The mathematics teacher identity development of non-specialist Grade 6 teachers in rural schools

by

Zanele Dibane

Submitted in partial fulfilment of the requirements for the degree

PHILOSOPHIAE DOCTOR

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DECLARATION

I, Zanele Dibane, student number: 04419995, declare that this Doctoral thesis entitled: **"The mathematics teacher identity of non-specialist Grade 6 teachers in rural schools"**, which I hereby submit for the degree Philosophiae Doctor, is my own work. I further declare that this thesis has never been submitted for examination at this or any other institution before. Work from other sources used in this study has been acknowledged accordingly.

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The author, whose name appears on the title page of this thesis, received ethical approval from all relevant authorities. The researcher, therefore, declares that ethical standards and guidelines were adhered to before engaging in the fieldwork.

DEDICATION

This study is dedicated to the Omniscient God, whose Grace enabled me to reach this life milestone, as well as to my parents, siblings, and children.

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ABSTRACT

The development of mathematics teacher identity in ten purposefully selected Grade 6 non-specialist primary school mathematics teachers was explored with reference to their subject matter knowledge and didactical expertise. This was done utilising Beijaard et al.'s (2000) framework. Semi-structured interviews, lesson observations, and document analysis of lesson plans were used to collect data. The researcher applied inductive and deductive analysis using themes that were predetermined from the conceptual framework, as well as the categories and codes that emerged from the data. This study has revealed that there is a limited possibility that non-specialist mathematics teachers can develop their Mathematics Teacher Identity (MTI) through practice. The results indicate that the MTI of non-specialist teachers is not developed through practice as the participants demonstrated insufficient subject matter knowledge and a lack of didactical expertise. In particular, the ten participants demonstrated a lack of confidence, made many mistakes, and could not explain the various concepts explicitly. They also did not plan their lessons sufficiently. All of the participants used only a teacher-centred approach, which did not accommodate the diverse needs of the learners. The general approach that was observed did not facilitate accessing the learners' understanding while teaching, since they only asked lower cognitive level questions. Furthermore, the results from this study showed that these non-specialist mathematics teachers' beliefs and contextual factors had a negative influence on their MTI development. It was concluded that when teachers who are not trained at tertiary level to teach mathematics are appointed to do so, professional development programmes should be provided with a specific focus on the development of subject matter expertise, as well as didactical expertise. In addition, such programmes should aim to modify these teachers' belief systems in order to bring about lasting MTI development. Furthermore, non-specialist mathematics teachers also need continuous support from school leaders who are mathematics experts.

Key words: Mathematics teacher identity, non-specialist teachers, professional development.

LANGUAGE EDITING CERTIFICATE

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To whom it may concern

The thesis entitled, "The mathematics teacher identity development of non-specialist Grade 6 teachers in rural schools" has been edited, proofread, technically formatted, and reference control has been carried out as of 29 March 2023.

As a language practitioner, I have a Basic degree in Languages, an Honours degree in French and a Master's degree in Assessment and Quality Assurance. I have been translating, editing, proofreading, carrying out reference control, and technically formatting documents for the past 12 years. Furthermore, I am a member of the Professional Editors' Guild (PEG).

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LIST OF ABBREVIATIONS

ANA	Annual National Assessment
BEd	Bachelor of Education
CI	Curriculum Implementers
DBE	Department of Basic Education
FET	Further Education and Training
HoD	Head of Department
IQMS	Integrated Quality Management System
LTSM	Learning and teaching support material
MPDE	Mpumalanga Department of Education
MTI	Mathematics teacher identity
PTI	Professional teacher identity
PMTI	Professional mathematics teacher identity
SACMEQ	Southern and Eastern African Consortium for Monitoring Educational Quality
TIMSS	Trends in Mathematics and Science Studies

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CHAPTER 1 INTRODUCTION AND CONTEXTUALISATION

1.1. INTRODUCTION

Non-specialist mathematics teaching is a matter of concern, both internationally and nationally (Hobbs & Torner, 2019). In South Africa, due to socio-economic inequalities in schools, mostly non-specialist mathematics teaching occurs in rural and township (underdeveloped and low socio-economic community) public schools (Spaull, 2019). The reason for this might be the shortage of qualified mathematics teachers (Hobbs & Porsch, 2021; Hobbs & Torner, 2019), and an unequal distribution of qualified teachers (Motala & Carel, 2019). Research has shown that non-specialist mathematics teaching has an influence on the quality of mathematics instruction and learning as these teachers have inadequate subject matter knowledge and didactical skills (Lane & Ríordáin, 2020). This has an influence on learners' achievement (Du Plessis, 2017; Ríordáin et al., 2017). As a result, the number of learners who continue with pure mathematics in the Further Education and Training (FET) phase (Grades 10-12) has decreased, and therefore they are not permitted to enrol for mathematical or technical courses at tertiary level. Furthermore, these learners lack the numerical, higher cognitive reasoning, and problem-solving skills that are important for the world of work (Reddy et al., 2019). In effect, it is essential that mathematics teachers have well-developed subject matter knowledge and didactical expertise for the effective teaching and learning of mathematics (Grootenboer & Zevenbergen, 2008; Van Zoest & Bohl, 2005).

Professional Teacher Identity (PTI) is described as teachers' perception, knowledge, and beliefs regarding teaching and learning in the classroom (Beijaard et al., 2000; Kaya & Dikilitaş, 2019). Van Zoest and Bohl (2005) have coined the term 'Mathematics Teacher Identity' (MTI) to describe mathematics teachers' knowledge, beliefs, commitment, and intentions about mathematics and mathematics teaching and learning. The distinction between PTI and MTI is that PTI refers to teachers' perceptions of themselves and others as teachers, whereas MTI refers to teachers' knowledge of mathematics and how it is taught and learned. In this study, I have adopted the term Mathematics Teacher Identity (MTI) when speaking of teachers' mathematical knowledge for teaching, specifically their subject matter expertise and didactical expertise. This is based on Beijaard et al.'s (2000) model (see Section 2.8.1). These two aspects are considered important for teacher development, and are in line with the National Policy Framework for Teacher Education Development in South Africa (DoE, 2006).

MTI is neither static nor fixed since it develops on a daily basis throughout a teacher's career (Graven & Lerman, 2020). Moreover, it develops through the interaction of personal (beliefs)

and professional (contextual factors and practice) factors (Beijaard et al., 2004; Grootenboer & Edwards-Groves, 2019). This study uses a sociological approach, suggesting that non-specialist mathematics teachers' MTI develops through practice in the school context as a result of interactions with learners, colleagues, school leaders, teaching and learning resources, workshops, and other training (Darragh, 2016; Pipere & Mičule, 2014).

Research on MTI development has generally focused on pre-service teachers' MTI development through teacher education training (Arslan et al., 2021; Cyrino, 2016; Losano et al., 2018; van Putten et al., 2014), and non-specialist mathematics teachers' MTI development through in-service professional development programmes (Crisan & Rodd, 2015; Goos & Guerin, 2022; Graven & Pausigere, 2017; Hobbs & Törner, 2019; Lane & Ríordáin, 2020; O'Meara & Faulkner, 2021; Paolucci et al., 2021). There is a paucity of studies on non-specialist mathematics teachers' MTI development in primary schools in the South African context. Studies about MTI development have shown that after teacher training, it is important that the subject matter knowledge and didactical skills that these fledgling teachers have acquired are implemented in their classroom practice (Skott, 2019; van Putten, 2011). There are also limited studies that focus on the development of mathematics teaching knowledge in non-specialist mathematics teachers, specifically in terms of subject matter expertise and didactical expertise, as per Beijaard et al.'s (2000) model. Furthermore, there is scant knowledge on the influencers of MTI development in non-specialist mathematics teachers.

Studies about non-specialist mathematics teachers' MTI development through in-service professional development programmes have reported effective development of their subject matter knowledge and didactical skills. In these studies, the participants' practice shifted from direct instruction and a teacher-centred approach to a more learner-centred approach (Goos & Guerin, 2022; O'Meara & Faulkner, 2021; Paolucci et al., 2021). Teachers' beliefs have also been associated with MTI development (Alsup, 2006; Törner, 2014; Vermunt et al., 2017), as well as with their practice (Beswick, 2012; Ernest, 1988; Polly et al., 2013; Purnomo, 2017). Additionally, is reported that contextual factors can either have a positive or negative influence on teachers' MTI development (Beauchamp & Thomas, 2009).

According to the research found, MTI development occurs as a result of interactions between personal and professional aspects (Beijaard & Meijer, 2017; Beijaard et al., 2004; Cross Francis et al., 2018; van Putten et al., 2014), all of which can have an influence on MTI development. This study has therefore explored the three influencers of MTI development, namely: teachers' beliefs, contextual factors, and practice in the context of primary schools in South Africa, specifically in terms of Grade 6 non-specialist mathematics teachers' MTI development. The following section describes the context of the study.

1.2. CONTEXT OF THE STUDY

Mathematics is taught to all learners in South Africa (SA) from Grades 1 to 9. This is done so that all learners can become mathematically literate adults. Therefore, from Grades 10 to 12, learners have a choice whether to take Mathematical Literacy, Technical Mathematics, or pure mathematics in the FET phase. Primary schooling is critical in the development of foundational mathematics skills, and conceptual understanding of mathematical concepts (DBE, 2011a). Mathematics as a subject can also assist learners to develop knowledge and skills that are necessary in the real world. However, mathematics education is a serious concern in South Africa, particularly in rural areas, as is reflected in the results of the Trends in Mathematics and Science Study (TIMSS). These issues are also reflected in a national study, the Annual National Assessment (ANA) (DBE, 2014, 2019; Reddy et al., 2016; Reddy et al., 2019).

There are two kinds of public schools in South Africa: fee-paying schools (the government contributes some funds, and parents pay fees), and no-fee paying schools (the school fees are subsidised by the government) (Reddy et al., 2019). Learners in no-fee schools come from lower-income families, live in poorer communities, attend schools with fewer resources, and are primarily taught by teachers with less specialised knowledge. Learners in fee-paying schools, alternatively, come from predominantly middle-class families, live in better-equipped homes, and attend schools with better-qualified educators and a school climate that promotes good teaching and learning. (DBE, 2019; Spaull & Jansen, 2019).

Rural schools lack basic services such as water, electricity, and sanitation, and have an inadequate infrastructure, as well as a shortage of learning and teaching support material (LTSM refers to the variety of teaching and learning materials used to support and facilitate teaching and learning in schools) (Du Plessis & Mestry, 2019; Hlalele, 2012; Isdale et al., 2017; Reddy et al., 2016; Spaull, 2019). Du Plessis and Mestry (2019) make mention that most of the Mpumalanga province's rural schools do not have water, sanitation or electricity, and classrooms are in a terrible condition. In fact, Jele (2022) reports that overcrowding and inadequate infrastructure remain a concern in Mpumalanga schools. These issues influence effective teaching and learning. Herselman (2003) claims that without adequate and proper infrastructure, basic services, and LTSMs, it becomes impossible for learners to receive quality education. According to the TIMSS report, successful learning is likely to be influenced by the calibre of educators, the quality of the classroom environment and instructional activities, as well as the resources available to support instruction (DBE, 2019).

In South Africa, there is an inequality in the education system based on socio-economic status. For instance, learners from rural areas often do not have access to quality education (Reddy

et al., 2019; Spaull, 2019). In support of the above statement, studies based on the TIMSS reports have shown that learners in no-fee paying schools perform poorly compared to fee-paying schools and independent schools (DBE, 2019; Isdale et al., 2017; Reddy et al., 2016; Zuze et al., 2017).The reasons for this, as suggested in the literature, involve a lack of parental involvement, learners' home environments, specific school contexts, a shortage of resources, underqualified teachers, multi-grades, and also the fact that learners are often exposed to teachers who are not satisfied with their jobs, all of which result in poor learner performance (Du Plessis & Mestry, 2019; Isdale et al., 2017; Reddy et al., 2016; Zuze et al., 2017).

A comparison of rural and urban learner performance generally involves different contextual factors that influence the teaching and learning of mathematics (Isdale et al., 2017; Reddy et al., 2016). The main issue in rural schools is that qualified teachers prefer to teach in urban schools, resulting in an unfavourable teacher-to-learner ratio in rural schools (Du Plessis & Mestry, 2019). In fact, filling mathematics and science teacher vacancies in rural or no-fee paying schools is difficult compared to fee-paying and independent schools (Carnoy & Chisholm, 2008; Zuze et al., 2017). In support of the above assertation, Motala and Carel (2019), and Spaull (2019) explain that fee-paying schools hire highly qualified teachers. It is noteworthy that the government mostly focuses on urban schools, which results in rural schools being neglected (Du Plessis & Mestry, 2019). In particular, research shows that schools with low socio-economic status in both rural areas and townships have a high level of non-specialist teaching (Darling-Hammond, 2010; Du Plessis, 2013; Du Plessis, 2017; du Plessis et al., 2014; Hobbs & Törner, 2019; Long & Wendt, 2019; McConney & Price, 2009; Price et al., 2019). According to Du Plessis (2017), and Hobbs and Törner (2019), public primary schools have a larger number of non-specialist teachers than secondary schools.

1.3. PROBLEM STATEMENT

South African learners performed poorly in mathematics in both international (TIMSS and SACMEQ) and national (ANA) assessments (DBE, 2014, 2019; Isdale et al., 2017; Reddy et al., 2019; Reddy et al., 2016). In the TIMSS 2015 and 2019 reports, South Africa is listed as one of the poorest-performing countries of all those participating (DBE, 2019; Reddy et al., 2019; Reddy et al., 2016). The last ANA assessment was done in 2014, and the results revealed that Grade 6 learners were underperforming in mathematics (DBE, 2014). The underperformance of learners in mathematics, specifically in primary schools, has been documented by several scholars (Isdale et al., 2017; Reddy et al., 2019; Spaull, 2013a; Venkat & Spaull, 2015). These researchers indicate that the reason for this might be that mathematics education in primary schools is mostly taught by non-specialist teachers (Bosse & Törner, 2015b; Du Plessis, 2013; Hobbs & Porsch, 2021; Hobbs & Törner, 2019; Onwu & Sehoole,

2015; Price et al., 2019; Spaull, 2013b). In addition, researchers indicate that in most cases, non-specialist teaching has a negative influence on the quality of teaching and learning of mathematics (Darling-Hammond, 2000; Du Plessis, 2010; du Plessis et al., 2014).

Teachers in South African primary schools, particularly in the intermediate phase (Grades 4 - 6), are expected to teach a variety of subjects, including mathematics, resulting in non-specialist teaching (Long & Wendt, 2019; Pausigere, 2015). Non-specialist mathematics teaching mostly often occurs in rural and remote schools, and in low socio-economic communities (Hobbs & Torner, 2019; Kilpatrick & Fraser, 2019; Vale et al., 2021; Weldon, 2016). Essentially, this occurs mostly in public primary schools (Long & Wendt, 2019). Teachers in rural areas are frequently required to teach subjects in which they have not specialised because of a shortage of teachers (Hobbs & Törner, 2019; Sharplin, 2014). This presents a challenge as they need to learn new content and didactical skills (Hobbs & Porsch, 2021). They are expected to learn through practice without the requisite support structures, adapt to mathematics teaching by researching in order to plan their lessons, and also learn from colleagues before teaching (Hobbs, 2013). These teachers subsequently have inadequate subject matter knowledge and teaching skills (Hobbs & Törner, 2019; Lane & Ríordáin, 2020; Schueler et al., 2015; Venkat, 2019; Venkat & Spaull, 2015). In support of the above claim, Venkat and Spaull's (2015) analysis of the SACMEQ results shows that 79% of South African Grade 6 mathematics teachers lack the mathematics content knowledge to teach. Importantly, learners' engagement and interest in mathematics has been shown to decrease during the transition from primary to secondary school due to a lack of appropriately qualified mathematics teachers (Paul, 2014).

Contextual factors are also described as an issue in learning through practice as these can influence what a teacher is willing to commit to in terms of their practice (du Plessis et al., 2019). Such factors include support from school leaders, and the availability of resources and opportunities to attend workshops. Hobbs (2013) indicates that when non-specialist teachers feel supported at school, they become committed to learning the subject, which leads to professional identity development.

In lower socio-economic schools, it has been found that learners fail to master basic mathematics concepts and problem-solving skills in the lower grades, and therefore struggle in the higher grades. This has been connected to teachers in the next grades not having the time to follow up on their learners' backlog (DBE, 2020). As a result, in the FET phase (Grade 10-12), learners choose Mathematical Literacy rather than pure mathematics, thus creating a vicious cycle as there will be fewer graduates in professions requiring mathematics (Grootenboer & Zevenbergen, 2008). According to Reddy et al. (2016), learners' mathematics

competence is important for the social and economic development of a country. Research indicates that South Africa underperforms in mathematics compared to other countries, and this has a negative influence on the country's development. It is thus important for a good mathematical foundation to be laid in the lower grades in order for learners to develop mathematical knowledge and skills. This will improve their mathematics achievement, and will also increase the number of learners doing pure mathematics in the FET phase.

South Africa has taken part in international and national primary school assessments. This includes three assessments of Grade 6 learners, namely, SACMEQ II (2000), SACMEQ III (2007), and SACMEQ IV (2013); the Annual National Assessment (ANA), which assesses learners in Grades 1 to 6 and 9 for three years (2012, 2013 and 2014); and the TIMSS test. The TIMSS test was administered to Grade 8 learners in 1995 and 1999, Grades 8 and 9 in 2002, Grade 9 only in 2011, and Grades 5 and 9 in 2015 and 2019. The learners were assessed with the goal of assessing their mathematical competencies and making informed decisions about how to improve primary school mathematics teaching and learning. The results from the international and national assessments revealed that South African learners perform poorly, particularly in mathematics (DBE, 2011b, 2017, 2019; Isdale et al., 2017; Reddy et al., 2019; Reddy et al., 2016; Spaull, 2011). The international and national assessment reports reveal that the performance of learners in rural areas (Eastern Cape, the Free State, KwaZulu-Natal, Limpopo, Mpumalanga, Northern Cape, the Northwest province) was poorer compared to learners in urban areas (Gauteng and the Western Cape) (DBE, 2011b, 2017, 2019).

In summary: in South Africa, non-specialist mathematics teaching is common as teachers are unevenly distributed in that learners in high socio-economic areas are taught by well-qualified teachers compared to low socio-economic areas (DBE, 2019; Long & Wendt, 2019; Motala & Carel, 2019). Mostly non-specialist teaching occurs in rural areas as they struggle to recruit and retain mathematics specialist teachers in low socio-economic, rural, and remote schools (Handal et al., 2013). Most of the studies on non-specialist mathematics teaching have been undertaken at high school level (Bosse & Törner, 2015b; Crisan & Rodd, 2015; Du Plessis, 2013; Hobbs, 2013; Ríordáin et al., 2017; Weldon, 2016), and only a few in primary schools (Bosse & Törner, 2015b; Du Plessis, 2013). Although there have been some studies on non-specialist teaching in South Africa, few studies report on MTI development. There is scant information on how rural non-specialist mathematics primary school teachers develop their MTI through practice. There is also little information in terms of these teachers' subject matter and didactical expertise, and how their beliefs, contextual factors, and practice influence their MTI development.

1.4. THE RATIONALE FOR THIS STUDY

During my time as a primary mathematics teacher in a public school, I discovered that in the Intermediate Phase (IP), one does not teach according to one's subject specialisation: an IP teacher is supposed to be able to teach all subjects. Primary school teachers are thus described as generalists (Brown & McNamara, 2011; Karaolis & Philippou, 2019; Price et al., 2019). The Integrated Quality Management System evaluations (IQMS) is a performance management system used to evaluate teachers' performance. During IQMS evaluations involving peer lesson observations, I observed that several colleagues found it difficult to explain mathematical concepts thoroughly. They struggled or were unable to use different practical examples and representations, or manipulatives, to accommodate the diverse needs of learners. This was evident in their inability to explain concepts thoroughly, and to pose questions that elicit reasoning and justification of thinking. It was clear that mathematics expert knowledge and teaching skills are prerequisites for teachers to provide effective teaching and to create meaningful learning opportunities. This experience motivated me to want to understand non-specialist teachers' mathematical identity development, and its influencers. Moreover, there may be a knock-on effect: learners perform poorly in mathematics, which may partly be due to weak in-service, non-specialist teachers' MTI. This could then be directly linked to these teachers' inadequate subject knowledge and teaching skills (Anthony & Walshaw, 2009; Du Plessis, 2013).

Studies on the development of pre-service mathematics teachers' identities have been conducted in both primary and secondary schools (Arslan, 2018; Botha & Onwu, 2013; Darragh & Radovic, 2019; Lutovac & Kaasila, 2011, 2014; Matheny, 2016; Pausigere, 2015; Pipere & Mičule, 2014; Torres & Uriza, 2013; van Putten et al., 2014; Van Zoest & Bohl, 2005). There are also studies on MTI development through in-service teacher training programmes (Bjuland et al., 2012; Crisan & Rodd, 2015; Hobbs, 2013; Hodgen & Askew, 2007; Hodges & Cady, 2012; Pausigere, 2015; Ríordáin et al., 2017). However, there remains a paucity of information regarding the MTI development of non-specialist teachers through practice, and how these teacher's beliefs, contextual factors, and practice influence their MTI development. This study investigated the in-depth complexities that are associated with the MTI development of non-specialist rural primary school mathematics teachers.

1.5. PURPOSE STATEMENT AND RESEARCH QUESTIONS

The purpose of this study was to explore Grade 6 non-specialist mathematics teachers' MTI development through practice. It was anticipated that the findings could explain how non-specialist teachers' MTI is developed through practice. The researcher also aimed to provide

evidence of how the teachers' beliefs, contextual factors, and practice may influence their MTI development. This study will contribute to the body of knowledge of non-specialist teachers' MTI development in the South African rural context. The primary research question that guided the study was as follows:

How do non-specialist mathematics teachers' subject matter knowledge and didactical expertise develop through practice?

The primary research question is addressed through the sub-questions below:

1. How can the beliefs that non-specialist mathematics teachers have about mathematics as a subject, and its teaching and learning, change through practice?
2. What contextual factors influence non-specialist mathematics teachers' MTI development through practice?
3. How does the practice of non-specialist teachers influence their MTI development?

1.6. Definitions of Terms

The following table presents the definitions of the key concepts in the study.

Table 1.1: Key concepts of this study

CONCEPTS	CLARIFICATION
BELIEFS	'Beliefs' is a cognitive element that develops consciously and unconsciously though experience and within a context (Cross, 2009). In this study, I focused on the teachers' views of mathematics as a subject, mathematics learning, and mathematics teaching (Ernest (1989).
CONTEXTUAL FACTORS	The school context, resources, and support received from school leaders (Beauchamp & Thomas, 2009; Flores & Day, 2006).
DIDACTICAL EXPERTISE	The teachers' knowledge of different teaching approaches, making use of different presentations, and making the content understandable to others (Shulman, 1986).
MATHEMATICS TEACHER IDENTITY	Mathematics teacher identity refers to teachers' knowledge, beliefs, commitment, and intentions regarding mathematics and mathematics teaching (Van Zoest & Bohl, 2005).
MATHEMATICS SPECIALIST TEACHERS	These teachers are specifically trained to teach mathematics and have particular knowledge, interest, and expertise in mathematics content and the teaching thereof (Reys & Fennell, 2003).
NON-SPECIALIST MATHEMATICS TEACHERS	Teachers who teach mathematics but who are not trained at tertiary level to teach it (Du Plessis, 2018).
PRACTICE	Practice is defined as an interaction with colleagues, students, and teaching and learning resources in an educational setting, whether in the classroom or in the community (Beijaard et al., 2004; Grootenboer &

CONCEPTS	CLARIFICATION
	Edwards-Groves, 2019). In this study, practice is considered to be learning as doing, and active participation in teaching and learning.
PROFESSIONAL DEVELOPMENT	This encompasses the "activities that develop an individual's skills, knowledge, expertise and other characteristics as a teacher" (Mayer & Lloyd, 2011, p. 49). The teacher engages in formal and informal learning about their subject outside of their field of specialisation in professional practice (Knapp, 2003).
PROFESSIONAL TEACHER IDENTITY	This has been described as consisting of three categories: subject, didactical, and pedagogical expertise (Beijaard et al., 2000). In this study, I focused on subject matter expertise and didactical expertise as these mainly concern the cognitive dimension of the teacher.
RURAL AREA	This can be described as a place with a low socio-economic status, and which is far away from towns. These places also lack basic services (running water and sanitation) (Hlalele, 2012).
SUBJECT MATTER EXPERTISE	This refers to teachers' knowledge to plan lessons, explain concepts at a higher cognitive level, develop effective tasks, and diagnose student understanding and misconceptions adequately (Beijaard et al., 2000).

