't, we have… where in learners just complete in chorus without understanding. When lesson continued, the teacher started asking high order questions like: why do you say 3 terms; what is the difference between x times y and xy. How many terms are in this expression	High order questions like: why did you choose to start with this one. How did you come up with the answer. Explain. Why did you start by subtracting not dividing since we have signs (minus and division). Explain your solution. Why did you change the minus sign to multiplication? When do we use BODMAS?
	A2. How is the quality of questions that the teacher asks?	The quality of the questions were very low. This is because the questions that the teacher was asking were not meant to find out the understanding of the student. The response to the questions were just rhetoric.	The questions were clarity and understanding checking. Probing the knowledge of the learners	The questions were clarity seeking, understanding seeking, and checking on different solutions done by each group and knowledge seeking questions
	A3. Are the questions checking on learners knowledge	The questions were rhetoric. Just meant for chorus answers without the teacher looking into them to help in identifying the difficulties if any the learners are encountering	The questions were checking for learners' understanding the teacher were looking into them but did not use the difficulties if any the learners are encountering to help the learners	The questions were looking on learners' understanding, the teacher was making sure the leaner
B. Assessment	B1. Is Assessm ent meant for	Assessment is meant for understanding	For understanding	For understanding
	B2. Is assessme nt based on the	The assessment was based on conjecture (Though the teacher did not realise it)	Assessment is based on tasks	Assessment was based on the task activities that were on the worksheet designed by the teacher
	B3. What type of assessme nt are	Formative in the form of classwork and summative in the form of a homework	Formative activities in the form of classwork and summative in the form of a homework	Formative assessment in terms of the activities on the worksheet and discussions

C. Resources	C1. What kind or resources are presented/used?	Calculators, workbook supplied by department of basic education	Calculators, workbook supplied by department of basic education. Halfway the researcher introduced the worksheet of that particular lesson to help the teacher in engaging the learners in group work)	The worksheet, workbook, calculator were used
	C2. Are the resources related to the content/ problem/	Yes, calculators were used to calculate the division, and the workbook was used to identify the activities for the topic. At the end of each activity here is a problem related to a real life situation in the workbook.	Yes, calculators were used to calculate the division, and the workbook was used to identify the activities for the topic. At the end of each activity here is a problem related to a real life situation in the workbook.	Yes the work sheet was relevant to the topic of the day and helpful in terms of time management by both the teacher and the learners
	C3. Are the resources accessibl	All learners are having the workbook since it was supplied by the department of the basic education	All learners are having the workbook since it was supplied by the department of the basic education. Nobody forgot them	
	C4. Who direct the use of resources?	The teacher does in terms of the workbook and there was no shortages. For calculators, learners were using them randomly	The teacher directs the use of work book and problems he wrote on the chalkboard.	The teacher gave the direction of the use at the beginning of the lesson but during the lesson some learners were continuing to use the worksheet in progressing towards other activities without being told.
	C5. Is there an inclusion of ICT on	No ICT inclusion	No ICT inclusion	No ICT inclusion

General Observations		The teacher was timeously urging the learners to follow algorithm as done on the chalkboard or the example. He was trying to check each individual' understanding sometimes He was ignoring the learners who were struggling There was no lesson plan rather a piece of paper Learners were not given a chance to negotiate their meaning on their solutions since there was no group work or even an individual to come and explain to other class members The teacher encourages learners not to discuss because he told them not to copy from each other or talk with somebody Most learners were relying on calculators not the how part of the solution Lack of interactions between the teacher and the learner or among the learners Low order questions Learners were not given the solutions of what they were doing and then given a homework. The teacher was very slow to come to what	Learners were grouped but not using the groups. The researcher came in and gave learners the worksheet made for algebraic expression based on what the teacher was doing. He asked each group of learners to identify and write down the operation signs that separate terms from the given expressions, to identify the number of terms each expression was having and circle them The teacher used wrong terminology for example, where there was a "+" operation sign they said it is positive operation instead of a plus sign and where it was "-" they said it was negative instead of minus sign The teacher was aiming at simplification of fractions using BODMAS rule but the prior knowledge which turned the lesson towards a certain goal was on algebraic expression. The teacher thought prior knowledge is what we did previously regardless of how it connects with the recent topic of interest. There was formal lesson plan on a 3 paged paper with a prior knowledge activity, objectives of the lesson and a classwork.	Learners were truly engaged in their respective groups finding the solutions to the activity given them. Teacher was mostly asking knowledge seeking questions Learners were solving the activity problems on their own and were able to discuss their own solutions in groups and the teacher. There was an improvement on time management There was individual as well as communication amongst the learners in a group. There was a formal lesson plan with worksheet which made learning and timing easier The issue of chorus singing is still a challenge to the teacher and learners