1.7. METHODOLOGICAL CONSIDERATIONS

The philosophical assumption that underpinned this study was the interpretivist perspective. The researcher's intention was to make sense of, and interpret the meanings of the data from the participants' perspectives and experiences. I believe that reality is not objectively determined, but is socially constructed from participants' natural environment. Nieuwenhuis (2016b) asserts that studying people in their social contexts provides a greater opportunity to understand their perceptions of their activities. The research approach employed was qualitative because "the researcher seeks to establish the meaning of a phenomenon from the views of participants" (Creswell & Creswell, 2018, p. 54). This study aimed to explore and understand the MTI development of non-specialist mathematics teachers from what they stated, and from observing their teaching practice. A case study research design was utilised in this study. According to Yin (2018), a case study allows the researcher to collect rich descriptive data from the participants within their natural setting, and construct meaning from their lived experiences and perspectives.

In this study, I adopted a purposeful sampling method when selecting the 10 schools and participants in rural areas in the Mpumalanga province. McMillan and Schumacher (2014, p. 4) describe purposeful sampling as a process that "allows choosing of small groups or individuals who are likely to be knowledgeable and informative about the phenomenon of interest". Creswell (2014, p. 189) confirms this, stating that it is essential to "purposefully select

participants or sites that will best help the researcher understand the problem and research questions". Ten Grade 6, non-specialist mathematics teachers were selected as participants, one per school. This sample size facilitated the gathering of rich, in-depth information from each participant (Creswell, 2014). The sample comprised non-specialist teachers who were teaching Grade 6 at the time of this study, and had two to 15 years of teaching experience in mathematics in rural public primary schools in the Mpumalanga province (see Chapter 3 for a more detailed discussion on the selection criteria). The selected Grade 6 non-specialist mathematics teachers were chosen because Grade 6 is a terminal class for the Intermediate Phase, preceding the Senior Phase (Grades 7 to 9), and it is assumed that these teachers have assisted their learners to master all Intermediate Phase mathematical skills. The rationale for choosing rural areas in the Mpumalanga province is that it is one of the provinces with underperforming learners in mathematics, based on national assessments.

In the individual semi-structured interviews conducted with the participants, questions were posed that were based on the participants' professional background, non-specialist teaching experience, beliefs, teaching approaches, planning, support, and the influence of context on their professional development. The interviews were transcribed and analysed using the themes and categories from the conceptual framework; and codes emerged from the transcribed data. I also observed their subject matter knowledge and didactical skills in the classroom while they were teaching mathematics. Lastly, a document analysis of their lesson plans was conducted. In this study, both inductive and deductive analysis were used. Deductive analysis was used to identify the predetermined themes and categories, while inductive analysis was used to analyse the codes that emerged from the raw data. I adhered to the quality criteria guidelines of credibility, dependability, confirmability and transferability, which are vital in qualitative research (Creswell, 2014; Nieuwenhuis, 2016a). The study used both triangulation and member checking (Baxter & Jack, 2008; Nieuwenhuis, 2016a) to ensure trustworthy findings.

I obtained ethical clearance from the Ethics Committee of the Faculty of Education at the University of Pretoria. I also received permission to conduct my research from the Mpumalanga Head of the Department of Education, as well as the schools' principals. The participating non-specialist mathematics teachers and their learners signed informed consent and assent letters, respectively, before I commenced with the study. I adhered to the ethical principles of confidentiality and anonymity throughout the study. I thoroughly explained to the participants their roles, and informed them that participation was voluntary, and that they could withdraw at any time. I developed a good relationship with the participants, which allowed them to feel comfortable in responding openly and unreservedly to the interview questions. The ethical principles applicable to this study are further discussed in Chapter 3.

1.8. POSSIBLE CONTRIBUTION OF THE STUDY

This study was positioned to contribute knowledge on how the MTI of non-specialist teachers can be developed through practice. According to past studies, PTI development is a continuous and dynamic process (Beijaard et al., 2004; Day et al., 2006; Flores, 2014; Vloet & Van Swet, 2010). This means that it continuously develops from being a learner at school, during teacher training, and even after teacher training through practice (Pipere & Mičule, 2014). PTI continuously develops through everyday practice where teachers continuously interpret and re-interpret their experience, as well as the interaction between themselves and learners, as well as the school context (Beauchamp & Thomas, 2009; Beijaard et al., 2004; Pausigere, 2015; Vermunt, 2014; Vloet & Van Swet, 2010). It was envisaged that non-specialist mathematics teachers would use their professional experiences involving their teaching knowledge and skills to develop their MTI.

It is not clear how non-specialist mathematics teachers can develop their MTI without any in-service training. This research may thus provide useful information about their MTI development in terms of subject matter expertise and didactical expertise. Furthermore, this research sought to provide information and recommendations on how non-specialist teachers can be supported through in-service intervention programmes, as this will enhance the effective teaching and learning of mathematics across South African rural classrooms. The findings could also be used to narrow the gap that exists between non-specialist mathematics teachers in rural and urban communities. It was also expected that the results of this study would also promote further research on the MTI development of non-specialist teachers.

Various studies have found that there are interrelationships between beliefs and practice (Ernest, 1989; Grootenboer, 2006; Korthagen, 2004), and that beliefs have an influence on MTI development in that teachers may be resistant to change (Westaway & Graven, 2019). The relationship between beliefs and MTI development was specifically investigated in this study. Many scholars have studied the MTI development of *pre-service* mathematics teachers (Arslan et al., 2021; van Putten et al., 2014; Van Zoest & Bohl, 2005), and in-service non-specialist *secondary school* mathematics teachers (Crisan & Rodd, 2015; Goos & Guerin, 2022; Graven & Pausigere, 2017; Kenny et al., 2020; Lane & Ríordáin, 2020; O'Meara & Faulkner, 2021; Paolucci et al., 2021; Richter et al., 2014). However, there is a paucity of information regarding *primary school in-service* non-specialist teachers' MTI development through practice in a South African context. This study may also contribute to the field of knowledge about the influence of these teachers' mathematical beliefs on their MTI development through practice. Furthermore, this research may provide useful information

about non-specialist teachers' MTI development, which could inform teacher trainers on how to enhance meaningful professional development programmes.

1.9. STRUCTURE OF THE THESIS

This thesis comprises five chapters. The structure of the thesis is briefly outlined below:

Chapter 1

Provides an overview of the study regarding the background, problem statement, rationale, and the purpose of the study. After presenting the research questions and defining the key concepts used in the study, I explained my philosophical assumption, as well as the research approach and design utilised. I also stated the data collection methods and analysis carried out. I then discussed the ethical guidelines to which I adhered, and briefly refer to the quality criteria followed in this study to ensure the trustworthiness of the findings. I conclude the chapter with the contribution of this study to the corpus of knowledge.

Chapter 2

This chapter gives an in-depth discussion of literature on Professional Teacher Identity (PTI), Mathematics Teacher Identity (MTI), the link between beliefs and MTI, PTI development, MTI development, and the influencers of MTI development. This study focused on the teachers' beliefs, contextual factors, and practice. I conclude Chapter 2 by discussing my conceptual framework and the way in which I adapted the existing PTI and MTI framework, which allowed me to explore non-specialist mathematics teachers' MTI development through practice.

Chapter 3

This chapter firstly describes the philosophical assumption underpinning the study. I give a comprehensive explanation of the research approach, design, data collection methods, and data analysis that I employed in this study. Also, I further discuss the quality criteria to which the study adhered in order to produce trustworthy findings. Finally, I explain the ethical considerations, which I respected when conducting the research.

Chapter 4

Both deductive and inductive data analysis were employed in this study. The findings are discussed in detail based on the data obtained from the three data collection methods, namely: semi-structured interviews, lesson observations, and document analysis of assessment tasks. The findings are discussed based on the predetermined categories from the conceptual framework, as well as emerging categories from the data collected. I situate the findings within the existing literature throughout the analysis thereof. I also indicate the correlations and

contradictions of this study's findings with those in existing literature. Lastly, I indicate where this study adds new knowledge.

Chapter 5

This chapter addresses the research questions and presents the conclusions reached. I contemplate the possible contribution of knowledge provided by this study. Finally, my reflection, the limitations of the study, and recommendations for further practice and intervention are provided.

1.10. SUMMARY OF THE CHAPTER

In this chapter, I have provided an introduction, and presented the context of the study. I stated the research problem, rationale, purpose of the study, and formulated the research questions. After that, I introduced the research paradigm, research approach, research design, as well as the data collection methods and analysis. I lastly discussed the possible contribution of this study to the field of knowledge. The next chapter presents a review of the relevant literature, as well as the conceptual framework that guided this study.

CHAPTER 2 LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

In Chapter 1, I argued that well-developed subject and didactical expertise are essential for the effective teaching and learning of mathematics. Therefore, it is necessary to understand and gain insight into this phenomenon from teachers' perspective to further guide educational stakeholders in advancing mathematics education in South African primary schools. Non-specialist mathematics teaching occurs not just nationally, but internationally too (Hobbs & Törner, 2019). It has been found to influence the teaching and learning of mathematics, and subsequently learners' achievement too (Ríordáin et al., 2017).

The literature reviewed in this chapter presents a discussion on Professional Teachers' Identity (PTI), Professional Mathematics Teacher Identity (PMTI), Mathematics Teachers' Identity (MTI), the link between beliefs and MTI, MTI development, and the influencers of MTI development. In addition, the three specific influencers of MTI in non-specialist teachers, namely, teachers' beliefs, contextual factors, and teachers' practices, are discussed. Moreover, I explain the teacher identity frameworks used in the literature. The exploration of the relevant literature led me to develop the conceptual framework that guided me in conducting this study, which is discussed further on in this chapter. Figure 2.1 below provides an overview of Chapter 2.

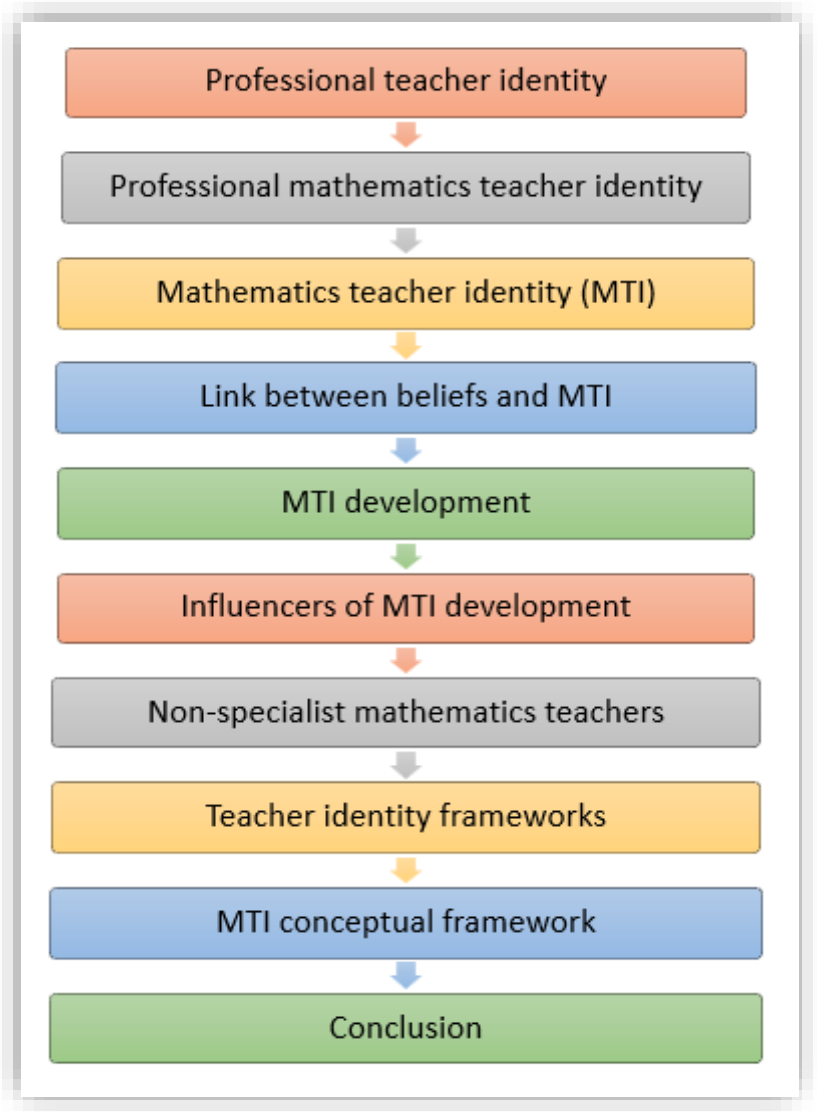

Figure 2.1: Chapter overview

2.2 PROFESSIONAL TEACHER IDENTITY

Professional Teacher Identity (PTI) “provides a framework for teachers to construct their ideas of ‘how to be’, ‘how to act’, and ‘how to understand’ their work and their place in society” (Sachs, 2005, p. 15). In this study, PTI is seen as “who or what someone is, the various meanings someone can attach to oneself, or the meanings attributed to oneself by others” (Beijaard, 1995, p. 282). This refers to the meaning that teachers attach to what it means to be a mathematics teacher, and the expectations placed on them as mathematics teachers by the school and community.

Beijaard et al. (2004, p. 122) reviewed studies on PTI in an attempt to develop an understanding of the concept. Four important and common features emerged regarding the definitions, namely:

> *(i) Professional identity is an ongoing process of interpretation and re-interpretation of experiences; (ii) Professional identity implies both person and context; (iii) A teacher's professional identity consists of sub-identities that more or less harmonize; and (iv) Agency is an important element of professional identity.*

Therefore, these aspects are important for understanding the development of PTI. The literature indicates that there are many definitions of PTI (See Table 2.1), most of them slightly modified from the Beijaard et al.'s (2004) definition. According to the definitions provided, PTI refers to teachers' personal perception of themselves as professional educators (Edwards & Edwards, 2017; Karaolis & Philippou, 2019; Mockler, 2011; Olsen, 2014; Strutchens et al., 2016; Vermunt et al., 2017); an interconnection of personal and professional aspects (Beijaard & Meijer, 2017; Cross Francis et al., 2018; van Putten et al., 2014), and is not static, but rather dynamic as it is constantly evolving (Akkerman & Bakker, 2011; Chong et al., 2011; Neumayer-Depiper, 2013; Pennington & Richards, 2016; Skott, 2019; Teng, 2017). From the various definitions of PTI presented in Table 2.1, there are common features such as teachers' perspectives; an ongoing and dynamic process; and the interaction of personal and professional aspects, which were also identified in the review carried out by Beijaard et al. (2004). It is important to understand that PTI is reliant on teachers' perception, and is not fixed or linear, but rather develops continuously throughout a teacher's life (Graven & Lerman, 2020). The table below presents the different definitions given by several authors.

Table 2.1: Definitions of PTI in recent literature between 2011 and 2022

Source	Definition
Beijaard and Meijer (2017, p. 177)	"Ones' image of self as a teacher and consist of a complex configuration of personal and professional factors".
Chong et al. (2011, p. 51)	"Is both a product, as a result of influences on the teacher, as well as a process that is not fixed but an ongoing dynamic interaction within teacher development".
Cross Francis et al. (2018, p. 135)	"Teachers' sense as a teacher, which encompasses ones' personal, professional, socio-political and cultural dimensions".
Edwards and Edwards (2017, p. 191)	"The way teachers view themselves as teachers, their professional teacher identity, develops over time".
Karaolis and Philippou (2019, p. 399)	"The conception one has of himself or herself as a person linked with how he or she acts as a professional".

Source	Definition
Mockler (2011, p. 519)	"The way teachers, both individually and collectively, view and understand themselves as teachers. It is thus understood to be formed within, but then also out of the narratives and stories that form the 'fabric' of teachers' lives".
Neumayer-Depiper (2013, p. 9)	"A continuous process of constructing and deconstructing understandings within the complexities of social practice, beliefs, and experiences".
Olsen (2014, p. 79)	"A view of teachers both as a socio-cultural product shaped by history, formal learning and social practice, and as phenomenological agents constructing themselves inside daily work of teacher preparation and classroom teaching".
Pennington and Richards (2016, p. 6)	"Emerges as a dynamic construct that is shaped by the context in which the teacher works and that may have different features at different times".
Skott (2019, p. 469)	"The study defines teacher identities as their shifting experiences of being, becoming and belonging related to the profession".
(Strutchens et al., 2016) page number	"Involves how one sees oneself as a teacher, including the capacity to reflect and act upon experiences to create ways of being".
Teng (2017, p. 118)	"A process wherein teachers construct their ideas or build practical knowledge about ways to be and act as a teacher".
Vermunt et al. (2017, p. 144)	"How teachers see themselves as professionals''.

Beijaard et al. (2000, p. 750) described PTI as teachers' perception as a "subject matter, pedagogical and didactical expert". This definition focuses on teachers' knowledge of teaching and their ability to do so effectively, therefore Beijaard's definition became the working definition of this research.

According to Beijaard et al. (2004), PTI is complex in both its nature and its development. van Putten et al. (2014, p. 370) agree with this claim, stating that it "is made up of personal as well as social aspects that come together in a construct that encompasses knowledge and beliefs, emotions and relationships, and context and experiences". PTI continuously develops and is an ongoing process through practice. This means that teachers must continuously interpret and re-interpret their experience, as well as the interaction between personal and professional dimensions in their lives (Chong et al., 2011; Vloet & Van Swet, 2010), which can be affected by context (Beijaard et al., 2000; Day et al., 2006). In support of the preceding assertion, Beijaard and Meijer (2017) and Loughran (2006) demonstrate that there is a connection between the personal and professional dimensions, and that they influence each other towards PTI development. PTI has been used as a key construct in understanding the development of PTI (Beijaard et al., 2004; Day et al., 2006).

Many scholars have described teachers' professional identity and the development of pre-service teachers (Izadinia, 2013; Kasten et al., 2014; Lutovac & Kaasila, 2014, 2018b; van Putten et al., 2014), and in-service teachers (Beijaard et al., 2000; Bjuland et al., 2012; Crisan & Rodd, 2015; Hobbs, 2013; Hodges & Cady, 2012; Pausigere, 2015). Lutovac and Kaasila (2018b) claim that pre-service teacher education often does not provide opportunities for students to develop the identities needed for their future profession. In support of the above claim, van Putten et al. (2014) found that pre-service teachers' perception of their PMTI was not congruent with their teaching practice. In line with this, I will discuss Professional Mathematics Teacher Identity in the following section.

2.2.1 Professional Mathematics Teacher Identity

van Putten et al. (2014) described PMTI as teachers' perception of their knowledge as subject specialists, teaching and learning specialists, and nurturers/carers. They formed the construct of PMTI to distinguish between teachers who studied mathematics with the purpose of teaching it (mathematics specialists), and those who are not trained to teach mathematics (non-specialist teachers) but are teaching mathematics anyway. The professional mathematics teachers in their study received tertiary education, and were taught mathematics content and didactics, specifically the use of various teaching approaches and representations in teaching. The goal thereof was to enhance learners' conceptual understanding, and utilise different assessment strategies to assess learners' conceptual understanding. In addition, the mathematics specialist teachers in their study had unique mathematical knowledge for teaching. This knowledge includes explaining terms and concepts to learners at a high cognitive level; interpreting learners' statements and solutions, judging and correcting textbook treatments of specific topics using accurate representations in the classroom; providing students with examples of mathematical concepts, algorithms, or proofs; and being able to employ various teaching approaches (Hill et al., 2005). Botha (2011) also found that specialist teacher training allowed students to develop content knowledge, curriculum knowledge, and knowledge about how to teach mathematics concepts and how learners learn mathematics. van Putten et al. (2014) investigated teachers' PMTI with three subsets: PMTI influencers; teachers' perceptions as mathematics teachers; and their PMTI actualisation in the classroom.

2.2.2 Mathematics Teacher Identity

MTI can be described as "who I am" being intertwined with "what I know" and "what I can do in the classroom" (Ní Ríordáin et al., 2022, p. 256). It implies that MTI is linked to teachers' subject matter knowledge and teaching skills, which actualise through classroom practice. MTI

has been described as teachers' relationship to mathematics, which encompasses their beliefs, knowledge, and teaching skills (Beijaard et al., 2000; van Putten et al., 2014; Van Zoest & Bohl, 2005). Scholars have used different terms to describe teacher identity in mathematics education: mathematics identity (Leatham & Hill, 2010; Lutovac & Kaasila, 2011, 2014); mathematics teacher identity (Arslan et al., 2021; Kasten et al., 2014; Van Zoest & Bohl, 2005); professional mathematics teacher identity (van Putten et al., 2014); mathematics-related teacher identity (Lutovac & Kaasila, 2018b), and primary mathematics teacher identity (Darragh & Radovic, 2019; Graven & Pausigere, 2017; Grootenboer & Edwards-Groves, 2019; Nanna et al., 2021; Palmér, 2016; Westaway & Graven, 2019). In the South African context, very few studies have focused on mathematics teacher identity in pre-service (Botha & Onwu, 2013; van Putten et al., 2014), and in-service teachers (Nel, 2012; Ntow & Adler, 2019; Pausigere, 2015; Pausigere & Graven, 2013).

van Putten et al. (2014) state that MTI includes teachers who teach mathematics, but are not qualified mathematics teachers. Researchers have studied the concept of MTI exploring how both specialist and non-specialist mathematics teachers understand themselves in the context of mathematics teaching (Karaolis & Philippou, 2019; van Putten et al., 2014). According to the definitions above, MTI comprises teacher knowledge, and can be constructed from interaction or engagement inside or outside the classroom, and is socially constructed. In this study, I used the construct MTI coined by Van Zoest and Bohl (2005) where MTI is posited as involving teachers who did not study mathematics at a tertiary level during their teacher training. MTI is described as teachers' knowledge for teaching (subject matter and didactical expertise). I argue that for the effective teaching and learning of mathematics, teachers should have a well-developed MTI (Van Zoest & Bohl, 2005).

Several researchers have conducted research on primary MTI in the international context (Arslan et al., 2021; Nanna et al., 2021), and in the South African context (Pausigere, 2015; Westaway & Graven, 2019). Pausigere (2015, p. 6) defines primary MTI "as a way of talking about who primary mathematics teachers are and how they name themselves and how they are recognized by others concerning the subject of mathematics and its corresponding activities". Pausigere's study (2015) described how an in-service professional development programme transformed mathematics teachers' identities in such a way that the teachers' practices shifted to a learner-centred approach, while also enhancing learners' conceptual understanding. Mathematics is taught as procedures, and is learned by listening and following clear explanations, which is difficult for learners with less skill or capability. Westaway and Graven (2019, p. 9) have discovered that primary school mathematics teachers continue to believe that "mathematics is difficult and not for everyone". These teachers are unable to

transition from being a transmitter of highly controlled knowledge to being a facilitator of learning in the new curriculum.

Additionally, Nanna et al. (2021) have investigated primary school MTI in terms of the teaching and learning aspect by employing Martin's (2000) six components of MTI. Furthermore, the MTI development of primary school teachers has been investigated in terms of subject matter expertise (Askew et al., 2019). Their study investigated first- and fourth-year pre-service, primary school mathematics teachers' Mathematical Content Knowledge (MCK) for teaching employing Ball et al.'s (2008) model. They found that there was an improvement in teachers' MCK in the area of low cognitive demand items. Alternatively, the difference between the first- and fourth-year primary school mathematics student teachers in terms of higher-cognitive demand items was very small.

Moreover, Arslan et al. (2021) have studied the influence of the Community of Practice on the MTI development of early career primary school teachers. Their study showed that there was a positive effect from the negative conditions (reform-unsupportive), communities, and no effect of positive conditions (reform supportive) working communities. However, there is a scarcity of research specifically exploring the MTI development of non-specialist teachers in rural primary schools in terms of their subject matter knowledge and didactical expertise. This study considered the MTI construct instead of using PTI or PMTI, as the aim was to focus on non-specialist mathematics teachers. Next, I will discuss the link between beliefs and MTI.

2.3 THE LINK BETWEEN BELIEFS AND MTI

Merseth et al. (2008, p. 91) states that "beliefs are the building blocks of a teachers' professional identity". This means that teachers' beliefs are intertwined with their mathematics identity, and it affects how they perceive their role as teachers (Ye & Zhao, 2019). This is reflected in Van Zoest and Bohl's (2005) work, which indicates that MTI encompasses teachers' knowledge, beliefs, commitment, and intentions about mathematics and mathematics teaching. Furthermore, teachers' mathematical knowledge is linked to their beliefs about what constitutes mathematical knowledge, and the types of teaching approaches that will be appropriate for learners' conceptual understanding needs. Moreover, it is teachers' complex views of themselves, and it shapes and get shaped by their subsequent beliefs and practices (Olsen, 2014). Research has indicated that MTI incorporates mathematical knowledge and skills, as well as the beliefs held by teachers (Beijaard, 2019; Grootenboer, 2013; Martin, 2012; van Putten et al., 2014). According to Timperley et al. (2008, p. 6), teachers' classroom practice is centred on "teachers' knowledge and beliefs about what is important to teach, how to manage students' behaviour and meet the curriculum demands".

This implies that the teachers' beliefs are essential for MTI development, as researchers argue that there is a link between teachers' beliefs, their mathematics knowledge, and teaching skills.

Törner (2014, p. 15) states that beliefs play an important role in PTI development. In support of this, Kirsti (2015) maintains that MTI is about knowing mathematics for oneself and for teaching, and is related to teachers' beliefs about the nature of mathematics and mathematics teaching and learning. Several researchers indicate that MTI development may also be influenced by the beliefs originating from the various mathematics learning and teaching contexts to which the individual has been exposed (Hodgen & Askew, 2007; Kim et al., 2019; Martin, 2012; Walkington, 2005). Furthermore, Vermunt et al. (2017) claim that the development of a teacher's professional identity is dependent on their beliefs about the learning and teaching of mathematics, their motivations to learn about the subject, and different teaching approaches. This may result in their MTI being developed or not developed. Desimone (2009) concurs, indicating that teachers' identity development is linked to their beliefs - when teachers' knowledge and skills (MTI) develop, their beliefs change as well. This is evident Westaway and Graven's (2019) findings, which reveal that teachers continue to hold onto old beliefs about mathematics being a difficult subject, resulting in no subject knowledge and teaching skill development. Additionally, researchers have found a correlation between teachers' beliefs and practice (Ernest, 1988; Philipp, 2007; Polly et al., 2013). Furthermore, I contend that the beliefs of teachers, specifically non-specialist teachers, can have an influence on their mathematical knowledge and teaching skills development.

2.4 Professional Teacher Identity development

According to Beijaard et al. (2004, p. 122), PTI, which may be seen as an overarching construct in terms of teacher identity, is an answer to the question "who am I at this moment?" and "who do I want to become?" So then, PTI *development* could be an answer to the question "who do I want to become?" Grootenboer and Zevenbergen (2008) assert that identity is a useful concept to explore and understand teachers' professional identity development within the broader context of teaching, bringing together individual elements such as life histories, affective qualities, and cognitive dimensions. Teacher identity development "is not just an accumulation of skills and information, but a process of becoming-to become a certain person or, conversely, to avoid becoming a certain person" (Wenger, 1998, p. 215).

PTI has been used as a key construct in understanding PTI development (Beijaard et al., 2004; Day et al., 2006). According to Neumayer-Depiper (2013), PTI development is a continuous process of constructing and deconstructing understanding within the complexities of social practice, beliefs, and experiences. Studies on PTI development indicate that it

develops as an ongoing process through interactions with learners, colleagues, school managers, context, and teaching and learning resources (Beauchamp & Thomas, 2009; Beijaard & Meijer, 2017; Beijaard et al., 2004; Pausigere, 2015; Vermunt, 2014). It means that PTI development takes place through the interaction between personal and professional contexts (Beijaard et al., 2004; Bjuland et al., 2012).

Beijaard and Meijer (2017) indicate that PTI development is closely bound to the personal and professional dimensions. In agreement with this, Olsen (2014) mentions that teachers develop their professional knowledge, selves, perspectives, and practices interactively and iteratively. They do this as they construct new educational interpretations and teaching approaches through the assemblage of personal and professional influences. Hence, “it seems unlikely that the core of the person will not impact the core of the professional” (Loughran, 2006, p. 112). According to Beijaard (2019, p. 3), PTI development is instilled in, and powered by many (primarily) personal aspects, such as one’s biography, aspirations, learning history, and beliefs. MTI may start developing early during childhood up to adulthood schooling, for instance, from primary school, through secondary school, to university while studying to become mathematics teachers. It then further develops in the workplace while teaching mathematics (Pipere & Mičule, 2014). These aspects must be considered in order to understand the nature of MTI development. In this study, I examined both the personal (beliefs and knowledge), and professional (contextual factors and practice) aspects that could influence teachers’ MTI development (see Figure 2.2.) below.

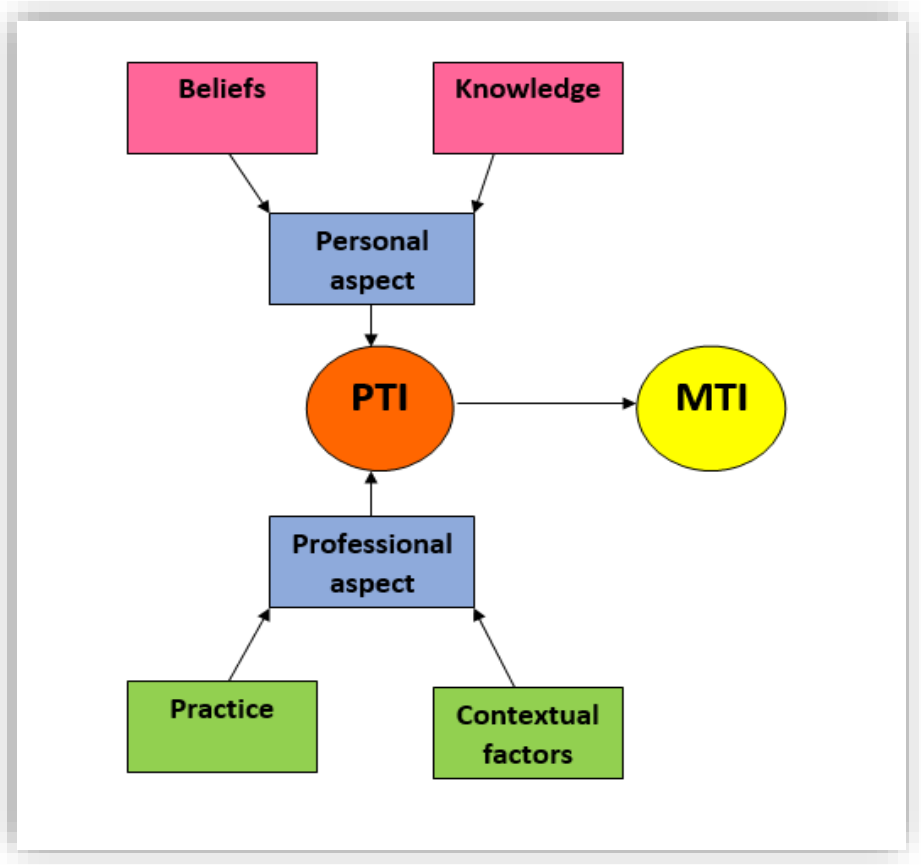

Figure 2.2: Mathematics Teacher Identity (MTI) development

2.5 MATHEMATICS TEACHER IDENTITY DEVELOPMENT

MTI development can be described from two perspectives: the sociological (action), and the psychological (acquisition) (Darragh, 2016). This study adopted the sociological perspective to explore MTI development through practice in a school context as teachers continuously interact with mentors, colleagues, learners, parents, and school leaders (Pipere & Mičule, 2014). Goos (2013) supports the sociological viewpoint as being useful in understanding mathematics teachers' learning and professional identity development in social practice participation. Darragh (2016, p. 19) agrees, describing identity as "an action and fit within a sociological frame". The sociological view provides the researcher with an opportunity to explore how participants interact within the school context, and how personal and professional aspects influence each other as part of the professional development process. PTI development takes place in a social environment (Vermunt, 2014). In this study, the social environment was the school and classroom in which the teachers participated in several activities and interactions with colleagues and learners (Desimone, 2009).

Matos et al. (2009, p. 171) claim that MTI development is "the process of coming to know". It takes time and is a complex process that entails the development of teaching knowledge and

skill (Edwards & Edwards, 2017). According to Kirsti (2015), MTI development is the process of becoming a mathematics teacher, and it involves changes in subject matter knowledge and didactical skills. In support of this notion, Ní Ríordáin et al. (2022) state that MTI development entails more than mastering knowledge of the content to be taught; it also entails developing a new professional identity, providing a sense of alignment with the community of mathematics teachers.

Research on mathematics education in recent years has placed considerable emphasis on the concept of MTI development (Arslan et al., 2021; Beijaard & Meijer, 2017; Botha & Onwu, 2013; Pipere & Mičule, 2014; Rodgers & Scott, 2008; Sfard & Prusak, 2005; Ye & Zhao, 2019). In accordance with the above descriptions, I agree that, as evidence of MTI development, there should be a shift in teachers' perception of themselves as subject and didactical experts. Furthermore, teachers should have an intrinsic motivation to become specialist mathematics teachers (Van Zoest & Bohl, 2005).

Barber and Mourshed (2007, p. 16) argue that "the quality of an educational system cannot exceed the quality of its teachers". This implies that what is learned in the classroom depends on the teacher's subject matter expertise and didactical expertise. Grootenboer and Zevenbergen (2008, p. 248) concur, explaining that "it is essential that teachers of mathematics (at all levels) have well-developed personal mathematical identities". Hence, MTI development is crucial for the effective teaching and learning of mathematics (Grootenboer & Zevenbergen, 2008; van Putten et al., 2014; Van Zoest & Bohl, 2005). I agree with the above assertions that learning in the classroom is dependent on the subject matter knowledge and didactical expertise of teachers. Mathematics teachers must therefore have well-developed MTI in order to explain content to learners at a high cognitive level, assist learners in actively constructing their own conceptual understanding, encourage problem solving or classroom discussion, and use both a teacher-centred and a learner-centred approach.

2.5.1 The MTI development of pre-service teachers through training programmes

According to Richter et al. (2014), PTI development is an uptake of formal and informal learning opportunities that deepen and extend teachers' professional competence, including knowledge and teaching skills. Richter et al. (2014) describe formal professional development as a structured learning environment and curriculum, such as graduate courses or teacher training programmes to develop their knowledge and skills. There are several studies on the development of pre-service teachers' MTI in different countries: Europe (Arslan et al., 2021; Lutovac & Kaasila, 2014); North America (Matheny, 2016); South America (Cyrino, 2016; Losano et al., 2018) and South Africa (Botha & Onwu, 2013; Essien, 2014; van Putten et al.,

2014). However, in South Africa, the majority of studies focused on secondary school mathematics teachers' identity development through a pre-service professional development programme (Botha & Onwu, 2013; Ivanova & Skara-Mincāne, 2016; van Putten et al., 2014). However, MTI does not develop exclusively in such a programme, as is explained in the next section.

2.5.2 MTI development through practice

Informal MTI development occurs through practice when teachers prepare, present, and reflect on lessons and assessment tasks. MTI development also takes place through professional interaction with learners and colleagues, as well as receiving support from colleagues (Ivanova & Skara-Mincāne, 2016). Informal professional development is also mostly found in school contexts that allow teachers to reflect on their practice, and interact with their colleagues and learners (Desimone, 2009; Putnam & Borko, 2000; Richter et al., 2014). In fact, Beauchamp and Thomas (2009) have found that PTI is shaped and re-shaped in interactions with learners and colleagues, and personal learning through using textbooks, the internet, and YouTube. MTI development is in line with a constructivist view of learning, which means that the teacher learns individually through self-reflection and self-study, as well as in collaboration with others, for example, colleagues and subject expert teachers (Ivanova & Skara-Mincāne, 2016; Richter et al., 2014).

2.5.3 MTI development through professional training and practice

Kovács and Kálmán (2022) claim that MTI development requires professional training *and* practice, implying that practice alone is insufficient. They also state that MTI development takes place "from diverse range of activities: from formal professional development programmes and through interaction with work colleagues, integrating different experiences outside work and all these in different combinations can shape their practice affecting professional development" (Kovács & Kálmán, 2022, p. 41). For example, if a teacher encounters a problem that they are unable to solve, they can seek assistance from colleagues or others, or they can look it up on the internet. However, this may result in the development of subject matter knowledge, but the neglect of didactical skills.

Beck and Kosnik (2017, p. 2) further argue that "pre-service teacher education cannot impart all the knowledge and skills required for teaching". Nixon et al. (2016) find that holding a degree in a subject area that you are teaching provides an important foundation for subject matter knowledge development, but is not sufficient - teachers require classroom practice as well. In this respect, teachers' subject matter knowledge and didactical skills continue to develop through their classroom practice. van Putten (2011) reports that if the mathematics

methodology modules that form part of formal training could be made more practical, the development of students' PMTI could be enhanced through interaction with mathematics in the real world. Nixon et al. (2016) buttress this point of view, maintaining that teachers' subject matter knowledge, coherence, and sophistication are not solely dependent on obtaining a degree in a specific discipline, but also on the practical aspect of classroom practice. This notion is corroborated by Wenger (1998, p. 152), who explains that "identity is formed through participation as well as reification" in the community of practice. Thus, after training, teachers require classroom practice to apply the knowledge that they have gained from teacher training programmes. Botha and Onwu (2013) agree that PTI is premised on a socio-cultural perspective in which teachers' identity develops through interactions within the school context. MTI continues to develop through interaction between personal (knowledge, beliefs, biography, emotions), and professional aspects (learners, colleagues, mentors, school leaders, and through their teaching and learning resources) (Beauchamp & Thomas, 2009; Pipere & Mičule, 2014; Rodgers & Scott, 2008).

According to the studies cited above, after teacher training, classroom practice helps pre-service and early-career teachers to develop their identities, and also boosts their confidence. I contend that non-specialist teachers require support from in-service professional development programmes for their MTI to develop effectively, and to continue to develop throughout their careers. In addition, I believe that such assistance should be tailored to their specific needs, as supported by Kenny et al. (2020). An in-service professional development programme should not only focus on teachers' knowledge (subject knowledge and teaching skills), but also on changing their beliefs about mathematics as a subject, and its teaching and learning. This is vital to the effective development of their MTI, as there is evidence of a correlation between teachers' beliefs and their practice (Beswick, 2012; Stipek et al., 2001; Tamba & Cendana, 2021). This implies that for non-specialist teachers' development of MTI, they require both professional training and practical experience in the classroom.

2.5.4 Non-specialist mathematics teachers' identity development through in-service professional development programmes (training)

Recently there have been several international studies that focus on non-specialist MTI development through in-service professional development programmes (Faulkner, 2019; Gardner et al., 2019; Goos & Guerin, 2022; Lane & Ríordáin, 2020; Ní Ríordáin et al., 2022; O'Meara & Faulkner, 2021; Ríordáin et al., 2017). Such studies also exist in the South African context (Graven & Pausigere, 2017; Nel, 2012; Ntow & Adler, 2019; Pausigere, 2015). Such programmes have resulted in the positive development of MTI (Crisan & Rodd, 2017; Faulkner, 2019; Goos & Guerin, 2022; Goos et al., 2021). The findings of these studies lead

me to believe that there is incontrovertible evidence that non-specialist mathematics teachers' MTI development necessitates in-service professional development programmes that address both the personal and professional aspects, as practice alone will not suffice.

Porsch and Wilden (2022) conclude that post-graduate courses specifically designed for non-specialist teachers are necessary, and that these courses should focus on both teaching methodology and developing teachers' subject knowledge. Ní Ríordáin et al. (2022, p. 246) have also discovered that developing upskilling programmes for non-specialist teachers is critical. Nixon et al. (2016) agree that non-specialist teachers require additional support to develop their subject matter knowledge and teaching skills. This implies that non-specialist mathematics teachers need professional support in the form of in-service professional training before their MTI can develop and evolve through everyday teaching practice. I am a firm believer that MTI can be developed through practice after a teacher has participated in an in-service professional development programme. Skott (2019) supports this viewpoint by stating that teachers can only continue to develop their MTI through practice after teacher training. This is then further bolstered through multiple engagements of practices, such as when they prepare, present, and reflect on lessons and assessment tasks, as well as professional interaction with learners and colleagues.

The studies mentioned above are reviewed in Table 2.2 below. These studies were chosen because they focus on non-specialist mathematics teachers' MTI development, and were published recently (between 2012 and 2022). The studies listed in the table are based on the MTI development of non-specialist mathematics teachers. They provide us with an understanding of the context in which they were conducted, as well as the research methodology, framework, and findings, which are discussed in the table. However, according to the reviewed research, there remains a scarcity of research on how primary school non-specialist mathematics teachers' MTI develops through practice.

Table 2.2: Overview of studies of non-specialist MTI development through in-service professional development programmes between 2012 to 2022

Sources	Context	Research methodology	Framework	Findings
Nel (2012)	The South African secondary school, in-service teachers participated in professional development programmes for the development of their professional identity. They were exposed to subject knowledge, integrated approaches to teaching and learning, classroom didactics, lesson plans, and group work activities.	Qualitative: semi-structured interviews.	Wenger (1998)	The teachers' attitudes, knowledge, subject expertise and identity changed positively after participating in a mathematics training programme.
Crisan and Rodd (2015)	This study reports on the in-service course of London-based, non-specialist secondary school mathematics teachers.	Qualitative: Interviews and observations.	Wenger (1998)	The teachers developed their subject knowledge during an in-service mathematics course.
Pausigere (2015)	In-service South African primary school MTI development through in-service teacher education programme.	Qualitative: observation, interviews, document analysis, and reflective journals.	Wenger (1998) and Sfard and Prusak (2005)	The study revealed that a primary school, in-service, professional development programme had the potential to transform primary school mathematics teachers' identities, and improve their understanding of key primary concepts and classroom teaching practices.

Sources	Context	Research methodology	Framework	Findings
Graven and Pausigere (2017)	This study investigates the participation enablers and learning affordances identified by South African primary school teachers through participation in an in-service professional development programme.	Qualitative: questionnaire, interviews, and reflective journal.	Lave and Wenger (1991); Wenger (1998); and Jaworski (2006)	This study revealed that the professional development programme domain and practice resources were highly valued as key learning enablers. Learning occurred through engagement in the community of practice.
Darragh and Radovic (2019)	This study reports on Chile's primary school mathematics teacher identities after participation in a professional development programme.	Qualitative: semi-structured interviews.	Graven (2012)	They discovered that teachers' attractive identities, particularly the "mother-saviour" and "successful" teacher, clashed with the teacher role promoted by professional development programmes, which were learner-centred approaches, as well as problem solving.
Ntow and Adler (2019)	In-service South African teachers' MTI development through participation in a professional development programme. It examines how two teachers' MTI developed following their interactions with the resources offered in a PD.	Qualitative research: lesson video recordings, and semi-structured interviews.	Nasir and Cooks (2009)	The two participating mathematics teachers' identities appeared to be linked to their backgrounds and initial motivations for joining the professional development. This, in turn, influenced their selective interaction with resources. It was also shown that a teacher may value and identify strongly with the resources offered in a professional development programme, yet act differently in their practice.
Kenny et al. (2020)	This study reports on the impact of government funded programmes designed to support Australian, out-of-field (OOF) secondary teachers in science and mathematics.	Qualitative case study: survey, interviews, and document analysis.	Hobbs (2013)	They reported that after professional development programmes, the teachers' confidence and practice were improved. They observed a movement towards more rational understandings of how the content was linked, how to apply different teaching approaches, more thoughtful planning, how to deepen student learning, and how to improve learner agency.

Sources	Context	Research methodology	Framework	Findings
Lane and Ríordáin (2020)	This study examines the out-of-field mathematics teachers' professional development in Irish secondary schools in terms of their beliefs and practices.	Qualitative research: document analysis.	Valsiner's Zone Theory	The findings indicate the prevalence of direct transmission or traditional teaching practices prior to the out-of-field teachers' action research. There was some inconsistency with professed constructivist beliefs. There was evidence of a majority shift towards constructivist beliefs and practices post-action research for countless of reasons. These included increased pedagogical confidence in mathematics and the successful experience of constructivist approaches.
Goos et al. (2021)	Their study evaluates the impact of a national professional development programme for out-of-field teachers at post-primary school mathematics in Ireland.	Mixed methods: surveys, interviews, and lesson observations.	Graham (2006)	The findings from the surveys of the PDMT programme show that there was a change in the teachers' practices, shifting from transmission towards more learner-centred approaches. They also reported a profile of teaching practices, emphasising links to students' prior knowledge, and encouraging students' explanation and discussion of topics.
O'Meara and Faulkner (2021)	This study evaluates the efforts made to develop competence among Irish OOF mathematics teachers. It also looks at the impact of one component of the professional development programme on teachers' self-efficacy and self-reported teaching approaches.	Quantitative data collection: pre-and post-workshop questionnaires.	Guskey's model	The results showed that the PD programme led to statistically significant improvements in mathematics teaching efficacy. There was also a shift from a traditional, teacher-centred to more learner-centred approaches that focused on the development of mathematical understanding.

Sources	Context	Research methodology	Framework	Findings
Paolucci et al. (2021)	This study set examined a professional development programme's impact on critical areas of need for mathematical knowledge development. The participants were Irish, out-of-field mathematics teachers. This was done in alignment with Ireland's curriculum for secondary mathematics.	Quantitative: online survey and pre- and post-papers, and a pen test.	Desimone (2009)	The study found that there was development in the participating OOF teachers' mathematical knowledge and self-efficacy after completing the programme. However, the other content area weaknesses in the teachers' knowledge persisted.
Vale et al. (2021)	The OOF Secondary mathematics teachers in this study were teaching in rural schools in three different states in Australia, with limited opportunities for formal professional learning.	Qualitative: interviews and lesson observation.	Akkerman and Bakker (2011)	The findings show that initially, most of these teachers held instrumentalist beliefs about the mathematics discipline and its teaching and learning. Those who continued to teach mathematics out of field beyond the first year of teaching presented evidence of some shifts in their beliefs about the teaching and learning of mathematics. This was observed through them including more learner-centred or problem-solving approaches.
Goos and Guerin (2022)	This study compares the self-efficacy beliefs, as well as the perceived and observed classroom practices of six post-primary mathematics teachers (three groups of two). They were either out of field, upskilled via the professional development programme, or in-field. The participants were post-primary mathematics teachers in Ireland.	Mixed methods: survey, classroom observation.	Desimone (2009)	The researchers found that the upskilled teachers were in the process of developing self-efficacy beliefs and pedagogical practices that are like those of in-field teachers of mathematics. In terms of the OOF practice, there were no changes in their practices.

Sources	Context	Research methodology	Framework	Findings
Ní Ríordáin et al. (2022)	This study examined OOF post-primary teachers in an Irish context. It examined their professional self-understandings on completion of the upskilling programme.	Quantitative survey.	Kelchtermans (2009)	They found that several out-of-field teachers experienced significant anxiety, stress, and feelings of inadequacy arising from their perceived lack of subject matter and pedagogical content knowledge. It was also found that the upskilling programme was effective in improving OOF teachers' subject and pedagogical knowledge.

Table 2.2 provides an overview of non-specialist mathematics teachers' MTI development from both international and national points of view. These studies were conducted in both primary and secondary schools in the following locations: England (Crisan & Rodd, 2015); Europe (Goos & Guerin, 2022; Lane & Ríordáin, 2020; O'Meara & Faulkner, 2021; Paolucci et al., 2021; Richter et al., 2014); Australia (Hobbs & Törner, 2019; Kenny et al., 2020; Vale et al., 2021); and South Africa (Graven & Pausigere, 2017; Nel, 2012; Ntow & Adler, 2019; Pausigere, 2015). Although there are more studies on this topic, the majority of them are international and address the MTI development of *secondary school* non-specialist mathematics teachers through professional development programmes. In South Africa non-specialist mathematics teachers' professional development has received little attention.

In terms of theoretical frameworks and research methods, most of these studies used Wenger (1998) as their theoretical frameworks as their focus was on MTI development through participation in a professional development programme. In my study, the professional teacher identity framework created by Beijaard et al. (2000) seemed more suitable. This framework has a particular focus on two aspects: subject matter expertise and didactical expertise, because they encompass teachers' knowledge required for teaching. As was the case in this study, several researchers used semi-structured interviews and observations (Crisan & Rodd, 2015; Goos et al., 2021; Ntow & Adler, 2019; Pausigere, 2015; Vale et al., 2021). However, few studies on MTI development have used document analysis (Kenny et al., 2020; Lane & Ríordáin, 2020; Pausigere, 2015). Alternatively, I made use of multiple data collection strategies: semi-structure interviews, lesson observation, and document analysis of lesson plans.

From the above discussion, it can be seen that these researchers are aware of the challenges faced by non-specialist teachers, and they understand the impact on mathematics teaching and learning (Ríordáin et al., 2017). They devised strategies to support teachers through in-service professional development programmes, which were generally subsidised by government. These studies show the positive influence and importance of non-specialist mathematics teacher in-service professional development programmes. These researchers were able to observe the participants' shift from a transmission or teacher-centred approach towards more learner-centred approaches, and the construction of an understanding of mathematical concepts.

In terms of the studies in a South African context that were reviewed, some were found to focus on MTI development through pre-service training (Botha & Onwu, 2013; van Putten et al., 2014), and others on in-service professional development (Graven & Pausigere, 2017; Nel, 2012; Ntow & Adler, 2019). Botha and Onwu's (2013) study focused on how first-year

foundation phase (primary school) teachers developed their science, mathematics, and technology teaching professional identity through different teaching contexts. They found that identity formation is an ongoing process, involving the integration of teachers' personal and professional histories and initial teacher education and training, alongside issues of school culture. They also found that teachers' beliefs can influence their practice, both positively and negatively. For instance, if a teacher's beliefs about mathematics are constructivist or based on problem solving, he or she will create a classroom environment that encourages knowledge construction, where learners work cooperatively, share ideas, and are provided with an opportunity to apply their knowledge on problem solving. However, if the teacher's beliefs lean towards behaviourism, in that they are convinced that mathematics is learned by mastering rules and procedures, they will use direct instruction and a teacher-centred approach in which learners learn by listening to them; this also involved the drilling of algorithms.

An example of MTI development through an in-service professional development programme in primary school teachers was investigated by Graven and Pausigere (2017) over a period of two years. They discovered that the MTI of the participants was transformed, resulting in improved primary school maths teaching and learning practices. Nel (2012), who investigated the MTI development of secondary school teachers, had similar findings to those of Graven and Pausigere (2017). She reported positive changes in participants' identity, subject knowledge, and didactical expertise. Ntow and Adler (2019) studied two secondary school teachers who participated in an in-service professional development programme. They explored how the participants interacted with the resources offered in the programme relevant to their classroom practice. They found that the participants' MTI development was linked to their backgrounds and motivation to join the professional development programme, which influenced their interaction with the provided resources. Their study showed that even though the teachers may have valued and identified strongly with the resources offered, their classroom practice could be incongruent with what they learned through the programme and the offered resources. One of the participants valued the resources and spoke highly of them, but failed to apply these to their classroom practice. So, while teacher training and professional development programmes may be considered as critical mechanisms for improving teachers' content knowledge and developing their teaching skills (Creemers et al., 2013), overall improvement and success are not guaranteed.

In conclusion, MTI development can occur through pre-service teacher training, interaction, and participation within the community of practice, or in-service teacher professional development programmes. There is, however, a paucity of knowledge on how non-specialist teachers' MTI develops through practice. Furthermore, the reviewed literature indicates

insufficient research on non-specialist mathematics teachers' identity development in the South African context.

2.6 THE INFLUENCERS OF MTI DEVELOPMENT

Bearing in mind that MTI is subsumed into PTI, research about the influencers of PTI development have been considered in this regard. Beijaard et al. (2000) describe three factors that influence PTI, namely: teaching context, teaching experience, and the biography of the teacher. Postholm (2018, p. 1) adds several factors: "Leadership within a school, collaboration between outside resource people and schools, teacher collaboration, teachers' professional development programmes, and several contextual factors". In fact, the literature reveals that there is a variety of personal (beliefs, biography, emotions, motivation, knowledge, and self-esteem), and professional factors (professional development programmes, resources, school context, learners, colleagues, and leadership) that influence PTI development (Beauchamp & Thomas, 2009; Beijaard et al., 2004; Beijaard et al., 2000; Bjuland et al., 2012; Botha & Onwu, 2013; Day et al., 2006; Flores & Day, 2006; Izadinia, 2013; Vermunt et al., 2017). Some studies have placed particular emphasis on the influence of certain developmental factors. For instance, professional teacher education (van Putten et al., 2014), the context (Arslan et al., 2021; Botha & Onwu, 2013), teaching experience (Neumayer-Depiper, 2013), teaching practicum (Ivanova & Skara-Mincāne, 2016; Mosvold & Bjuland, 2016), and teachers' beliefs (Grootenboer, 2006; Muhtarom et al., 2019). According to Kaya and Dikilitaş (2019), personal background and contextual factors are key elements in professional teacher identity development. Based on this plethora of factors identified by researchers, I decided, upon consultation with my supervisors and other academics in this field, to focus on three factors that are of particular relevance to non-specialist mathematics teaching. According to researchers, these three factors are all influential in terms of teachers' MTI development (Beijaard et al., 2000; Day et al., 2006; Ernest, 1988; Flores & Day, 2006; Izadinia, 2013; Rodgers & Scott, 2008).

2.6.1 Mathematics teachers' beliefs

Beijaard and Meijer (2017, p. 177) explain that "who one is as a person is strongly interwoven with how one works as a professional". Korthagen (2004, p. 81) come to the same conclusion, "[T]he beliefs teachers hold with regard to learning and teaching determine their actions". In the context of my study, this implies that teachers' beliefs about mathematics as a subject, as well as its teaching and learning, have a strong influence on the kind of teacher they are and wish to become. In fact, several researchers describe the correlation between teachers' beliefs and practice in their mathematics classroom (Beswick, 2012; Purnomo, 2017; Staub

& Stern, 2002; Stenberg et al., 2014; Stipek et al., 2001; Tamba & Cendana, 2021). Conversely, it has also been found that teachers' practice can influence their beliefs (Botha, 2011). Simmons et al. (1999), however, find that there are incongruities between teachers' beliefs and their practice.

Teachers develop beliefs about teaching and learning from the early days when they are at school as a learner, during their teacher education programme, and eventually when working as a teacher (Beauchamp & Thomas, 2009; Chong et al., 2011; Flores & Day, 2006). Cyrino (2016, p. 168) explains that a teacher's self-concept and their conceptualisation of "their profession, of what it means to be an excellent teacher and the type of teacher they want to become, among other things, are interconnected and affect the knowledge they develop about their work and classroom practices". Moreover, teachers' beliefs "have a powerful impact on teaching through such processes as the selection of content and emphasis, styles of teaching, and modes of learning" (Ernest, 1989, p. 20).

Many studies on mathematics teachers' beliefs have focused primarily on pre-service teachers (Grootenboer, 2006; Handal, 2003; Muhtarom et al., 2019; Van Zoest et al., 1994; Walkington, 2005; Zakaria & Musiran, 2010). There are, however, few studies on in-service mathematics teachers' beliefs (Beswick, 2005, 2012; Stipek et al., 2001). Most research concerning teachers' beliefs about mathematics as a subject, and mathematics teaching and learning, is qualitative (Beswick, 2005, 2012; Handal, 2003; Muhtarom et al., 2019). In one of the few quantitative studies reviewed, Stipek et al. (2001) find congruency between beliefs and practices. They observed that teachers hold traditional beliefs, and that they consequently employed traditional practices that emphasise performance, learning procedures, and getting correct answers. This promotes learners' dependence on the teacher. Such beliefs obviate inquiry-orientated mathematics teaching, a constructive view that encourages understanding where learners explore mathematics problems, are encouraged to be creative and to attempt multiple strategies, all with a view to supporting learner independence. Polly et al. (2013) have also found consistency between mathematics teachers' beliefs and their practice. They reported that teachers with a transmission-based orientation towards mathematics were more teacher-centred in their classrooms. Alternatively, teachers with a discovery or connectionist orientation towards mathematics reported frequent use of student-centred approaches. However, these studies did not focus on non-specialist mathematics teachers' beliefs about mathematics as a subject, as well as mathematics teaching and learning.

Teachers enter into non-specialist mathematics teaching with their own beliefs about mathematics as a subject, and its teaching and learning. Ernest (1989) described mathematics teachers' beliefs according to three components: the nature of mathematics, mathematics

learning, and mathematics teaching. He also distinguished between three categories of philosophical views of mathematics teachers' beliefs, namely: instrumentalist; Platonist; and problem solving (Ernest, 1989). Van Zoest et al. (1994) identified three elements of mathematics teacher beliefs: content focused, with an emphasis on performance; content focused, with an emphasis on understanding; and learner focused, with an emphasis on social interactions. Similar components of mathematics teaching were described by Kuhs and Ball (1986). Having found that the work of Ernest (1989) and Van Zoest et al. (1994) offer definitive descriptions of the teaching and learning of mathematics, Beswick (2005, p. 40) has summarised these descriptions, as seen in Table 2.3.

Table 2.3: The categories of mathematics teachers' beliefs (Beswick, 2005, p. 40)

Beliefs about the nature of mathematics (Ernest, 1989)	**Beliefs about mathematics teaching (Van Zoest et al., 1994)**	**Beliefs about mathematics learning (Ernest, 1989)**
Instrumentalist	Content focused, with an emphasis on performance.	Skill mastery, passive reception of knowledge.
Platonist	Content focused, with an emphasis on understanding.	Active construction of understanding.
Problem-solving	Learner focused, with an emphasis on social interactions.	Autonomous exploration of own interests.

Grootenboer (2006, p. 270) finds that "beliefs of pre-service primary teachers towards mathematics have been seen as problematic in their development as teachers of mathematics". Westaway and Graven (2019) concur with this, relating that teachers hold onto beliefs of the past, which then inform their training and practice. These past beliefs are mainly that mathematics is difficult, is taught through procedures, and is learned by listening to the teacher and following algorithms or explanations. Muhtarom et al. (2019) also indicates that pre-service teachers' beliefs influence their development. These beliefs begin to develop early on through their own experience as mathematics learners at school (Handal, 2003; Zakaria & Musiran, 2010).

Teachers' beliefs are understood as influencers of both teaching and learning (Korthagen, 2004), and also of their professional development (Beijaard et al., 2000). This specifically relates to how they perceive mathematics as a subject, their subject matter knowledge, and how it is taught and learnt. Ernest (1988) argued that teachers' beliefs have a powerful impact on teaching mathematics. He claimed that two teachers can have similar mathematical knowledge, but use different teaching approaches because of the beliefs they hold. He designed a model to describe the relationship between mathematics teachers' beliefs and

their teaching of mathematics. This model is relevant to this study because I explored the influence of beliefs on non-specialist mathematics teachers' MTI development. Ernest (1988) identified three belief components that influence teaching, namely: the nature of mathematics, mathematics teaching, and the process of learning mathematics. These three components of teachers' beliefs described by Ernest (1988) are discussed below.

2.6.1.1 Beliefs about the nature of mathematics

The importance of teachers' beliefs about the nature of mathematics lies in the fact that these beliefs influence how they teach it (Anthony & Walshaw, 2009; Beswick, 2012; Stipek et al., 2001). According to Ernest (1989), there are three categories of philosophical views of teaching mathematics. These are based on teachers' beliefs about the nature of mathematics, namely: instrumentalist, Platonist, and problem solving. Ernest (1988) describes these three views as follows: the *instrumentalist view* is based on the belief that mathematics is an accumulation of facts, rules, and skills to be used in the pursuance of some external end. The mathematical facts and rules do not have any correlation to one another. Then there is the *Platonist view,* which holds that mathematics is a static but unified body of absolute and certain knowledge. Lastly, the *problem-solving view* rests on the belief that mathematics knowledge is discovered and not created; it is a dynamic, continually expanding field of human creation and invention.

2.6.1.2 Beliefs about mathematics teaching and learning

According to Handal (2003) and Thompson (1992), mathematics teachers have beliefs about how mathematics is learned and how it should be taught. The categories of mathematics teachers' beliefs described by Ernest (1989) can be associated with the behaviourist (traditional) and constructivist theories of learning (Handal, 2003; Muhtarom et al., 2019). Teachers' beliefs are aligned with their instructional practice. For instance, a teacher whose teaching philosophy is instrumentalist will employ behaviourist (teacher-centred) practices, and will stress the didactic values of formulas, procedures and drilling, as well as products rather than processes. Such teachers see learners as passive recipients of knowledge and learning through rote learning, drilling, and memorising (Handal, 2003; Ren & Smith, 2018). The Behaviourist Theory of Learning is related to the instrumentalist and Platonist view, and is associated with a teaching mode where the teacher is the instructor, explainer, or transmitter of knowledge, while the learners are the receivers of knowledge (Ernest, 1989; Handal, 2003). It is also associated with a focus on mathematics performance rather than conceptual understanding. This approach to teaching and learning is in contrast with the shift to a constructivist, learner-centred approach, which is advocated by educationists (Polly et al., 2013; Ren & Smith, 2018).

Teachers who espouse the Constructivist Theory of Learning believe that learners actively construct knowledge and conceptual understanding (Ernest, 1989; Kuhs & Ball, 1986). Muhtarom et al. (2019) claim that teachers who hold constructivist beliefs view mathematics as dynamic knowledge that continuously evolves, with rules and procedures that are subject to change. In the classrooms of such teachers, learning takes place in an active engagement with mathematical problems and tasks, which leads to conceptual understanding (Voss et al., 2013). The problem-solving view is associated with learner-centred classrooms, and constructivism as the applied theory of learning. In this context, the teacher's role is that of a facilitator of learning, where learners actively construct knowledge and understanding of concepts, and independently engage with the content (Ernest, 1989; Voss et al., 2013). This then begs the question: what is the government's stance on the teaching of mathematics? Is what happens in the classroom entirely up to teachers and the philosophies that they espouse?

In South Africa, the primary school mathematics curriculum (CAPS) encourages an active and critical approach to learning, rather than rote and uncritical learning (DBE, 2011a). Furthermore, the South African curriculum requires teachers to be facilitators of learning, where learners actively participate in the construction of their knowledge. Thus, teachers must develop a constructivist approach to teaching (DBE, 2011a; Pausigere & Graven, 2013). It can therefore be said that the national mathematics education context in South Africa is constructivist and learner centred.

2.6.2 Contextual factors

Several researchers have highlighted the contextual factors that contribute to, or hinder teachers' PTI development (Beauchamp & Thomas, 2009; Beijaard et al., 2000; Bennison, 2016; Day et al., 2006; Flores & Day, 2006; Ye & Zhao, 2019). The contextual factors might be teachers' social context, relationship with colleagues and learners, teachers' educational contexts, and school contexts (Izadinia, 2013; Van Zoest & Bohl, 2005; Vermunt et al., 2017). Flores and Day (2006), Pausigere (2015), Botha and Onwu (2013), and more recently, Durmaz and Yiğitoğlu (2017) indicate that contextual factors influence PTI development. In particular, they influence learner profile, classroom dynamics, and the programme or curriculum (Durmaz & Yiğitoğlu, 2017). In this study, I contend that certain contextual factors may influence non-specialist mathematics teachers' MTI development, but that there are also definite negative influences in this regard.

Handal (2003, p. 49) indicates that "schools' context obliges practising teachers to teach in the traditional approach, even when they may hold alternative views about mathematics teaching and learning". This may occur because of overcrowding, a shortage of resources, or

school culture. Different school contexts have different effects on individual teachers (Palmér, 2016), which may be positive or negative. In a study by Arslan et al. (2021), the participating teachers' MTI was influenced by the school context. Two participants who graduated from the same reform-orientated teacher education programme worked in different communities that could be respectively characterised as unsupportive and supportive of reform. The researchers found that one participant's reform-unsupportive work community had no negative impact on her reform-orientated MTI development. Alternatively, the other participant's reform-supportive work community was unable to foster a reform-orientated MTI development. I assert that it is critical that in-service professional development programmes should consider the role of the school context so that teachers can effectively adapt to various school contexts (Ye & Zhao, 2019).

Hobbs and Torner (2019) propose that research on non-specialist teachers' contexts be conducted because school contexts differ vastly. They also claim that rural areas have fewer support mechanisms available because their area has limited subject specialists who can be asked for advice. Furthermore, professional development programmes are held at great distances from these schools. For this reason, this study explored the influence of contextual factors on non-specialist mathematics teachers' MTI development, specifically in a rural area. This was done with a view to describing the availability of resources, collegial support, and professional development opportunities. Furthermore, this study analysed how school context, resources, and support from school leaders may influence the MTI development of non-specialist teachers.

2.6.3 Practice

Wenger (1998, p. 149) states that "there is a profound connection between identity and practice". Through practice, the teacher's personal and professional aspects interact, which may lead to MTI development (Palmér, 2016). Grootenboer and Edwards-Groves (2019) indicate that practice is important for the positive development of MTI. This generally applies to the school context where the teacher's pedagogical skills are engaged. Nanna et al. (2021) highlight that teachers' MTI can be developed through interactions with learners, both inside and outside of the classroom.

Vale et al. (2021) investigated secondary school non-specialist mathematics teachers in three rural schools. Their study shows that initially, most of these teachers held instrumentalist beliefs about mathematics as a discipline, and its teaching and learning. However, those who continued to teach mathematics out of field beyond the first year of the study presented evidence of some shifts in their beliefs about the teaching and learning of mathematics by including more learner-centred or problem-solving approaches.

Professional identity development through practice can transform “who we are and what we can do” (Wenger, 1998, p. 215). Thus, through practice, teachers can acquire subject knowledge and teaching skills in the process of developing MTI (Ivanova & Skara-Mincāne, 2016; Mosvold & Bjuland, 2016). In this study, teachers’ practice is described in terms of their interaction with learners, colleagues, school leaders, and teaching and learning resources. MTI develops through interaction with others within various contexts, or in teaching and learning communities (Bjuland et al., 2012; Van Zoest & Bohl, 2005). Lutovac and Kaasila (2011) also find that MTI develops in and through narratives as a process of interaction between the individual and the social mathematical context. Teachers learn from participation, observation, and informal discussion with colleagues to improve their practice and further learn through lesson planning and reflection on lesson presentation (Richter et al., 2014). Cyrino (2016) asserts that teachers’ systematic reflection supports their identity development.

Kirsti (2015) claims that mathematics practice is different from that of other subjects, and that developing MTI in mathematics is different from developing teacher identity in another subject. This implies that MTI development requires a deeper draw of knowledge (Cross Francis et al., 2018). Porsch and Wilden (2022) state that it is expected that non-specialist teachers develop their MTI through practice, including self-study and receiving support from colleagues and school management. I contend that even a teacher with several years of teaching experience, but without mathematics training in terms of subject matter knowledge and didactical skills, will have difficulties in developing a sound MTI through practice; there is a need for professional support from subject specialists.

Several researchers have investigated mathematics teacher identity development through pre-service teacher training programmes, training and practice, as well as non-specialist mathematics teachers’ MTI development through in-service professional development programmes (See Section 2.5). There is a paucity of knowledge on how non-specialist mathematics teachers’ MTI develops solely through practice, and that is the focus of the current study. Next, I will discuss non-specialist mathematics teachers.

2.7 NON-SPECIALIST MATHEMATICS TEACHERS

Non-specialist teaching is a global issue; it exists in most countries and has been extensively researched in countries such as Australia, Germany, Ireland, the United Kingdom, the United States, and Indonesia (Price et al., 2019). Different terms are used in the literature to describe these teachers, such as out-of-field teachers (du Plessis et al., 2019; Goos & Guerin, 2022; Hobbs & Törner, 2019), mathematics-related teachers (Lutovac & Kaasila, 2018a), teachers of mathematics (Graven, 2004), and non-specialist mathematics teachers (Crisan & Rodd,

2017). In the current study, the term 'non-specialist mathematics teachers' was used. I use the definition of non-specialist teaching as "when teachers teach subjects or year levels outside their field of qualification or expertise" (Du Plessis, 2018, p. 1).

Mathematics in primary schools is often taught by non-specialist teachers because it has never been seen as a problem since primary teachers are seen as generalists (Brown & McNamara, 2011; Price et al., 2019). This means that any teacher with a teaching qualification focused on primary school-level can teach any subject. Teachers, as generalists, teach several subjects without necessarily personally identifying with the subject; they do not consider themselves as mathematics teachers (Karaolis & Philippou, 2019). According to research, rural and township schools have a larger number of non-specialist mathematics teachers (Hobbs & Torner, 2019; Kilpatrick & Fraser, 2019; Spaull & Jansen, 2019; Vale et al., 2021; Weldon, 2016). There could be several reasons for this, including a shortage of qualified mathematics teachers (Hobbs & Porsch, 2021; Hobbs & Torner, 2019), as well as the uneven distribution of qualified mathematics teachers (Motala & Carel, 2019). Non-specialist teaching is employed "as a quick fix action to have a teacher in specific subject or in a classroom" (Du Plessis & McDonagh, 2021, p. 1).

Ríordáin et al. (2017) report that the non-specialist mathematics teachers in their study demonstrated low achievement in subject content knowledge. There was also evidence of conceptual errors in these teachers' teaching, which indicates inadequate subject content knowledge. Furthermore, they experienced difficulty with the content of the curriculum that they were teaching. It seems logical, then, that non-specialist mathematics teachers will have difficulties in effective teaching and learning, as well as the development of a conceptual understanding of mathematics in their learners. Furthermore, Ní Ríordáin et al. (2022, p. 256) clarify that non-specialist mathematics teachers "experience significant anxiety, stress and feelings of inadequacy arising from their perceived lack of subject matter and pedagogical content knowledge". As a result, they find it challenging to use a learner-centred approach as it requires deep subject matter and didactical expertise (Cross Francis et al., 2018). Other studies show that non-specialist mathematics teachers lack the subject matter and didactical expertise to plan lessons, and lack the ability to use various teaching approaches that encourage mathematical critical thinking and conceptual understanding (Hobbs & Törner, 2019; Lane & Ríordáin, 2020).

Non-specialist teachers lack the necessary subject and didactical knowledge to effectively teach with the complexities of a low socio-economic status environment (Du Plessis, 2019, p. 150). Non-specialist mathematics teaching thus influences the quality of teaching and learning of mathematics (Du Plessis, 2016, 2017). A mathematics teacher needs to know "how the

concept should be taught", which includes knowledge of different teaching strategies, making use of representations and the application of real-life contexts when explaining concepts (Van Zoest & Bohl, 2005, p. 333). In contrast, non-specialist mathematics teachers struggle to deliver the subject knowledge, even the basics of mathematics, and they find it difficult to use cooperative learning (Du Plessis, 2018). Therefore, non-specialist teaching negatively influences the learning of mathematics and achievement in the subject (Bosse & Törner, 2015a; Du Plessis, 2017; Ríordáin et al., 2017). This links directly to the absence of a well-developed mathematics identity (Grootenboer, 2006; Grootenboer & Zevenbergen, 2008).

In summary, the findings of these studies indicate that non-specialist teachers have inadequate subject knowledge, which influences the teaching and learning of mathematics. What is common in these studies is that teachers lack the subject content knowledge and didactical skills necessary for the development of learners' mathematical conceptual understanding (Baumert et al., 2010). In the South African context, limited studies have focused specifically on in-service, non-specialist mathematics teachers' MTI development through a teacher education programme (Graven & Pausigere, 2017; Nel, 2012; Ntow & Adler, 2019; Pausigere, 2015).

2.8 TEACHER IDENTITY FRAMEWORKS

Various studies have used different frameworks to study the PTI development of teachers. Below, I will discuss three frameworks that were relevant to my study: PTI (Beijaard et al., 2000), MTI (Van Zoest & Bohl, 2005), and PMTI (van Putten, 2011). These three theoretical frameworks informed this study's conceptual framework.

2.8.1 Professional Teacher Identity (PTI) framework

Beijaard et al. (2000) define teacher identity in terms of three categories, namely: subject matter expertise, didactical expertise, and pedagogical expertise. Subject matter expertise pertains to being able to change programmes, develop effective tasks, explain things at a high-quality level, and diagnose students' understandings and misconceptions adequately. The teacher as a subject matter expert should have the subject knowledge to be able to explain concepts correctly. Didactical expertise refers to teachers' knowledge in terms of lesson preparation, presentation, and the evaluation of an effective teaching and learning process. The teacher should be able to apply different teaching approaches, both learner-centred and teacher-centred approaches, when teaching to accommodate the diverse needs of the learners. The third aspect, pedagogical expertise, refers to teachers' professional knowledge and skills in supporting learners' social, emotional, and moral development. This encompasses, among other things, what is going on in students' minds, ways of

communicating when speaking about other people, and personal and private problems that students might have.

2.8.2 Mathematics Teacher Identity (MTI) framework

Van Zoest and Bohl (2005) indicate that mathematics teachers' identity development includes both the aspects of *self in the mind* and *self in the community*. The first aspect concerns the cognitive dimensions of teachers' mathematics identity, with three domains. The second aspect is self in community, which is also divided into three domains, namely: others' perceptions of self, perceptions of others, and own perceptions of others' perceptions. This aspect is based on the social understanding of mathematics teachers' identity.

The first domain of self in the mind is the *content and curriculum knowledge domain,* which refers to teachers' subject knowledge of what needs to be taught. Teachers need subject knowledge for the preparation and presentation of lessons, creating assessment tasks, explaining concepts to learners, and responding to their questions appropriately. The second domain is the *pedagogy domain*, which refers to teachers' teaching skills. Examples of this are knowledge regarding the use of different teaching approaches; encouraging learning; the ability to engage learners in classroom discussions; as well as using learners' responses and misconceptions to thoroughly explain concepts. The third domain, the *professional participation domain,* includes the areas of knowledge and activity required to participate productively within the various communities outside of the classroom that are related to the act of teaching. These communities include the school mathematics department committee, interaction with colleagues outside of school, the sharing of teaching materials and knowledge, and the guidance of a district support team.

According to Van Zoest and Bohl (2005, p. 320), professional identity development includes "knowledge and experiences, but also our perceptions of ourselves and others' perception of us, and our perceptions of others, and perceptions of us that develop as we participate in communities with one another". Figure 2.3 below represents the professional development framework.

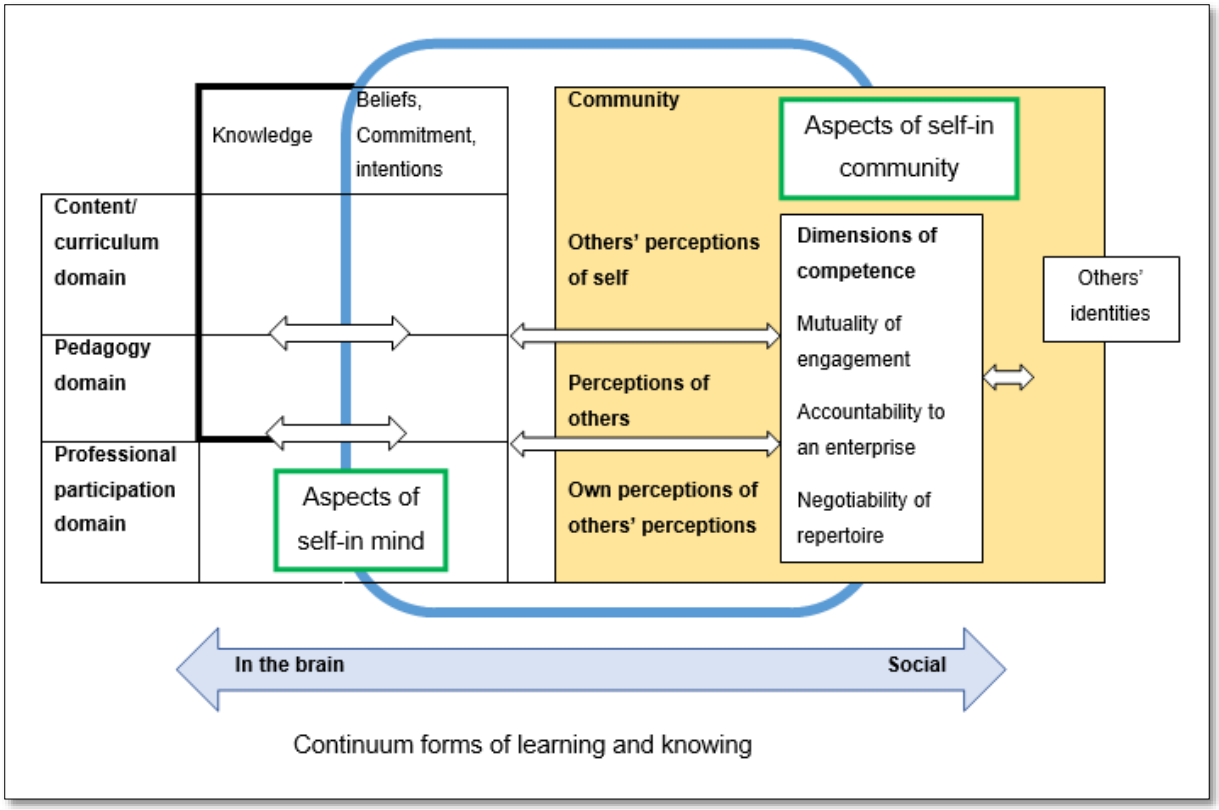

Figure 2.3: Mathematics teacher identity development (Van Zoest and Bohl (2005)

2.8.3 Professional Mathematics Teachers' Identity (PMTI) framework

van Putten (2011) constructed a conceptual framework to explore mathematics teachers' identities. Specifically, it was used to analyse the participating teachers' perception of their PMTI, and its actualisation in the classroom. As seen in Figure 2.3 below, there are three related parts in this framework. On the left side of the PMTI framework, there are four subcategories of PMTI influencers: biography, tertiary training, teaching practice and view of the subject mathematics. These subcategories were developed based on several studies (Beijaard et al., 2000; Ernest, 1988; Flores & Day, 2006; Thompson, 2009). These four categories indicate the influencers of the PMTI development process. However, there is no specific focus on *how* the contextual factors influence the PMTI development process.

The second part of the framework is the perceived PMTI in terms of being a subject specialist, teaching and learning specialist, and carer/nurturer. These subcategories were developed based on Beijaard et al.'s (2000) study. The third category on the right side of the framework is actualisation, of which there are five subcategories*:* mathematics expertise; evidence of understanding; teacher or learner centeredness; flexibility or rigidity in teaching; and evidence and purpose of nurturing. These subcategories were developed based on the studies of Ernest (1988) and Thompson (2009). Thus, van Putten's framework conceptualises three

components, namely, influencers, perceived PMTI, and actualised PMTI. The influencers of PMTI focus on individuals' personal history, while actualisation is what can be observed in the classroom. The study revealed that the participants' perceived identity was different from their actualised identities.

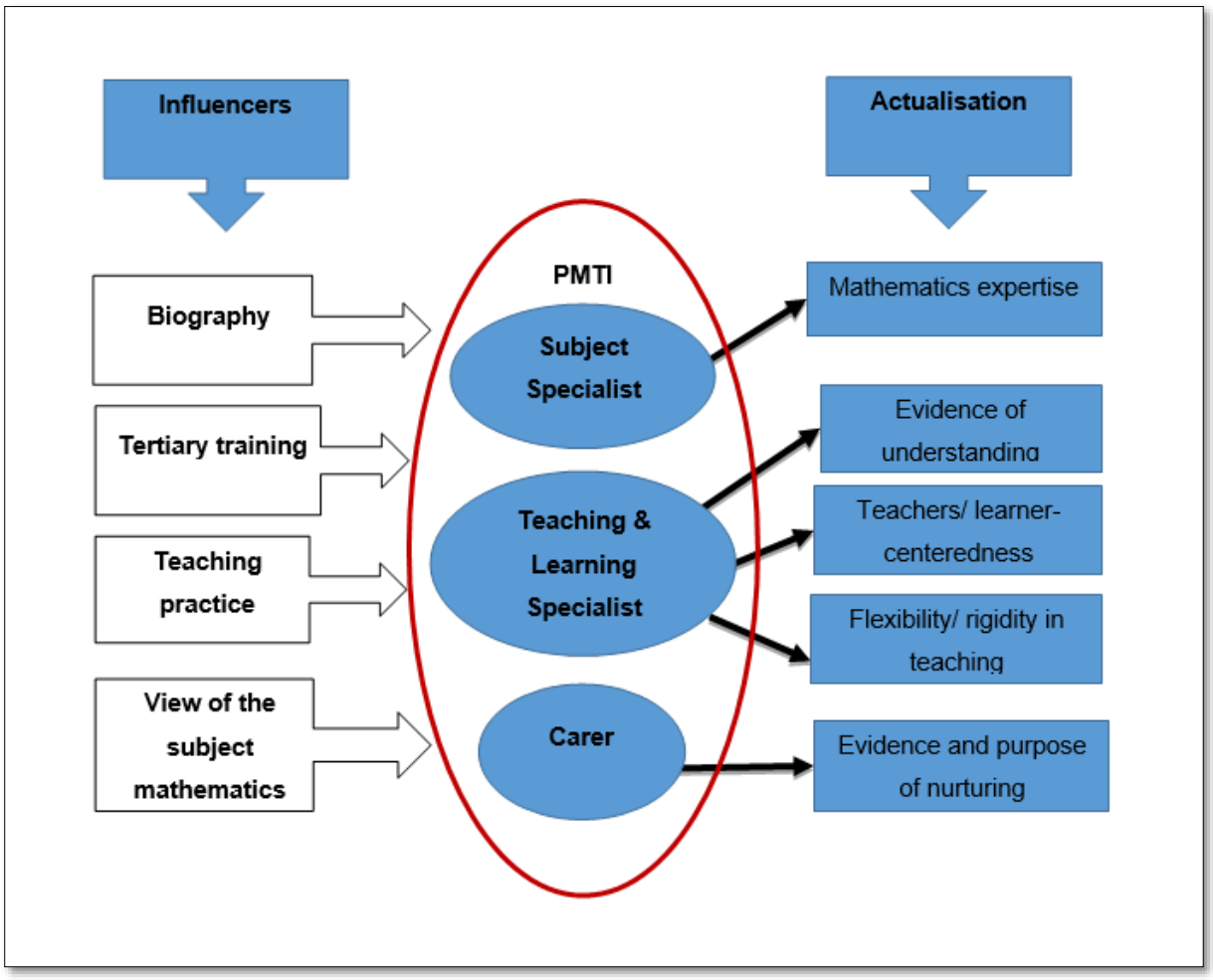

Figure 2.4: Professional mathematics teachers identity framework (van Putten, 2011)

2.8.4 Conceptual framework of the current study

The purpose of this study was to explore the MTI development of non-specialist teachers through practice. It was also endeavoured to investigate the influence of teachers' beliefs, contextual factors, and practice on their MTI development. Arising from the literature study and theoretical frameworks, a conceptual framework was developed for this research (Beijaard et al., 2000; Ernest, 1988; Flores & Day, 2006; Thompson, 2009; van Putten, 2011). The conceptual framework was heavily influenced by Beijaard et al. (2000), which allowed the teachers' MTI to be investigated in terms of them being *subject matter experts, didactical experts* and *pedagogical experts*. However, in this study, I focused only on subject matter expertise and didactical expertise as these categories of MTI align with the topic of teachers'

knowledge required for mathematics teaching. Pedagogical expertise was excluded from the framework because it was not the focus of this study to explore how the teacher supports the socio-emotional and development of learners, but rather how non-specialist teachers have developed their subject knowledge and teaching skills through their teaching practices.

van Putten's (2011) framework focuses on four aspects as influencers of PMTI, while this study only focused on three aspects: teachers' beliefs, contextual factors, and practice. The reason for focusing on only these three aspects is that they seem to be the most influential in terms of non-specialist mathematics teachers' MTI development and the effect thereof on practice (Beauchamp & Thomas, 2009; Beijaard et al., 2000; Chong & Low, 2009; Flores & Day, 2006). Ernest (1988) and Thompson (2009) find that there is a correlation between teachers' beliefs and the way in which they teach. The contextual factors may have a positive or negative influence on teachers' MTI development (Beauchamp & Thomas, 2009; Beijaard et al., 2000; Bennison, 2016; Day et al., 2006; Flores & Day, 2006; Ye & Zhao, 2019). Moreover, researchers have indicated that there is a correlation between teachers' practice and their MTI (Beijaard et al., 2004; Lutovac & Kaasila, 2018a; Van Zoest & Bohl, 2005). Thus, teachers' beliefs, contextual factors, and practice were explored as the influencers of MTI development. The contextual factors that could influence teachers' MTI are: school context; resources; and school leaders' support (Beijaard et al., 2000; Bennison, 2016; Flores & Day, 2006). Teacher practice is also further influenced through interaction with learners, colleagues, and teaching and learning resources (Chong & Low, 2009; Van Zoest & Bohl, 2005).

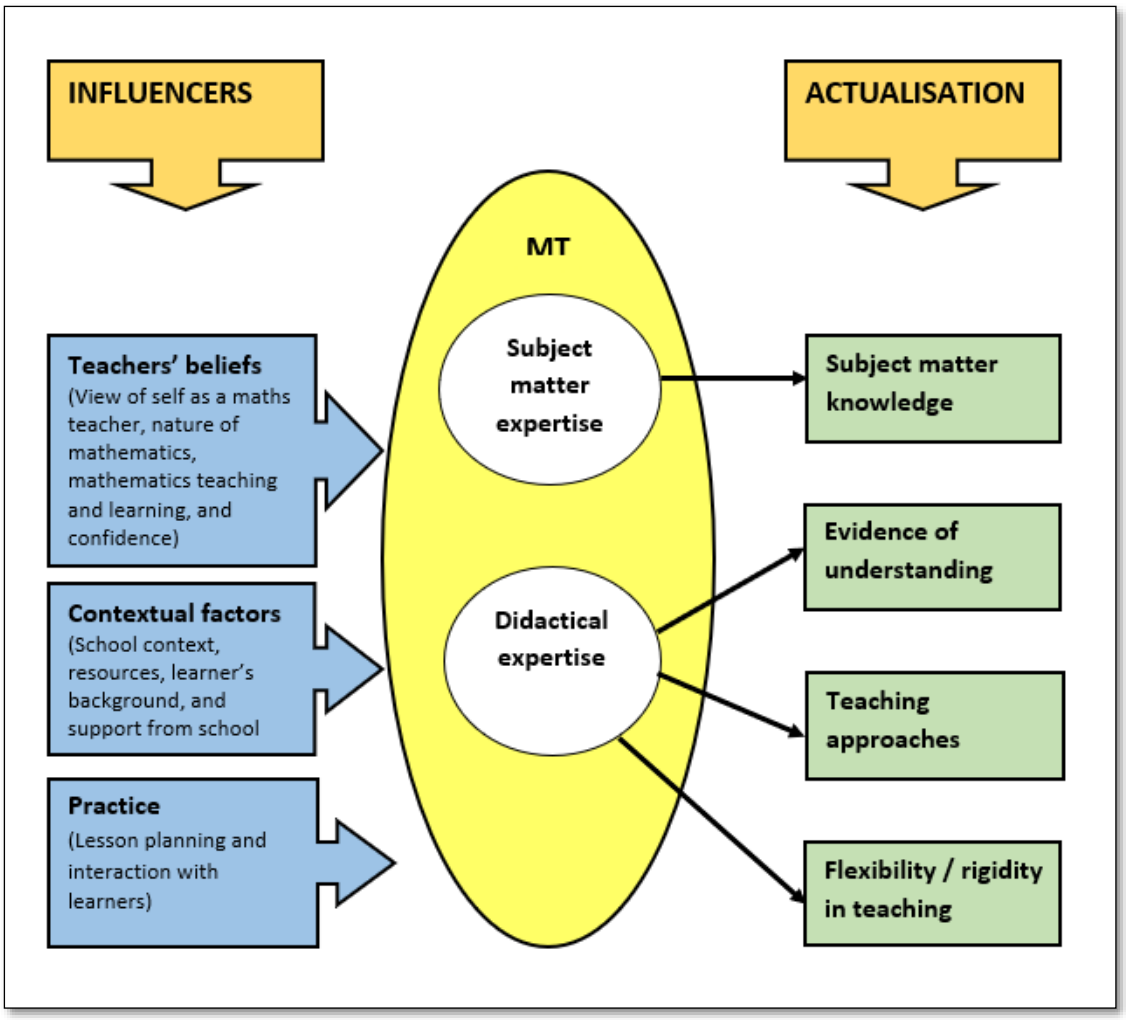

Figure 2.5: Conceptual framework for MTI (adapted from the work of Beijaard et al. 2000; Ernest, 1988; Flores & Day, 2006; Thompson, 2009; van Putten, 2011)

2.8.4.1 MTI

For the purpose of this study, MTI was explored with reference to subject matter expertise and didactical expertise using the two aspects from Beijaard et al.'s (2000) framework. The National Policy Framework for Teacher Education and Development in South Africa (DoE, 2006) emphasises the importance of these aspects for teacher development, and for effective teaching and learning.

2.8.4.2 Subject matter expertise

In this study, this aspect of MTI deals with teachers' "subject-specific knowledge of how and what to teach and how children learn" (Hobbs, 2012, p. 1). Shulman (1986, p. 9) calls this 'subject matter knowledge', and defines it as "the amount and organization of knowledge the teacher has about the content to be taught, being able to plan and explain the content to be understandable to learners and appropriately respond to the learner's questions". The

literature emphasises the importance of teachers possessing subject matter knowledge for effective teaching and learning. This includes the ability to explain content at a high cognitive level, assessing learners' understanding and misconceptions adequately, and creating effective assessment tasks (Ball et al., 2008; Beijaard et al., 2000; Hill et al., 2005; Ní Ríordáin et al., 2019; Vermunt et al., 2017). In this study, the teachers' subject matter knowledge was studied in terms of their ability to present the content accurately and adequately, explain concepts explicitly and at a higher level of understanding, make use of representations and real-life examples to explain the concept thoroughly, and the ability to ask and respond to learners' questions accurately. The participating teachers' subject matter expertise was investigated through semi-structured interviews, lesson observations, and a document analysis of their lesson plans.

2.8.4.3 Didactical expertise

The second aspect of the MTI framework considers teachers' knowledge and skills concerning the effective teaching and learning of mathematics. A didactical expert has knowledge of different teaching approaches and representations to be applied effectively in the classroom to develop learners' conceptual understanding (Beijaard et al., 2000; Ernest, 1988). This aspect includes teachers' knowledge and skills related to the preparation, execution, and evaluation of the teaching and learning process (van Putten, 2011). In this study, I looked at teachers' abilities to teach mathematics effectively. Firstly, this referred to their ability to assess their learners' understanding of what is being taught while the lesson is in progress. Secondly, this applied to their ability to employ both teaching approaches, namely, learner or teacher centred approaches; and finally, the flexibility or rigidity in teaching. This meant analysing the teachers' ability to adapt the lesson as it unfolds, and being able to encourage classroom discussions or learner participation. An example of this ability is the use of learners' questions and responses to further elaborate on the content. The actualisation of didactical expertise was observed during lesson presentation by paying attention to the teachers' assessment of learners' evidence of understanding, classroom teaching approaches, and flexibility or rigidity in teaching.

2.8.4.4 Influencers

Researchers have indicated different influencing factors in terms of PTI development (see Section 2.6). This study focused on three influencing factors, firstly: the *beliefs* that teachers hold with regard to the nature of mathematics, and its teaching and learning. The mathematics teachers' beliefs categories (see Table 2.3) were used to analyse their beliefs. Secondly, *contextual factors*, as I investigated the school context, resources, and the support received from school leaders. The contextual factors were explored through semi-structured interviews

and lesson observations Lastly, *practice*, which required me to look specifically at the teachers' lesson planning and interaction with learners when presenting lessons, as well as the use of teaching and learning resources when teaching.

2.8.4.5 Actualisation

In this study, the actualisation of the teachers' MTI was observed through their classroom practices. I observed the teachers' presentation of a lesson, and their interaction with the learners, as well as the teaching and learning resources available. Next, I will discuss the four categories of MTI actualisation.

Subject matter knowledge

Subject matter knowledge is defined by Ball et al. (2008) and Hill et al. (2005) as the mathematical knowledge required for teaching, such as the knowledge and use of correct terminology and algorithms. In this study, the actualisation of subject matter knowledge was investigated in terms of lesson planning and the presentation of content. The lesson observation allowed me to investigate the teachers' mathematics knowledge, specifically whether they explained the content correctly and adequately, thoroughly, and at a high-quality level, and whether they corrected any possible misconceptions the learners may have had. Furthermore, I analysed their ability to correctly respond to the learners' questions and thoroughly explain the concept to them using various real-life examples and representations (Hill et al., 2005). Moreover, I used a document analysis of lesson plans to see if their lesson plans had clear objectives, if the concept was adequately and explicitly explained, and if learners' prior knowledge was assessed.

Evidence of understanding

I studied how the teachers assessed their learners' understanding of the content being taught. I observed the teachers' ability to pose questions that assessed learners' prior knowledge and understanding of the content while teaching. This is an important aspect as it allows teachers to correct any misconceptions that learners might have developed, or further explain the content to the learners.

Teaching approaches

In this category, I observed the teachers' teaching skills and knowledge of lesson presentation. These skills include a knowledge of teaching approaches, specifically using a learner- or teacher-centered approach. Ernest (1988) describes three modes of instruction that teachers can use: instructor, explainer, and facilitator. The teacher as an instructor and explainer means that they employ a teacher-centred approach, while a facilitator uses a learner-centred

approach. Actualisation can reveal either learner-centered or teacher-centered approaches, or both, with an emphasis on mathematical concepts and skill development. Teachers, alternatively, are expected to actively engage learners in lessons, to encourage knowledge construction rather than passive or rote learning, and to accommodate learners' diversity (DBE, 2011a).

Flexibility or rigidity in teaching

I examined the teachers' ability to integrate mathematical concepts with learners' prior knowledge, and use real-life examples. I also looked for their ability to respond to learners' questions unrelated to the current lesson presentation. Additionally, I analysed the teachers' ability to relate a new concept to the learners' prior knowledge, and adapt to how the lesson unfolded. Lesson observation was used to determine whether the teachers were flexible or rigid in their teaching of mathematics. I explored the MTI actualisations of non-specialist mathematics teachers through lesson observations. I further observed the teachers' didactical skills, including how they interacted with learners and responded to their questions, how they accommodated learners' varying needs by using both teacher- and learner-centered approaches, and whether they used representations when teaching.

2.9 CONCLUSION

In this study, an in-depth literature review was conducted on several aspects of MTI and its development within classroom practice. This chapter also explored the influencing factors of MTI development. This was necessary because this study aimed to explore how non-specialist teachers develop their MTI through their teaching practice. From the reviewed literature, it is evident that mathematics teachers' identity development has been studied in both international and South African contexts. The various mathematics teacher identity studies focused on both pre-service and in-service teachers' development through teacher education programmes, and in-service professional development programmes. After studying the teacher identity frameworks that were relevant to the study in this chapter, I constructed the conceptual framework which guided this study. I have also discussed the literature findings on MTI development and non-specialist mathematics teaching. Chapter 3 provides a detailed discussion of the research methodology employed in this study.

CHAPTER 3 METHODOLOGY

3.1 INTRODUCTION

In the previous chapter, I discussed the literature, theoretical frameworks and conceptual framework guiding this study. In this chapter, I explain the philosophical assumption that is the foundation of the study, as well as the research methodology adopted to achieve its purpose. The research problem required a qualitative approach, with a case study research design within the interpretive paradigm. The sampling method, data collection strategies, and data analysis procedures, as well as the quality criteria of data and findings, ethical consideration, and the role of the researcher are also discussed in this chapter.

3.2 RESEARCH PARADIGM

The research philosophy that underpinned this study is the qualitative interpretivist paradigm. According to Cohen et al. (2007, p. 19), a researcher using an interpretive paradigm aims to "understand and explain social reality through the eyes of different participants". This philosophy was best suited for this study as it was qualitative research, and the study's purpose was to explore a number of Grade 6 non-specialist mathematics teachers' MTI development through practice. To understand the research phenomenon from an interpretive stance, I had to comprehend the participants' various perspectives and experiences regarding non-specialist mathematics teaching, as well as their MTI development; and observe their lesson presentations. My perception of reality (ontology) and how knowledge is constructed (epistemology) now follows.

3.2.1 Ontological assumption

Ontology is described as the nature of reality (Creswell & Poth, 2018). I believe that there are multiple realities that are subjectively or socially constructed from participants' perspective, because people are unique and interpret events differently, leaving multiple perspectives of reality (Cohen et al., 2011; Nieuwenhuis, 2016b). According to the interpretivist paradigm, reality exists and knowledge is constructed from participants' perspectives and is not dependent on the researcher (Nieuwenhuis, 2016b). In support of the above claim, Merriam (2009) states that reality is socially constructed, that is, there is no single, observable reality. The reality in this study was constructed through the participants rather than through my own experience.

3.2.2 Epistemological assumption

The epistemological assumption of this study was that reality is known through an exploration of the participants' understanding concerning the research phenomenon (Nieuwenhuis, 2016b). Epistemology "concerns the very bases of knowledge, its nature and forms, how it can be acquired and communicated" (Cohen et al., 2011, p. 6). My epistemological assumptions are related to my belief that knowledge is constructed, and not discovered. The interpretivist stance allows the exploration and understanding of participants' views, and perceptions of their MTI development. Merriam (2009) states that reality is socially constructed, that is, there is no single, observable reality. As a result, I had to gather information from the participants in their working environment in order to develop an understanding of the MTI that they developed through their practice and experience. I inductively developed an understanding of the phenomenon from the participants' perspectives. Based on this perspective, I interacted with the participants through individual, semi-structured interviews, and questioned them to better understand their reality. Additionally, I carried out lesson observations while they taught and interacted with learners in the classroom.

3.3 RESEARCH APPROACH AND DESIGN

In this study, a qualitative research approach was employed to develop a deep understanding of non-specialist mathematics teachers' MTI development. According to Denzin and Lincoln (2011, p. 3), qualitative research is described as studying "things in their natural settings, attempting to make sense, or interpret, phenomenon in terms of the meanings people bring to them". Merriam (1998, p. 11) further elaborates that qualitative research "seeks to discover and understand the phenomenon, a process the perspectives and world views of people involved". This method allowed me to collect rich descriptive data, and construct meaning from the participants' lived experiences and perspectives, particularly within their school settings.

This study adopted an exploratory case study design. Yin (1994, p. 19) describes a research design as a "work plan that helps you to get from here to there, where 'here' may be defined as the initial set of questions to be answered, and 'there' is some set of conclusions (answers) about these questions". According to Yin (2014, p. 16), a case study is "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be evident". In other words, clear evidence was required in this study to explain the participants' perspectives on MTI influencers and development through practice. The case study design allowed me to gain different perspectives on their MTI development. According to Cohen et al. (2007, p. 254),

a case study “portrays what it is like to capture the reality of participants’ thoughts, feelings and lived experiences about a phenomenon in its real-life context”. In this study, a case study design allowed me to capture the participants' perspectives, allowing for an analysis of their words and actions from multiple perspectives. It also allowed for the interpretation of their mathematics teaching experiences as non-specialists. This study attempted to gain in-depth understanding of the phenomenon from the perspective of those being studied, which offers the greatest promise of making significant contributions to the knowledge base and practice. Therefore, within a case study, “the end product is a rich, ‘thick’ description of the phenomena under study” (Merriam, 1998, p. 29). Therefore, the focus of this qualitative case study was on the accuracy of the findings rather than their generalisability. A variety of approaches were used to improve the qualitative validity of the findings, including triangulation, member checking, a rich and detailed description of the sample, the setting, and the participants’ perspectives on the themes and categories discovered. Moreover, a case study research design was deemed appropriate for this study as it allowed in-depth data collection involving multiple data collection strategies, namely, semi-structured interviews, lesson observations, and document analysis. The details of the sampling process carried out are explained in the following section.

3.4 SAMPLING METHOD

A qualitative case study employs non-probability sampling methods in which the researcher focuses on a specific group, and uses a small sample size. Non-probability sampling is essential because it provides more depth to the research problem than random sampling. The participants do not represent the entire population, but rather themselves. This study used both purposive and convenient sampling. Purposive sampling enabled me to choose schools and participants who had the knowledge and experience to help me gain a thorough understanding of the research problem. Alternatively, convenience sampling enabled me to choose participants who were easily accessible and available. Purposive sampling provides an in-depth understanding as it is “based on the assumption that the investigator wants to discover, understand the gained insight and therefore must select a sample from which the most can learn” (Merriam, 1998, p. 61). Purposive sampling was employed in this study to capture rich data from the sampled teachers knowing that it represents the population that met the selection criteria. Participants were chosen based on the following inclusion criteria: primary school level, non-specialist mathematics teachers who were teaching Grade 6 mathematics at the time of this study; had two to 15 years of experience teaching mathematics; and who were all teaching in rural public primary schools in the Mpumalanga province. Additionally, the exclusion criteria were: mathematics specialists, non-specialist

mathematics teachers who did not teach Grade 6; those who had less than two years of teaching experience; and non-specialist mathematics teachers who did not teach in rural public primary schools in Mpumalanga.

This study engaged 10 participants who, at the time of this study, were Grade 6 non-specialist mathematics teachers; they were chosen from 10 different schools. I chose Grade 6 non-specialist mathematics teachers as it is a terminal class for the Intermediate phase (Grade 4 - 6) going to Senior phase (Grade 7 - 9). In addition, the SACMEQ analysis of results generated by Venkat and Spaull (2015) have revealed that Grade 6 teachers lack mathematics content knowledge. Furthermore, the ANA results revealed the poor performance of learners in mathematics in Grade 6 (DBE, 2014). Grade 6 is a vital grade as learners are expected to have mastered the basic concepts before advancing to the Senior phase. The sample size was appropriate for the study since a qualitative case study design was employed. Because of the small sample size, I was able to interact with the teachers through interviews where they had the opportunity to explain their perspectives and experiences. The classroom observations enabled me to form meanings of what they claimed during the interviews, and in this way, I collected rich, descriptive data.

In addition, the sample size allowed me to verify the credibility of the information by comparing the findings from each participant to another to determine whether they were consistent or whether their experiences of non-specialist teaching differed. Moreover, I had enough data to answer the research questions, and to gain an in-depth understanding of the phenomenon. This implies that the findings of this study cannot be generalised to a large population of non-specialist mathematics teachers, however, it provides a better understanding of the reality of these teachers. Creswell (2014, p. 189) suggests that in a case study design, the number of cases chosen could be four to five. In contrast, Patton (2015, p. 470) indicates that “there are no rules for sample size in qualitative inquiry”. He further explains that “the size of the sample depends on what you want to find out, why you want to find it out, how the findings will be used, and what resources you have for the study” (Patton, 2015, p. 470). In this study, I selected 10 participants in order to achieve a degree of data saturation, and to develop a deep understanding of the phenomenon across a large range. The demographic information of all of the participants that took part in this study is presented in Table 3.1.

Table 3.1: Demographic information of participants

School	Participant name	Gender	Qualification and specialisation	Area specialisation	No. of years teaching mathematics
School A	Plato	Male	Bachelor of Education.	Languages.	3 years
School B	Zano	Female	Bachelor of Education, Foundation phase.	Foundation phase subjects.	7 years
School C	Thando	Female	Bachelor of Education.	Languages.	6 years
School D	Thato	Male	Bachelor of Education, FET.	Geography and tourism.	14 years
School E	Bonga	Male	Bachelor of Education, FET.	Geography.	11 years
School F	Xoli	Female	Diploma in teaching, ACT certificate in science and technology.	English, science, and technology.	2 years
School G	Lihle	Female	Diploma in teaching.	English and school library.	15 years
School H	Thoko	Female	SPTD (Senior Teachers Diploma). ACE in management, and participation certificate in Natural Science.	Xitsonga and geography.	12 years
School I	Buhle	Female	Diploma in teaching, Foundation phase.	Foundation phase.	11 years
School J	Mpho	Female	Degree in family and Consumer Sciences with education.	Consumer Science.	9 years

3.5 DATA COLLECTION METHODS

Meaning was constructed in this study by using multiple data collection strategies, namely: in-depth semi-structured, individual interviews; lesson observations; and document analysis. The pre-determined interview questions, observation checklist, and document analysis checklist (see Appendix B, C, and D) used in this study were developed from the literature, a discussion with my supervisors and on my conceptual framework.

The table below shows the data collection methods and documentation in this research. To ensure that all research questions were answered with appropriate data, Table 3.3 below was created to align the research questions, data collection methods, instruments, data to be collected, and the conceptual framework. It illustrates the planning of data collection to yield rich results. This is followed by a discussion of the data collection strategies and instruments that were used.

Table 3.2: Summary of methodology

Main research question: How do non-specialist teachers' subject matter knowledge and didactical expertise develop through practice?				
Research approach: qualitative research				
Research design: case study				
Research sub-questions	**Data collection methods**	**Instruments**	**Data to be collected**	**Conceptual framework**
How can the beliefs that non-specialist mathematics teachers have about mathematics as a subject, and its teaching and learning, change through practice?	An individual, semi-structured interview; and one lesson observation per teacher.	Semi-structured interview protocol and lesson observation checklist.	Teachers' beliefs about the nature of mathematics, and mathematics teaching and learning.	Beliefs.
What contextual factors influence the non-specialist mathematics teachers' MTI development through practice?	An individual, semi-structured interview; and one lesson observation per teacher.	Semi-structured interview protocol and lesson observation checklist.	The school context, resources, and school leaders' support.	Contextual factors.
How does the practice of non-specialist teachers influence their MTI development?	An individual, semi-structured interview; one lesson observation; and one lesson plan document analysis per teacher.	Semi-structured interview protocol; lesson observation checklist; and document analysis checklist.	The teachers' mathematical knowledge and teaching skills.	Practice.

3.5.1 Semi-structured interview

In this study, I conducted a single qualitative, individual, semi-structured interview to collect data from the participants' perspectives. According to Nieuwenhuis (2016c, p. 93), "Qualitative interviews aim to obtain rich descriptive data that help in understanding the participants' construction of knowledge and social reality". I chose this method because of the following:

> We interview people to find out from them those things we cannot directly observe…. We cannot observe feelings, thoughts, and intentions. We cannot observe behaviours that took place at some previous point in time. We cannot observe situations that preclude the presence of an observer. We cannot observe how people have organized the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things (Patton, 2015, p. 628).

The interviews with the different participants in this study were used to gain access to their perspectives since we cannot observe everything. For example, it is difficult to discover through observation what teachers believes about the nature of mathematics, and about mathematics teaching and learning. The interviews were also used to obtain information about the participants' professional experiences, such as the contextual factors and practices that influenced their MTI development. The interviews were conducted with each of the participants before classroom observations in order to understand their perception of MTI, and to determine if the described MTI was consistent with the actualisation of their MTI in the classroom. The interview questions were prepared beforehand to be used as a guide to gain in-depth information about the teachers' perceived and actualised professional MTI, and to explore their mathematics beliefs, contextual factors, and practice that had influenced their MTI development (see Appendix B).

The pre-determined questions were used and followed up to probe deep into the participants' explanations, and to clarify any misunderstandings on what was said. Each interview lasted 15-30 minutes. All of the interviews were audio-recorded using a tape recorder. For analysis purposes, they were then transcribed and coded based on the participants' responses. The interviews were conducted during the participants' free periods and in the afternoon, at the school, during scheduled appointment dates and times. In my interview transcription, I categorised various themes that were predetermined from the conceptual framework, as well as new categories that emerged from the transcribed data, as collected based on my research questions. It helped me to stay focused on gaining an in-depth understanding of the phenomenon under study.

The interview questions were developed in line with the understanding of the literature reviewed, and the purpose of the study. The interview protocol was aligned with the study's

conceptual framework of the three influencing factors (see Table 3.3). Interview Questions 2-5 were designed to provide information about the participants' beliefs about mathematics as a subject, and about mathematics teaching and learning. Questions 10 and 12-13 were intended to investigate the contextual factors that influenced the teachers' MTI development, namely, the school context, resources, and support from the school leaders. Lastly, Questions 6-9 and 11 assessed the teachers' practice of their subject matter, and their didactical expertise.

Table 3.3: Sample of the interview questions

Sub-domains: Influencers	**Interview questions**
Teachers' beliefs	2) How do you view mathematics as a teacher? 3) How do you see yourself as a mathematics teacher? 4) Do you believe that you have sufficient subject matter knowledge to teach mathematics effectively? or is there any content you find difficult? 5) How confident are you in teaching mathematics?
Contextual factors	10) Which teaching resources do you use when teaching? 12) Is there anything that influences your teaching and learning of mathematics? 13) What support did you receive from the school leaders?
Practice	6) Which teaching approaches do you employ when teaching mathematics? why? 7) How do you assess the learners understanding while teaching? 8) How do you accommodate the diverse needs of learners while teaching? 9) How has your mathematical knowledge developed since you started teaching mathematics? 11) How do you plan your lessons?

3.5.2 Lesson observation

To enhance the data gathered from the semi-structured interviews conducted with the participants, I also formally observed the 10 participants in the field. This allowed me to understand their MTI development better in terms of actualisation of their subject matter and

didactical expertise, and also the contextual factors and practice that might have influenced their MTI development. According to Patton (2015), the purpose of observations is to see what is happening in a natural setting, rather than simply assuming we know or taking teachers' word for what they claim to do. The lesson observations could confirm (or not) the claims that were made through the semi-structured interviews. I employed this data collection strategy to develop an in-depth understanding of the reality of non-specialist mathematics teachers in their classrooms. Nieuwenhuis (2016c, p. 90) indicates that "observation is a systematic process of recording the behavioural patterns of participants, objects and occurrences without necessarily questioning or communicating with".

My role in this study was that of a participant-observer, and I obtained information on how the participants' MTI had developed through their practices. Nieuwenhuis (2016c) states that the participant-observer has an opportunity to get the participants' insider perspective of the phenomenon being studied. The lesson observations provided me an opportunity to observe the teachers' subject matter knowledge and teaching skills, how they explained the content to learners, and how they asked and responded to learners' questions. This enabled me to acquire knowledge about their mastery of subject matter, their teaching skills, as well as their experiences without influencing the dynamics of the setting.

During the lesson observations, I had the opportunity to acquire more knowledge on aspects that the participants may have been unwilling or unable to put into words during the interviews. The observer may find things to which no one has ever really paid attention (Patton, 2015). Through the lesson observation data collection strategy, I had the opportunity to observe the participants teaching in their classrooms, and I could hear and see what was happening in reality. I was seated at the back of the classroom and was unobtrusive to the lesson, simply observing the participants teaching their normal lessons. I observed one lesson per participant with them teaching any topic in accordance with the revised annual teaching plan, which was developed in response to the unprecedented disruption caused by COVID-19. The observed lessons covered the following topics: common fractions (comparing, ordering, addition, and subtraction with different denominators and with mixed numbers); numeric patterns; capacity and volume; percentage; division of three digits by one; and integers. During the lesson observations, I video recorded the teachers. I also made notes about things that might not have been apparent in the recordings during later analysis, but were important in terms of the lesson observation checklist, as suggested by Kekana (2016). The checklist was divided into five categories based on the conceptual framework: MTI Aspects and Influencers of MTI (see Appendix C). In observing the teachers' lesson presentations, it was my intention to see their MTI actualisation in terms of subject matter expertise and didactical expertise as demonstrated in their classrooms (see Section 2.8.4.3). The lesson observations were carried out during the

teachers' normal periods as allocated in their school timetable. In all of the schools, each lesson lasted for 60 minutes.

3.5.3 Document analysis

After the semi-structured interviews and lesson observations, I conducted a document analysis of one lesson plan per participant, which was also the lesson plan of the lesson being observed. Nieuwenhuis (2016c) explains that document analysis is a data-gathering technique that focuses on all types of written communication that may shed light on the phenomenon being investigated. According to Simons (2009, p. 63), "Document analysis has a potential for adding depth to a case that has not perhaps been fully exploited". The participants' lesson plans were collected before the commencement of the lesson observation to assess their subject matter knowledge. Additionally, the document analysis was used to validate the participants' claims from their interview on how they planned their lessons. Furthermore, the lesson plans assisted me to understand the teachers' lesson plan goals, the content to be taught, the questions to be asked, and the resources to be used for teaching. The lesson plans were also analysed to ascertain if the teachers had subject expertise knowledge. I looked at how the teacher planned to explain the concept to learners, and if the concepts were explained adequately, explicitly with no errors, and at a high cognitive level. I also looked for knowledge of different teaching approaches, and what manipulatives would be used when teaching. The analysis of the lesson plan was conducted using a document analysis checklist (see Appendix D).

3.5.4 Data collection process

The data collection consisted of three stages. Firstly, each participant was interviewed face-to-face once, which took place at the school in their classrooms or in the Head of Department's (HoD) office. The documents to be analysed, namely, the lesson plans, were then collected just before the lessons were presented. This allowed me to have a clear understanding of what the lesson was about, and easily follow the lesson presentation. Finally, the lessons were observed, and each participant was observed teaching once during their normal teaching periods in accordance with their revised Annual Teaching Plan (ATP), which resulted in different topics being taught (see Section 3.5.2). Lastly, for the document analysis of the lesson plans, the teachers gave me their lesson plans before the lesson presentation.

3.6 DATA ANALYSIS

According to Cohen et al. (2018, p. 315), data analysis involves "making sense of data in terms of participants' definitions of the situation, noting patterns, themes, categories and

regularities". In qualitative data analysis, the goal of the researcher is to "summarize what you have seen or heard in terms of common words, phrases, themes, or patterns that would aid to the researchers' understanding and interpretation of that which is emerging" (Nieuwenhuis, 2016a, p. 110).

This study employed both deductive and inductive analysis (Creswell & Creswell, 2018). The inductive analysis was used to analyse the data, and to identify the multiple realities potentially present in the data. The inductive analysis also allowed the research findings to emerge from the frequent, dominant, or significant categories that emerged from the raw data. The deductive analysis was employed where the themes for analysis were formulated in advance from the literature review and presented in the conceptual framework.

After collecting the data through the semi-structured interviews, lesson observations, and document analysis, I transcribed the verbal and visual data in Microsoft Word. The transcripts were read several times to make sense of the data before it was coded. I employed Saldaña's (2015) seven steps for manually coding the data using Microsoft Word. I analysed the transcribed data from the interview tape recordings using Microsoft Word to manually create codes. Following that, a thematic analysis was used to examine the transcripts in relation to the conceptual framework's predetermined categories and themes, as well as new categories that emerged from the data. I lastly created a visual presentation of the codes and themes. For coding, I used the descriptive and in-vivo coding method, prioritising the participants' voices, particularly when participants repeatedly made use of certain significant statements. The themes provided answers to the research questions. According to Saldaña (2015), conducting data analysis using the aid of Microsoft Office involves seven stages, as shown in Figure 3.2.

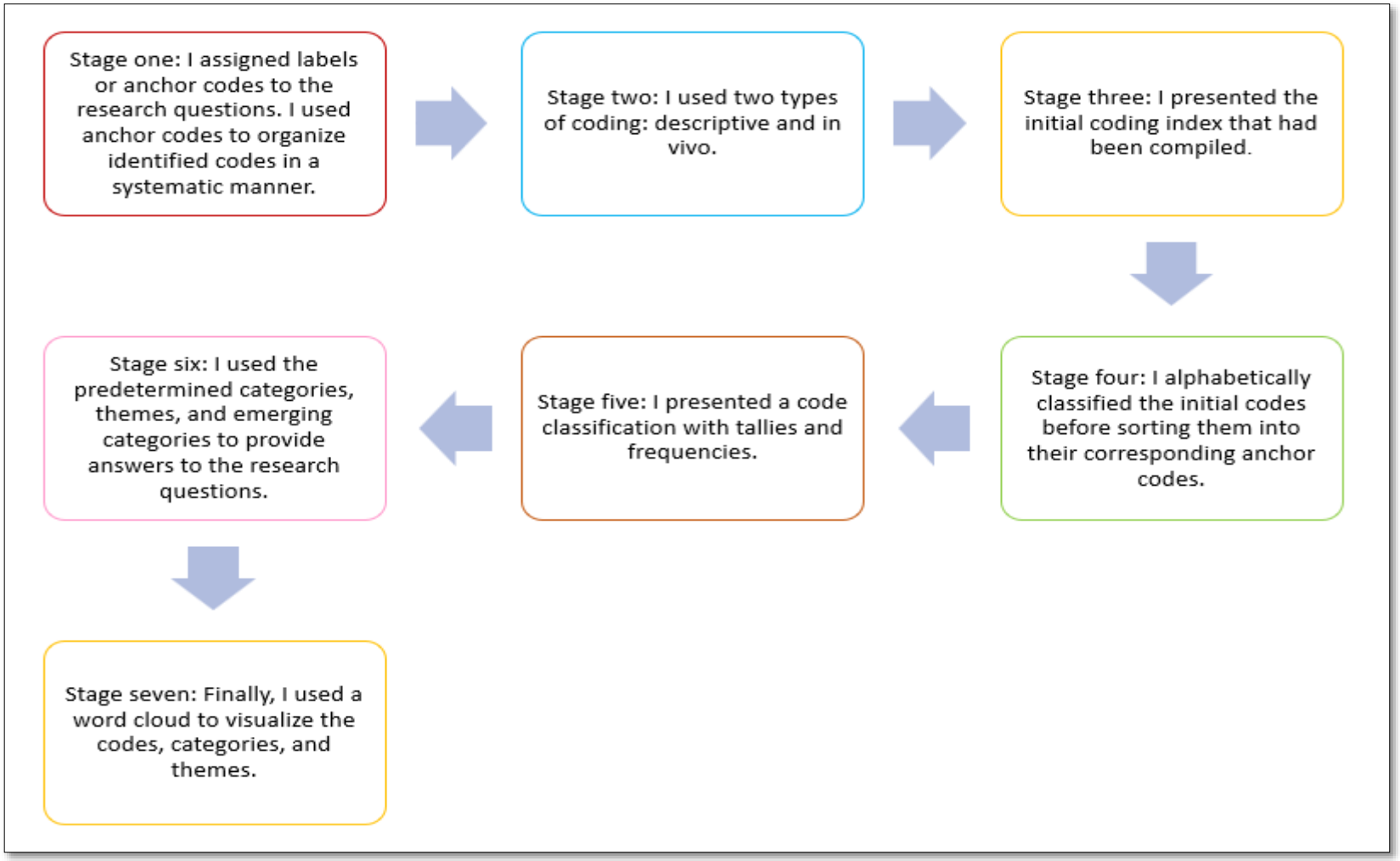

Figure 3.1: The seven stages of data analysis as used in this study

To understand and interpret the participants' perspectives and experiences, I categorised their words and actions into themes predetermined from the literature and presented in the conceptual framework, as well as other categories that emerged from the data. In the conceptual framework there were two themes, namely: Influencers; and MTI and actualisation. There were five sub-themes: beliefs; contextual factors; practice; subject matter expertise; and didactical expertise. These themes are used as headings in Chapter 4, where I present the data obtained in this study. Table 3.4 below presents the themes with the corresponding categories.

Table 3.4: Overview of the themes and their corresponding categories

THEMES	SUB-THEMES	CATEGORIES
INFLUENCERS	Beliefs	• Personal view as a mathematics teacher. • Mathematics as a subject. • Mathematics teaching and learning. • Confidence.
	Contextual factors	• School context. • Resources. • Learners' background. • Support from school leaders.
	Practice	• Lesson planning. • Interaction with learners.
MTI AND ACTUALISATION	Subject matter expertise	• Subject matter knowledge.
	Didactical expertise	• Evidence of understanding. • Teaching approaches. • Flexibility or rigidity in teaching.

3.7 QUALITY CRITERIA

Lincoln and Guba (1985, p. 290) define trustworthiness as "persuading the audience that the findings of the inquiry are worth paying attention to". The trustworthiness of the study was established by employing the criteria of credibility, dependability, conformability, and transferability, which are significant in qualitative research (Creswell, 2014; Lincoln & Guba, 1985; Nieuwenhuis, 2016a).

3.7.1 Credibility

This study employed triangulation and member checking to enhance its credibility (Baxter & Jack, 2008). This study used multiple data collection strategies: semi-structured interviews, lesson observations, and document analysis to triangulate the data (Nieuwenhuis, 2016c). The different data collection strategies promoted the credibility of the data. I was also able to develop an understanding of the participants' experiences, beliefs, knowledge, and challenges through the interviews, lesson observations, and document analysis of lesson plans. For accuracy of findings, the data gathered from the interviews were verified with the lesson observation videos and checklist, as well as the document analysis. Nieuwenhuis (2016a, p. 123) states that ensuring credibility may include member checking, which implies that "you submit your transcripts to the participants to correct errors of fact". I integrated a process of member checking by asking the participants to review the transcribed data obtained from the interviews and observations to check for any misinterpretations. Also, through member checking, the participants had an opportunity to discuss and clarify my interpretation, as well as add new or additional viewpoints on the matter (Baxter & Jack, 2008).

3.7.2 Dependability

According to Nieuwenhuis (2016a), dependability may be enhanced through the analysis process. It should thus be documented in detail so that another person can see why you made decisions that you made, how you went about the analysis, and how you arrived at the findings. Baxter and Jack (2008, p. 556) explain that "dependability of the data can be promoted by having multiple researchers independently code a set of data and then meet, and together come to consensus on the emerging codes and categories". In this study, dependability was enhanced by involving a critical reader, and my supervisors to check my data analysis and interpretation.

3.7.3 Confirmability

To ensure confirmability, I was careful to not be biased concerning data collection and interpretation (Nieuwenhuis, 2016a), while remaining aware that my motivation and interests might influence the study's findings. Triangulation and member checking also strengthened the confirmability of the study's findings. To ensure triangulation of the data in this study, I used multiple data sources interviews, lesson observation, and document analysis of the lesson plans. The data gathered from the interviews were verified through the lesson observation and document analysis. Furthermore, data from different data sources were used to support one another for the confirmability of the research findings. Moreover, the multiple data sources (interview transcripts, observation checklist, document analysis checklist, the

audio and video recordings) were submitted to my supervisors to check the accuracy of the data analysis and interpretation. I also used direct quotes from the participants' responses in order to strengthen my interpretation of the text.

3.7.4 Transferability

While the purpose of the study was not to generalise its findings, I provided rich and thick descriptions of the sample, context, data collection method, data analysis, and justification of the findings, supported by the literature (Creswell, 2007; Merriam, 2009). I carefully described the context of the study which, according to Adu (2019), also contributes to the transferability of the study. In describing the context in detail, I aimed to allow the reader to understand the circumstances in which the findings were discovered with a view to imagining how such findings might be applied in a similar context. I also collected demographic information about the participants' education level, specialisation, working experience, and environment, which might add to the transferability of the data.

3.8 ETHICAL CONSIDERATIONS

I sought permission from the different stakeholders to ensure that this research was conducted following the ethical research guidelines. Firstly, I obtained permission to conduct this study from the Ethics Committee of the University of Pretoria's Faculty of Education, as well as the Mpumalanga Province Department of Education provincial district office (Appendix A1 and A2). Secondly, I sought permission from each of the 10 school principals (Appendix A3) and the 10 non-specialist mathematics teachers, whom I interviewed, and video recorded (Appendix A4). I also sent informed consent letters to the parents of the learners who were present in class when I observed the teacher while normal teaching and learning took place (Appendix A5). Finally, I obtained learners' assent after explaining to them the nature of the study and the reason for me being present during their mathematics lesson (Appendix A6).

Before obtaining their informed consent, I explained to the participants that participation was voluntary, and that they could withdraw at any time from the study without any negative consequences (Cohen et al., 2011). I also closely attended to building good relationships and trust with the participants. The participants were assured of confidentiality and anonymity, as suggested by Simons (2009). I did this by using pseudonyms when referring to individuals and schools. Lastly, the raw data that I collected through the interview audio recordings, video-recordings, and copies of samples of lesson plans will be stored in a locked cabinet at the University of Pretoria for 15 years. In this way, confidentiality and anonymity were maintained throughout the study, and only my supervisors had access to the data and may use it in future studies.

3.9 ROLE OF THE RESEARCHER

My role in this study was that of a participant-observer. Nieuwenhuis (2016c) states that the participant-observer has an opportunity to get the participants' insider perspective of the phenomenon being studied. I was immersed in the data collection process through conducting interviews with the participants, but also by doing lesson observations. The observations provided opportunities to observe the teachers' subject matter knowledge and teaching skills, how they explained the content to the learners, and whether they asked and responded to learners' questions. This enabled me to acquire a knowledge base on the participants' mastery of subject matter and teaching skills. I was the primary instrument for collecting and analysing data. This increased the opportunities to collect and produce meaningful information (Merriam, 1998). As the primary investigator, I sought to understand the participants' MTI development from their perspective.

3.10 CONCLUSION

In this chapter, I described the research methodology employed in this study. I have explained the research paradigm that underpinned the study, and discussed the use of my research approach, design, and data collection methods, as well as the data analysis procedure followed. I concluded the chapter by discussing the quality criteria used in this study, and the ethical principles to which I adhered, as stipulated by the University of Pretoria. Lastly, I described my role as the researcher in this study. In the next chapter, the data is presented, and the findings obtained from the study are explored.

CHAPTER 4 DATA ANALYSIS

4.1 INTRODUCTION

In Chapter 3, I discussed the research paradigm and methodology employed in this study. In this chapter, I present the results of the data generated in this study. All 10 participants' biographic information was presented in Section 3.4, which contributed to rich data being collected. The gathered data were analysed using two key themes: influencers, and MTI and actualisation. There were also several sub-themes (see Figure 4.1), each one of which is organised according to the research sub-questions. The findings from the interviews are presented and supported by the results from the lesson observations, and the document analysis of lesson plans. Lastly, I include visual representations of all 10 participants' MTI development summaries (see Appendix H).

4.2 FINDINGS

This section presents the findings of the deductive and inductive analysis of the data generated from the semi-structured interviews, lesson observations, and document analysis of lesson plans. Based on the two main themes, and sub-themes, as predetermined from the conceptual framework, a thematic analysis was applied, while some new categories also emerged from the data. The data analysis process is presented in Figure 3.2 in Chapter 3. Figure 4.1 shows a representation of the themes, sub-themes, and categories for the data analysis. Each theme appears as a unique heading, but all of the themes connected to one another to paint a picture of the MTI development of the participants.

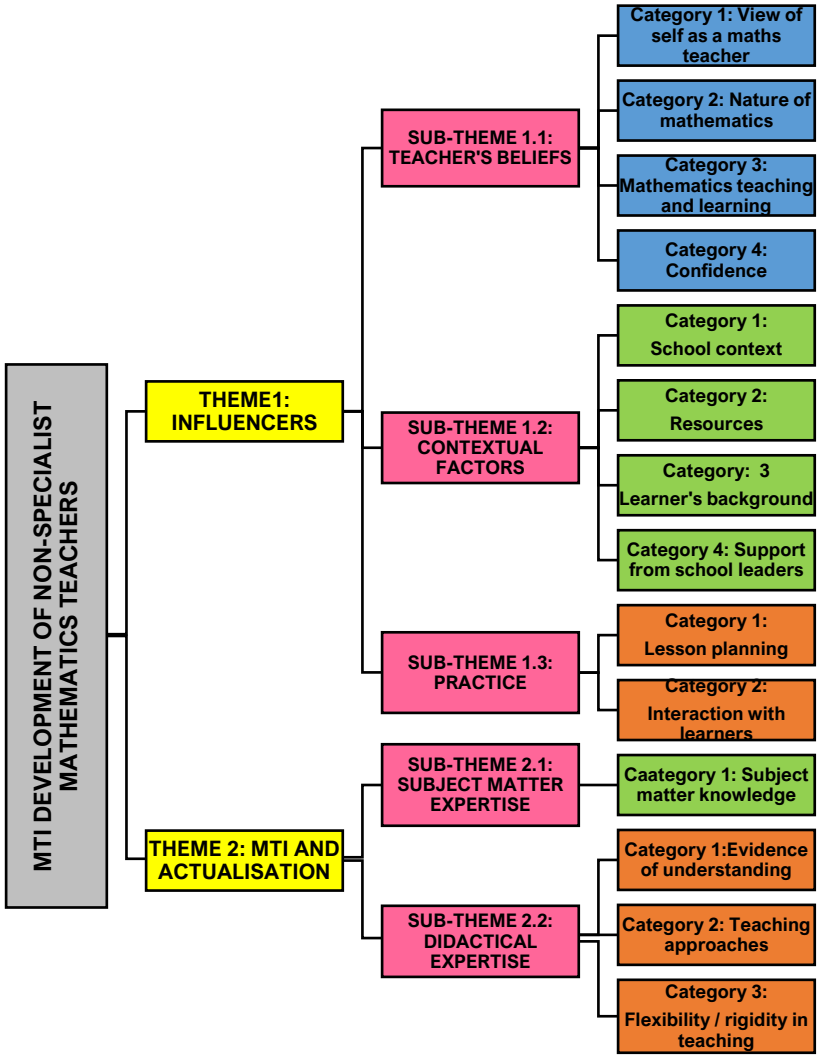

Figure 4.1: Main themes, sub-themes, and categories from the thematic analysis of the data

4.3 THEME 1: INFLUENCERS

This theme focused on the factors that influenced the MTI development of non-specialist mathematics teachers through practice. During the analysis of the results, it came to light that these influencers could be positive *and* negative. Three sub-themes underpinned Theme 1, and related to different categories. Sub-theme 1.1 concerns the teachers' beliefs as described in terms of four categories: view of self as a mathematics teacher, nature of mathematics, mathematics teaching and learning, and confidence. Sub-theme 1.2 deals with contextual factors according to four categories: school context, resources, learners' background, and support from school leaders. Sub-theme 1.3 focuses on the actual practice of the teacher, with the analysis focusing on two categories: lesson planning, and interaction with learners. Below, I provide a diagram of Theme 1, together with its sub-themes and categories.

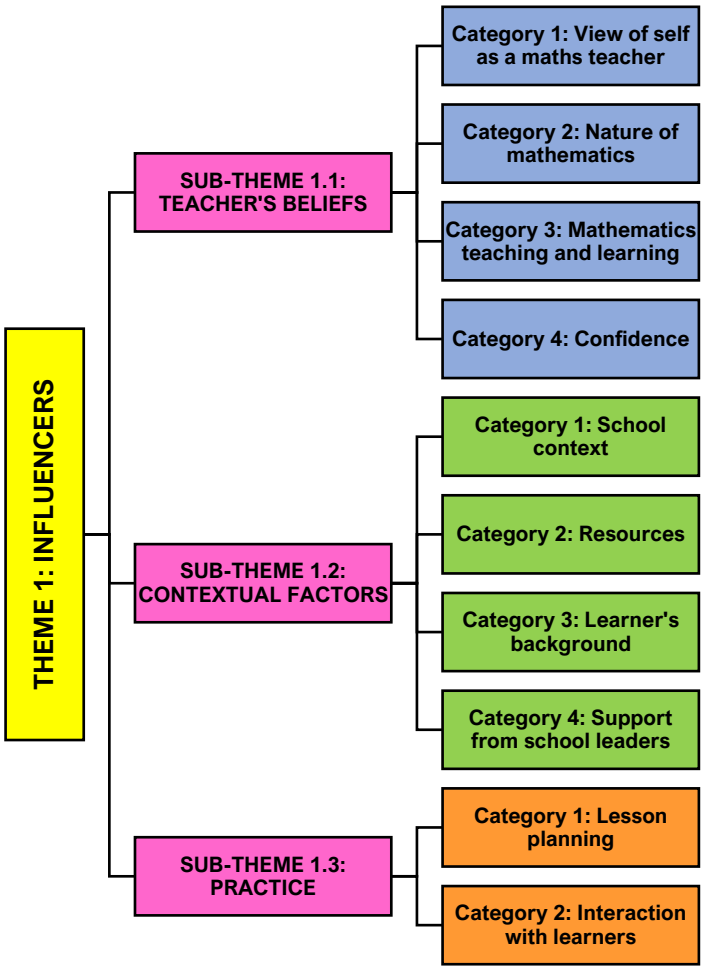

Figure 4.2: Theme 1: influencers of MTI development adapted from Beauchamp and Thomas (2009), Beijaard et al. (2000), Ernest (1988), Van Zoest and Bohl (2005), and Wenger (1998)

4.3.1 Sub-theme 1.1: Teachers' beliefs

Category 1: View of self as a mathematics teacher

This category revealed that although the participants taught mathematics, they did not view themselves as mathematics teachers. Despite the fact that they taught the subject, the participants emphasised during the interview that they were not mathematics teachers, and that mathematics is a difficult subject, some even indicating a lack of interest in the subject. In addition, some of the participants indicated that although they had taught mathematics for several years, they were still working hard to acquire the knowledge and skills necessary to become mathematics teachers. The participants shared their views of themselves as not being mathematics teachers, in fact, not even one of the teachers stated the opposite. Below are some examples of the participants' sentiments on the topic. Plato stated:

> *I am teaching mathematics; I do know that I am a language teacher. I see myself as a language teacher as I am qualified to teach languages. But now because I am also teaching mathematics. I always try to be a mathematics teacher, but deep down I know that I am not a maths teacher. Ehh… firstly I am not happy to teach the subject because they promised me that they will be changing me back to languages, but still, it's not happening so… yahh… that's how I see myself: not a mathematics teacher. I am teaching it, but I am a language teacher* (Appendix E: lines 28-34, PA).

While Zano explained:

> *I don't see myself as a mathematics teacher because it is very difficult. But since… I have been teaching the intermediate phase I am trying to develop myself in mathematics* (Appendix E: lines 22-24, PB).

Bonga said much the same:

> *I am a very resolute teacher, and I am trying even though I encounter challenges. Because ehh…you find that there are learners who encounter challenges but eehh… it is difficult for me because I do not have the necessary skills and tools which I must use in terms of assisting learners who are having challenges and barriers to learning. But I am trying my level best, eehh… I am working extremely hard* (Appendix E: lines 21-25, PE).

Category 2: Nature of mathematics

The participants shared their perspectives on the nature of mathematics as a subject, stating that it is a practical and challenging subject that requires much more practise. The participants' perceptions of the difficulty of mathematics influenced their subject knowledge development and classroom practice significantly. This perception of the subject caused them to develop a negative attitude toward mathematics, with all of them claiming to have become uninterested in learning it. The quotes below reflect the participants' perspective on the nature of mathematics as a subject. Some said that mathematics was challenging, and others that it was simple, however, it was clear that those who found the subject simple had reduced it to a mere manipulation of the four basic operations, and they later contradicted themselves in their observed lessons.

On this topic, Thando answered *"[Mathematics] is a challenging subject because it needs more practice"* (Appendix E: line 13, PC). Buhle held the same point of view: *"I view mathematics as a challenging subject and need more practice"* (Appendix E: lines 13, PI). Zano concurred, explaining that:

> *Mmmm… Since I am a foundation phase teacher, I view mathematics as a simple subject because it is where learners have to learn operation signs such as addition and so on. But… now since I am teaching intermediate phase it is an exceedingly difficult subject because it involves a lot of topics that have different kinds of methods* (Appendix E: lines 17-20, PB).

Thato described his view of mathematics as follows, *"Mathematics is a very challenging subject and is more practical"* (Appendix E: line 29, PD); while Lihle claimed that:

> *In mathematics once you master the four basic operations that are multiplication, division, eehh… subtraction, and addition you cannot go wrong* (Appendix E: lines 20-21, PG).

The dominance of mathematics as a challenging subject was a common thread in all of the interviews on the nature of mathematics as a subject. Mathematics was viewed by the participants as a subject with fixed rules that learners must master, such as mastering the four basic mathematics operations. They considered mathematics to be a practical subject in which you learn or develop an understanding of the concepts through practise, or the drilling of the concepts along with mastery of the procedural skills. The participants believed that mathematics is a practical subject in which the teacher explains the algorithms (step-by-step with procedures shown to the learners) or the concept to the learners, and then the learners do exactly what the teacher has shown them to do. Through lesson observation, it was clear

that the teachers believed that mathematics is a difficult subject as they explained the concepts to the learners using direct instruction, leaving no room for problem solving or constructive learning, and classroom discussion was not encouraged. In addition, after explaining the concepts, the teachers gave the learners activities to complete individually in order to practise what they had learned. The teachers' beliefs about the nature of mathematics is associated with the instrumentalist and Platonist philosophical view.

Category 3: Mathematics teaching and learning

In the semi-structured interviews, the participants described their beliefs about mathematics teaching and learning as being founded in a teacher-centred approach, and thus a Behaviourist Theory of Learning. The participants described their mathematics teaching and learning beliefs according to two categories: instrumentalist, and Platonist.

> *I demonstrate sums on the board. And the learners listen to me that is how they learn. I also work with ehh… I work with the examples that are in the textbook. Then I work with the learners using the examples that are given in the textbook. Following all the steps that are there* (Plato) (Appendix E: lines 65-69, PA).

> *As a teacher, you show them maybe one example, then the second one you need to invite the class. This means we work together as a group* (Thando) (Appendix E: lines 55-56, PC).

Other participants' description of their beliefs about mathematics teaching and learning were more Platonist. For example, Thato explained:

> *I apply the demonstration approach and with the demonstration approach, it assists me to relate the concept [to real-life situations or examples], since I have said that maths its practically start from the bathroom going to the kitchen. So, with this the demonstrating method, before I introduce the lesson, I use the demonstration, and then since the learners will have the primary background of what they have done in the morning. So, it assists me while I am teaching in terms of the demonstration. I am using more demonstration and practically* (Appendix E: lines 90-97, PD).

These participants' description of their beliefs about mathematics teaching could be viewed as teacher centred, with an emphasis on performance or mastering the steps, as well as understanding and learning being relegated to a passive reception of knowledge. In the lesson observations, the participants were clearly instructors and explainers, while the learners were receivers of knowledge. The teachers used direct instruction and taught mathematics as a set of fixed rules, step by step, teaching the procedures that the learners needed to master. In addition, they did not support flexibility, constructive learning, and critical thinking, but rather

procedural and rote learning. Moreover, they worked out the solutions for the learners without allowing them to solve the problems independently. Plato, Zano, Thando, Xoli, Lihle, Thoko, and Mpho demonstrated instrumentalist pedagogical characteristics (see Appendix F). Furthermore, the other three participants' (Thato, Bonga, and Buhle) pedagogical beliefs and practices were related to Platonist views, with a greater emphasis on explaining and drilling concepts in order for learners to grasp them. It can be concluded that their beliefs about mathematics teaching and learning are associated with the two categories: instrumentalist, and Platonist.

Category 4: Confidence

In this category, several participants confessed that they did not have the confidence to teach mathematics since they still had difficulties in teaching several of the required topics. Moreover, they were not confident to teach in the presence of their colleagues or seniors during IQMS lesson observations. Their responses when asked about their confidence in teaching mathematics were as follows:

> *Mmhh… Less confident (laughs)… No confidence at all. Due to challenges from learners and other topics are difficult. I cannot deliver them properly even if I can try, I see that this is difficult and also the learners are incredibly challenging on asking questions* (Zano) (Appendix E: lines 33- 36, PB).

> *Eehhm… a colleague comes in for lesson observation, then I do not have confidence. ehh… I am even scared to teach in front of them. Sometimes my senior will come and observe my lesson, so I feel very intimidated. And ehh… I do not have enough confidence even ehh… ehhrn the learners are having homework other parents will call me and ask how this is supposed to be done. And at the time I had to be defensive and tell them that I cannot work while I am not at school* (Plato) (Appendix E: lines 52-60, PA).

It was evident in the observed lessons that the participants lacked confidence in teaching mathematics. They relied heavily on the DBE workbook and textbook, and continuously read directly from the DBE workbook and textbook during the teaching process. They asked a few lower-cognitive level questions, did not use the learners' responses to explain the content more thoroughly, did not encourage class discussion, and made many mistakes (see Appendix F). It appears that these teachers lacked confidence due to inadequate subject matter knowledge and teaching skills. Participants Xoli, Lihle, Thoko, and Mpho professed that they were confident in teaching mathematics, but this was belied by what was observed in the lessons. There were six participants who demonstrated a lack of confidence in the observed

lesson: Plato, Zano, Xoli, Lihle, Thoko, and Mpho; while four participants showed confidence in presenting their lessons: Thando, Thato, Bonga, and Buhle.

4.3.2 Sub-theme 1.2: Contextual factors

Category 1: School context

All of the participants' schools were public primary schools in a remote rural area of South Africa. The schools had poor facilities, and the buildings were old, but neat. The schools had water tanks, and some had vegetable gardens. The medium of instruction was English, but teachers and learners often used siSwati in the lessons. The number of learners in the classrooms varied greatly: Buhle's classroom had 48 learners, Plato and Xoli had 54 learners, Thando had 55 learners, Mpho had 62 learners, Lihle and Thato had 64 learners, Thoko had 66 learners, Zano and Bonga had 68 learners. In this regard, Bonga summed it up, stating, *"Yahh most of our classes are overcrowded"* (Appendix E: line 67, PE). He also said, "we are having highly packed classes in this environment" (Appendix E: lines 70-71, PE).

Lihle explained that:

> *Eish that one, I will not say I do not have overcrowding because eehh… now it is easier because they do not come in large numbers. But when there is no COVID-19 it is a problem because you will find that the class is overcrowded you cannot even move to assist the learners that are having learning barriers. So… so in that way, it negatively influences me, the overcrowding. Yeah, it is a contextual factor that one* (Appendix E: lines 120-124, PG).

The observed lessons confirmed these interview excerpts: the classes were packed, and the number of learners in the classroom did not meet COVID-19 regulations. Despite the rotational attendance patterns (i.e. Grades 1, 3, 5, and 7 attending on the same day; and Grades R, 2, 4, and 6 attending the following day), and the fact that learners were divided into smaller groups within the grades, the classrooms remained overcrowded.

Category 2: Resources

The participants explained that they use DBE workbooks, textbooks, and chalkboards, with some also mentioning teaching aids. Thando clarified, *"We are using the DBE workbook as a primary resource. They use it to write it as classwork and homework" (Appendix E: lines 81-82, PC).* This was confirmed during the lesson observations. All of the schools had the DBE workbooks, and used them for teaching learner activities:

> *I am using a workbook, textbooks, and teaching aids. So… we do not have the technical teaching materials, such as smart boards, eehh… or TVs, smartphones, or*

laptop. So, I am currently focusing a lot on using the textbooks and the workbooks from the department of basic education (DBE), those are the ones that I am using currently (Bonga) (Appendix E, lines 83-87, PE).

Using the textbook and also the workbook. And all the pictures when it is needed like when you are teaching the 2-D shapes and 3-D it needs some pictures, the objects like when you teach 3D, there are polygons hexagons. So, you have to show the learners what is a hexagon, then even the net when doing 3D: how to find the net there (Thoko) (Appendix E: lines 50-57, PH).

The preceding interview excerpts contradicted the observed lessons because all of the participants presented their lessons utilising the chalkboard, textbook, and DBE workbooks rather than teaching aids. The exception was Thato, who brought empty bottles and water to illustrate the difference between volume and capacity. For example, during Lihle's observed lesson, she taught using 3-D objects, but did not have teaching aids to demonstrate 3-D objects, or their properties. She did, however, use a broken tabletop to demonstrate to the learners the properties of a rectangular prism, but other 3-D objects were not presented (Appendix F, Lihle, 31/05/21). The observed lessons revealed that the schools did not have teaching aids. Lihle confirmed this:

The problem is the teaching aids. Yahh… Because this subject needs you to involve in the things that are happening in real life. Even if you make examples, you make examples using the children inside the classroom. Using their chairs and tables (Appendix E: lines 41-44, PG).

Figure 4.3: A picture of Lihle showing the learners the properties of a rectangular prism

Lihle's demonstration of rectangular prism properties in Figure 4.3 was unclear, and the concept was incorrectly presented. Furthermore, it revealed a lack of creativity, subject matter knowledge, and pedagogical skills on the part of the teacher. Moreover, there were a number of 3-D objects that she could have brought and used to explain the properties of 3-D objects, as well as practical examples of 3-D objects that the learners have and use at home.

The lack of resources was confirmed in the observed lesson when Lihle used the broken tabletop to demonstrate rectangular prism properties. However, this also revealed that she lacked subject matter knowledge and pedagogical skills because she could have created her own 3-D objects, or brought real-life objects as examples to demonstrate the properties of 3-D objects rather than using the table-top and pictures from the DBE workbook. In addition, it was observed that all of the schools' learners had DBE workbooks, but there was a shortage of textbooks and teaching aids. This was confirmed by the teachers always referring learners to examples from the DBE workbook while teaching, and also giving the learners a written task to complete from them. This demonstrates that the teachers lacked subject matter knowledge and pedagogical skills because they were unable to create their own teaching aids, writing activities for the learners to complete, their own examples, and use real-life examples to explain the concepts.

Category 3: Learners' background

The participants explained that their learners came from various backgrounds, and that some were neglected by their parents or were orphans, lived with grandparents, or lived in child-headed families. Consequently, these teachers carried the responsibility of operating in loco-parentis responsibility. The participants also raised concerns about how this negatively impacted the discipline of the learners, as well as the effectiveness of teaching and learning mathematics. This was particularly the case as some did not do their schoolwork since they had no one to assist them. During the interview, the participants explained as following:

> *Some do their schoolwork, and some do not because when you look at the fact that some mothers, they leave the house at 3am in the morning and when they come back, they have no time…. So, you need to make sure that you do justice at work, you give them work that they can do* (Mpho) (Appendix E: lines 144-146, PJ).

However, Thando complained:

> *We do not collaborate [sic] with the learners, like when you give them a project to do it at home, they don't do it. For example, you can give them a project in February and other kids bring it in April not done, saying he/she does not know what to do. It is one of the challenges. Even if you can say you will stay with them in the afternoon and help*

> *them to write other learners do not stay behind. Or if you ask them to come on Saturday a few will come and the other ones won't come* (Appendix E: lines 99-105, PC).
>
> *Aahh the negative influence is that some of the learners do not do their homework due to they do not have parents, they are staying with grannies. Their grannies cannot help them with my homework* (Xoli) (Appendix E: lines 58-61, PF).

Lihle confirmed:

> *Aahh…* a majority of learners write their work, very few learners do not write*. And if you look at the background of the child who comes to school, [they] did not write the home activity. You will find that the children are staying with the brothers. He or she does not have parents, so it becomes a problem and also those who stay with grandparents or grandmothers. Some of them are illiterate so it becomes a problem for that child to write the home activity* (Appendix E: lines: 126-130, PG).

During the lesson observation, I observed the discipline issue that Thando had raised (Appendix F, Thando, 02/06/21). The learners were disturbing the class, causing the teacher to reprimand them, telling them to be quiet and stop what they were doing. A similar issue of discipline was observed ing Lihle's class; she even asked one learner to stand up and move to the back of the classroom because he was sleeping in the class while Lihle was teaching. What Lihle said in her interview (see excerpt above) was confirmed during the observed lesson when, again, there was a learner who was sleeping in class. This confirmed the assertion regarding the learners' background influencing the teaching and learning of mathematics. Also, when Bonga started his lesson by doing corrections with the learners, he noticed that a number of learners had not done their homework (Appendix F, Bonga, 27/05/21). There could be several reasons for this, one of which is that the lesson was boring, and the learners were not engaged, or the learners were simply tired. Moreover, some of the learners were not paying attention and disturbing other learners while teaching took place (Appendix F, Lihle, 31/05/21).

Category 4: Support from school leaders

The participants explained how workshops helped them to develop their subject matter knowledge, despite the fact that they only attended once in a while. Several participants indicated that school leaders did not provide them with any support. The participants expressed concern that the school leaders could not, in fact, assist them because they were also not mathematics specialists (Plato, Zano and Bonga). Thoko and Buhle's schools did not have a Head of Department at all, the only leader being the principal. The teachers stated that their leaders were aware of the challenges they faced, yet nothing was done to help them. In

response to the question of whether or not school leaders supported them, Plato and Zano explained:

> *Aahh…from the school leaders I do receive support but its aahh… it is not sufficient. It is not sufficient because aahh… like the person that I am reporting to is also not a maths specialist, is just a HOD for an intermediate phase so is not a specialist for maths. So, the support that I am getting is extremely limited as far as the content is concerned. For me to get the support I must contact eehh… other teachers from neighbouring schools who are teaching the subject so, in the school, I do not receive much support.* (Appendix E: lines 132-199, PA).

> *There is no support that we are receiving from the school leaders. They only do the workshops from the Department of Education, the subject specialists help us. Here at school, they only do IQMS, and but in the end, they do not implement it. They only go to class observe your lesson and identify your challenges but, in the end, they will not help you* (Zano) (Appendix E: lines 74-76, PB).

It was evident that any support the participants received from the school's management was inadequate to meet their needs in terms of subject matter knowledge and the teaching skills required for teaching mathematics. It seems that the participants received support from the Curriculum Implementers (CI) when they attended workshops, and during school visits. Bonga confirmed that:

> *We do have the teacher development programmes [workshops] and also, we do have eehh… eehh. Subject advisors who are gradually invited by the principal and the deputy principal to come and assist in terms of making sure that what we teach is in line with that in the Annual Teaching Plan (ATP) (Appendix E: lines 105-108, PE).*

Mpho concurred with this:

> *We attend workshops. Yes, the workshop they are not benefiting us much because we simply address tackling problems concerning certain methods or calculating mathematical problems, you see. It not helping us much* (Appendix E: lines 95-97, PJ).

The teachers attended workshops for professional development. However, these were not perceived as being particularly effective as the participants confessed that they continued to experience difficulties in teaching certain topics. It was confirmed during the observed lessons that they had insufficient subject matter knowledge and inadequate didactical skills.

4.3.3 Sub-theme 1.3: Practice

Category 1: Lesson planning

The ten participants indicated that they did not plan their own lessons, but were using the Mpumalanga Department of Education's (MPDE) provided lesson plans. They explained that they made alterations to the MPDE lesson plans in order to accommodate their learners' needs, using the MPDE lesson plans as a guideline. In fact, only Thando and Thato planned their own lessons, albeit with a number of important aspects missing. In response to the question of how they planned their lessons, the participants explained as follows:

Plato said:

> *Mmmm…when planning the lessons, the Department has provided the lesson plans for all of the schools. But you know that the context of the school is not the same. Some schools are different from others and the learners are also different. So, to adapt, I use the very same textbook, which is Platinum, to prepare for the lessons and make sure that my learners understand* (Appendix E: lines 110-115, PA).

Zano said much the same:

> *We do not plan lessons; the subject specialists [MPDE] provide us with lesson plans. I only go through them, prepare myself, and go to class* (Appendix E: lines 64-65 PB)

The lesson plans that were shown for the observed lessons did not include any modification; they were taken exactly from the MPDE Workbook (see Appendix I). Even then, the participants did not follow the lesson plan while explaining the concept, and did not use the examples, activities, and teaching approaches indicated in the lesson plans. This indicates that the participants did not spend time preparing or modifying the lesson, which could be due to a lack of subject matter knowledge and interest in the subject. This, in turn, had an influence on their MTI development.

Thando explained:

> *Lesson plans we plan every week. This means every Friday we prepare for next week. But we receive the lesson plans from our Curriculum implementers (CI), then check on the ATP if they are aligned with the ATP. But we do not teach everything in their lesson plans, because we are not used to their lesson planning. Their lesson plan has activities and they have advised us that since they have prepared the lesson plans for us, we should use them* (Appendix E: lines 91-96, PC).

According to her, they were supplied with lesson plans by the MPDE CIs. However, when she showed me the lesson plan that she had prepared, it was clear that she had been using the

same lesson plan for some time. When asked for the lesson plan prior to lesson observation, she spent time looking for it in her file, then erased the date. The lesson plan was not aligned with the observed lesson.

There were several elements of the lesson plans that were missing (Appendix G, Thando): for example, her lesson plan did not include the outline of goals and objectives for the lesson, nor did it make provision for learners' prior knowledge. Additionally, her lesson plan did not describe specifics about the method she would use to teach the content. The lesson plan did not cover the detailed content knowledge to be taught. Furthermore, during the observed lesson, Thando did not present what was outlined in the lesson plan - the lesson plan was about equivalent fractions, while the observed lesson was about comparing and ordering the fractions. She did not follow her lesson plan at all.

Thato explained how he planned his lessons:

> *I use the CAPS documents since you know that the policy guides us. So, I use CAPS document, from CAPS document… Aahh I will have my textbook ready, and my workbook ready. Then for more concept eehh… more information from other teachers. That is when I will use YouTube videos on how other teachers around the world aahh are… are extracting information and how they teach the concept. I am more ICT and yahh practical when it comes to planning* (Appendix E: lines 170-175, PD)

Thato showed me the lesson plan he prepared for the observed lesson (see Figure 4.4 below). In the lesson plan, some of the elements are missing namely: the lesson objectives, learners' previous knowledge, teaching strategies, the form of assessment, and detailed information on the teacher's instruction for a specific lesson. The lesson plan did not cover the entire focus area of the presented topic (Appendix G, Thato). The teacher only explained to the learners about litres and millilitres. Notably, he did not mention kilolitres despite the fact that according to the ATP in the CAPS document, the learners should learn the three SI units. Below is a sample of Thato's lesson plan.

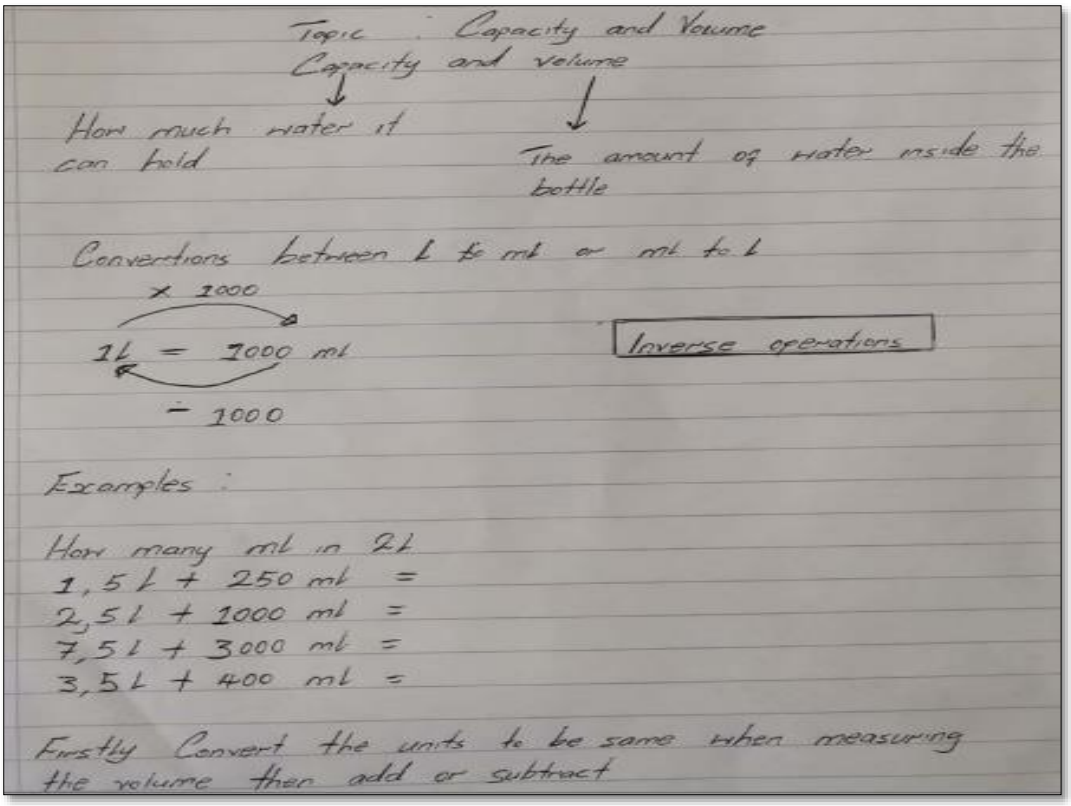

Figure 4.4: A copy of Thato's original lesson plan on capacity and volume

Category 2: Interaction with learners

The participants focused on explaining and writing on the chalkboard, and there was little interaction between the teachers and the learners. They exclusively used the method of chalk and talk. In fact, Plato declared, *"I use the old method, which is chalk and talk"* (Appendix E: line 66, PA). In the observed lessons, the participants were instructors and explainers. The learners did not ask any questions, while the teachers, acting as instructors, asked a few low cognitive-level questions. Classroom discussions were not encouraged by the teachers, and no opportunity was created to use learners' responses to ask more questions and elaborate or correct misconceptions. They used a question-and-answer method, to which only certain learners responded, resulting in the teachers answering with a yes or no, then continuing with their teaching.

4.3.4 Summary of the findings of Theme 1: the influencers of MTI development

According to the findings of this study, the participants' perspectives on mathematics were instrumentalist and Platonist. The teachers' perceptions of themselves as not being mathematics teachers, alongside of their belief that mathematics is a challenging and difficult subject, influenced their MTI development. They, in fact, demonstrated a lack of interest in the subject. In addition, they believed that mathematics teaching required more time for planning and practice, so instead they largely abandoned lesson planning, which might have aided

them in developing subject matter knowledge. They demonstrated a lack of confidence in their ability to teach the subject. Furthermore, the teachers believed that direct instruction, explaining, and the drilling of algorithms (with learners acting as knowledge receivers) was the best way to teach mathematics. The contextual factors included school context, a lack of teaching resources, learners' background, and school leaders who were not mathematics specialists. The learners only used the DBE workbooks. In summary, because the school leaders were not mathematics specialists, they were not supportive of the participants' MTI development as non-specialist teachers. The learners' backgrounds also had an effect because they lacked parental support for their schoolwork, putting additional pressure on the teachers to assist them with their schoolwork. This data revealed that the teachers' beliefs and contextual factors had a negative influence on their MTI development.

4.4 THEME 2: MTI AND ACTUALISATION

Theme 2 focuses on the non-specialist teachers' MTI development and actualisation. It is important that mathematics teachers have a well-developed MTI (Grootenboer & Zevenbergen, 2008), taking cognisance of the fact that MTI is dynamic, and continually evolves through practice (Skott, 2019). The two sub-themes that constitute Theme 2, and their corresponding categories, are as follows: Sub-theme 2.1 deals with subject matter expertise in terms of one category, namely, subject matter knowledge. Sub-theme 2.2 focuses on didactical expertise relating to three categories: evidence of understanding, teaching approaches, and flexibility and rigidity. Figure 4.5 presents a diagrammatic presentation of Theme 2.

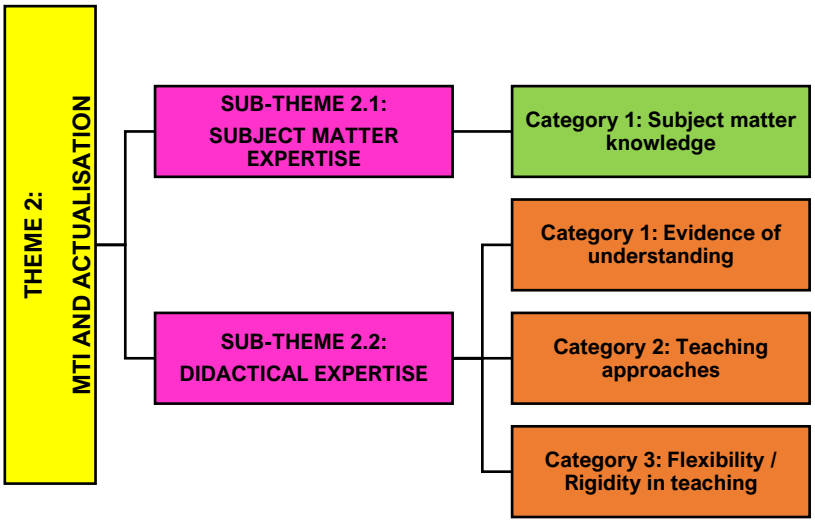

Figure 4.5: Theme 2: MTI and actualisation adapted from Beijaard et al. (2000), Ernest (1988), Thompson (2009), and van Putten (2011)

4.4.1 Sub-theme 2.1: Subject matter expertise

Category 1: Subject matter knowledge

The participants confessed that they did not have sufficient subject matter knowledge, and there were certain topics in which they experienced difficulties teaching. The participants were observed in order to determine their understanding of the concepts being taught. During the lesson observations, it was found that the participants were unable to explain the concepts thoroughly through the use of different examples and representations. They invariably taught the concepts by reading and referring to the textbook, DBE workbook, and the given lesson plan. They showed the steps, and roughly explained the algorithms to find solutions. Moreover, during the observed lessons, it was confirmed that none of the participants had sufficient subject matter knowledge as they made mathematical mistakes, presented the content incorrectly, and could not explain the concept explicitly.

The participants' perception of their subject matter knowledge was expressed in the semi-structured interviews, and demonstrated through lesson presentations. The participants were asked whether they believed that they had sufficient subject matter knowledge to teach mathematics effectively, or whether there was any content they found difficult. Below are the participants' responses and descriptions of their subject matter knowledge.

Plato's subject matter knowledge

In the observed lesson, Plato wrote the topic of the day on the board (Appendix F, Plato,24/05/21). He then tried to access the class's prior knowledge. For example, he asked the learners whether they remembered the fractions that they had done in Grade 5. He then asked them for examples of fractions. He said that they had also learned about the addition of fractions and asked them the answer to the following sum: $\frac{1}{2}+\frac{1}{2}=$. One of the learners answered by saying, "we add the ones on top which are the numerators." Plato agreed and then said that they also add the denominators, but the learners disagreed. Plato asked them why they disagreed, but no-one responded. He did not explain to them why they should or should not add the denominators. Instead, he said, "Let us not add them for now". He proceeded with examples of adding fractions with different denominators. Below are the examples he explained to the learners.

a). $\frac{1}{2}+\frac{1}{4}=\frac{2}{6}$

b). $\frac{1\times2}{2\times2}+\frac{2}{4}=\frac{2}{4}+\frac{1}{4}=\frac{3}{4}$

LCM = 2
2 = (1, 2)
4 = (1, 2, 4)

In example (a), the learners looked confused when the teacher was adding the denominators. The teacher corrected his mistake, but incorrectly explained how to find the lowest common denominator. He continued with the following examples:

c). $\frac{2}{4}+\frac{1}{8}=\frac{2\times2}{4\times2}+\frac{1}{8}=\frac{5}{8}$

LCM = 2
4 = (1, 2, 4)
8 = (1, 2, 4, 8)

d). $\frac{1}{3}+\frac{2}{9}=\frac{1\times3}{3\times3}+\frac{2}{9}=\frac{3}{9}+\frac{2}{9}=\frac{5}{9}$

LCM = 3
3 = (1, 3)
9 = (1, 3, 9)

e) $\frac{2}{8}+\frac{1}{2}=\frac{2}{8}+\frac{1\times2}{2\times2}=\frac{2}{8}+\frac{2\times2}{4\times2}=\frac{2}{8}+\frac{4}{8}=\frac{6}{8}$

LCM = 2
2 = (1, 2)
8 = (1, 2, 4, 8)

Plato incorrectly presented the content to the learners, and his presentation was indicative of his own confusion about this topic. He did not use real-life examples or representations to explain the concepts. He emphasised the requirement that before learners could add the fractions, they had to make sure that the denominators were the same. If not, they had to find the Lowest Common Multiple (LCM). Plato confused multiples with factors. He said that multiples are numbers that go into another number without leaving a remainder. He also mistakenly showed them how to find the LCM with factors, not multiples. The lesson observation thus confirmed the teacher's own statement that his subject matter knowledge was inadequate (Appendix F: Plato, 25/05/21). In the interview, he described the difficulties he had in the subject, as well as the resultant poor performance of his learners:

I do not have… enough knowledge in the subject. For example, I am still struggling to date to teach probability the last chapter in Grade 6. So, for me, it is exceedingly difficult to teach the subject. Ehh… At some point, I only teach it aahh… half of the content I am supposed to cover. Ehhm… and as a result, my learners are not performing well on the topic. It is not only probability because I do not have enough content in mathematics as a whole. Aahhmm most of the content or topic I do not cover fully. Because the other things I do not cover fully. Because of some of the things I do not know. Yes, I do consult sometimes but eehh… you know I will not be able to get all the information that I want. Yahh… I still need Ehh… to learn a lot in the subject (Appendix E: lines 40-49, PA).

Zano's subject matter knowledge

Zano professed that she did not have sufficient subject matter knowledge as she still found topics such as long division difficult to teach. During the observed lesson, it was evident that her subject matter knowledge was limited as she relied heavily on the DBE workbook and the learners' responses without any innovative contributions of her own. She did not use the learners' responses to thoroughly explain the concept; she would either reply yes or no, and then move on. Zano explained her views on this as follows:

> *I do not believe that I have sufficient subject matter knowledge to teach mathematics. And… I find the content difficult. Eehh… I found the content long division method difficult. It is exceedingly difficult to teach and also difficult for the learners to master because it is very long; it involves all the operations signs* (Appendix E: lines 27-30, PB).

Moreover, with regard to her subject matter knowledge, she stated that:

> *Is developing but still struggling. It is developing but still struggling. As… aahh… as I am still teaching the intermediate phase. I do understand some of the content but some, it is exceedingly difficult* (Appendix E: lines: 55-57, PB).

Furthermore, Zano revealed that:

> *The challenge on the lesson, during lesson presentation they ask questions that sometimes I am… (laughs) not able to answer so I have to branch. So yes… it's very difficult* (Appendix E: lines 69-71, PB).

The interview extracts show that Zano had insufficient subject matter knowledge, although, according to her, her subject knowledge had changed since she had first started teaching mathematics. The observed lesson confirmed that she had insufficient subject matter knowledge as she heavily relied on the DBE workbook examples for teaching (Appendix F, Zano, 28/05/21). Furthermore, there was no lesson plan, which could be because she did not want to make any effort to plan her own lesson, or that she either lacked interest in the subject or lacked subject matter knowledge.

Zano started the lesson by writing a problem on the board and solving it together with the learners. She made mistakes and the learners correct her. She indicated that they would work on commutative and associative properties, and therefore they should open their DBE workbook to page 106. She then explicated that they would prove that the left-hand side is equal to the right-hand side using commutative and associative properties. However, the lesson was not about commutative and associative properties. It seemed as if the teacher did

not know the associative and commutative properties herself. She wrote examples from the DBE workbook on the board, as shown in Figure 4.6 below.

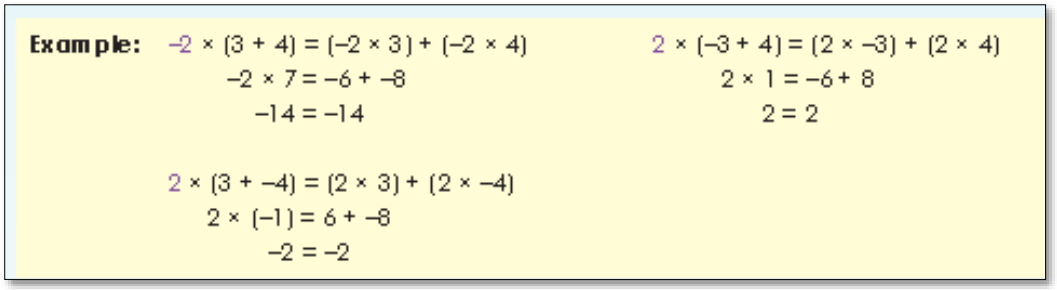

Figure 4.6: Examples to prove that the left-hand side is equal to the right-hand side

Figure 4.6 presents the example that Zano used to show the learners the algorithm to prove that the left-hand side of an equation is equal to the right-hand side. She wrote the sums on the board because she had taken in the learners' DBE workbooks and did not give them back. The learners also copied the activity into their workbooks at the end of the lesson.

The teacher asked questions to solve the problem on the board, and could not correct the learners' misconceptions when they gave a positive number instead of a negative number, she simply went on to ask another learner. One learner asked, *"Ma'am, it doesn't matter that the steps are not the same, but the answers are the same"?* The teacher said*, "Yes, at the end the results should be the same".* She could not explicitly explain the concept to the learners.

Thando's subject matter knowledge

Thando also confessed that she did not have enough subject matter knowledge and that some topics were still a mystery to her. She described:

> *When teaching mathematics, some content is difficult because now, we are teaching a new curriculum that we did not do previously. But fortunately, we do have our coordinators, which develop us to teach certain content. Yahh… there is a number of challenges like time, the topic about time, the topic about long division, the topic about the multiplication of four digits numbers by three digits. Those are the topics that are difficult for me as well as the learner. Because now we do not use the old methods that they used to do at our schools, now they use the new methods. Also, as teachers, we are trying to fit in the new methods and also need to apply those methods to the children* (Appendix E: lines 37-45, PC)

In the observed lesson, Thando started the lesson by telling the learners that they would be learning about comparing and ordering fractions (Appendix F, Thando, 02/06/21). She asked

the learners to open to page 30 in their DBE workbook, and then showed them the fraction wall in the DBE workbook. She used a loaf of bread as an example, explaining that the first strip on the fraction wall was one whole, just like a loaf of bread. She asked questions from the fraction wall, like 'what is the fraction on the second strip after 1 whole, which is divided into two equal parts', she wrote this on the board as $\frac{1}{2}+\frac{1}{2}=\frac{2}{2}=1\ whole$. The second strip on the fraction wall was divided into two equal parts, each representing a half; one half plus another half equals one whole. She explained that they would add the numerators and the answer would be two, but she did not explain why the two in a denominator remains the same and equal to a whole. She moved on to the third strip on the fraction wall, asking how many equal parts it had. She further explained that when three equal parts are added together, they are equals to three-thirds and equals a whole, $\frac{1}{3}+\frac{1}{3}+\frac{1}{3}=\frac{3}{3}=1\ whole$. She emphasised that any fraction with the same numerator and denominator would equal one whole. However, she did not explain what fractions are or why learners should only add the numerators and not the denominators.

Thando further explained to learners the comparing of fractions >, < or =.

a) $\frac{1}{6}$ $\square$ $\frac{1}{8}$

She continued using the loaf of bread as an example, explaining that one over sixth $\frac{1}{6}$ will get a bigger piece of bread compared to one over eighth $\frac{1}{8}$, and that is how we compare. Rather than explaining that the first fraction means that the strip (1 whole) has been divided into six equal parts, and the second fraction means that the strip (1 whole) has been cut into eight pieces. The fraction part becomes smaller as the strip is divided into more equal parts.

She did not explain why $\frac{1}{6}$ is greater than $\frac{1}{8}$, or why the fraction part decreased as the strip was divided into more equal parts.

She continued explaining to the learners how to compare bigger fractions, as seen in the picture below (Figure 4.7).

Figure 4.7: A picture of Thando's lesson presentation on common fractions

Thato's subject matter knowledge

Thato declared that he did not have sufficient subject matter knowledge to teach mathematics. He complained about the curriculum and teaching approach changes. He detailed that he found it difficult to teach other topics since he had lost the mathematical knowledge basis that he should have acquired in secondary and tertiary education. He had to conduct some research every day, or ask other teachers who were specialists in the subject to assist him with difficult topics.

Thato explained:

> *I cannot say that I have a sufficient subject matter, eehh… since while I was eehh… doing my first year of teaching as a maths teacher. Yahh… I was even afraid to go to class. Coming to the next year, which was in 2007. Yahh… it was a challenge after a challenge. Eehh… since even the issue of curriculum was ever changing you get use to this tomorrow it changes to another approach. So, I cannot say that I have sufficient subject matter. Since this content, the content on its own its changes now and then. Even the approaches, the strategies and also the diversity of learners that with which I am dealing. It changes year to year. Also, you can check the issue of the current technologies issues and the innovations that are going on. So, all this eehh…things that surrounds the subjects on its own. It impacts or hinders some of the opportunities of becoming a specialist in the subject. So, I cannot say I have sufficient information or quantity of matter, but I can say due to the passion that I am having yes, I am getting there* (Appendix E: lines 56-68, PD)

He also mentioned that:

> *There are some concepts, especially when you go to the eehh, go word sums to Grade 6, eehh… yahh division using the other method. We used to use the long division*

> *method eehh… it is exceedingly difficult because aahh… because I have lost some basics yahh… while I was in Secondary school and also while I was at tertiary level. Since I have never done maths. I have a gab there, then yahh it is a challenge; I have to make research every day, I have to consult every day. I have to approach even my younger… those once are coming after me, the specialists in maths. Especially the new teachers to assist me* (Appendix E: line 69-76, PD).

He believed, however, that his subject matter knowledge had grown a little compared to when he started teaching mathematics. He had acquired a *"little bit of understanding in terms of maths concept. Then I can say now, I have developed a little bit. I can say I am moderate"* (Appendix E: lines 153-155, PD).

During the observed lesson (Appendix F, Thato, 26/05/21), Thato started the lesson by demonstrating to the learners the difference between capacity and volume (see Figure 4.8). He brought 2 litre, 1,25 litre, and 500 millilitre bottles and water to illustrate capacity and volume. He explained the difference between capacity and volume, as well as the conversions between the standard units (standard units of measurement for capacity are millilitres, litres, and kilolitres), making use of a number line. He emphasised that one cannot add and subtract volumes using different SI units. He explained that firstly they had to convert the SI units to make them the same. He showed the learners step-by-step on the board how to do the conversions, then did the calculation to find the solution (see Figure 4.8). Even though Thato provided representations of volume and capacity, he did not explicitly explain and demonstrate them.

Figure 4.8: A picture of Thato showing learners algorithms to find solutions

Bonga's subject matter knowledge

Bonga admitted that when teaching, he used the subject knowledge and teaching skills that he developed while he was still a learner at school. He explained:

> *I am using my knowledge of mathematics from high school and primary school. And I am using that to teach and… aahh… there are other contents that I find difficult for example, time zones because those require eehh… you to measure with other subjects so it is somewhere somehow difficult. So, when I venture into that particular content. I am usually requesting my Grade 7 teacher to come and teach but with other content, I am now having the expertise to teach Grade 6 learners* (Appendix E: lines 29-35, PE).

In terms of his subject matter knowledge, Bonga claimed that:

> *It has developed quite a lot. Aahh…exponentially or automatically because I have been attending workshops and seminars where other teaching methods and techniques were explained and the support from the curriculum implementers (CI) and subject advisors. So currently, I developed, I am no longer the same as I have started. So, I have a lot of knowledge and a lot of skills which I can use in terms of teaching. But you will understand since it is not my area of learning. I do have some shortfalls, but I am trying somewhere and somehow, I am going to gain knowledge. And make sure that my knowledge is developed every time* (Appendix E: lines 74-81, PE).

Bonga demonstrated some subject matter knowledge as he was explaining the topic of the day to the learners; the content was presented adequately. Also, Bonga demonstrated professionalism by starting with doing corrections of the learners' previous homework, even though he did not mark the books himself.

Xoli's subject matter knowledge

Xoli claimed that her subject matter knowledge had undergone some development. She said, *"I have developed a lot, my mentor played a huge role in making me a maths teacher"* (Appendix E: lines 50-51, PF).

She also mentioned that:

> *The challenge I had was teaching long division. My mentor plays a huge role in how to explain it to my learners. And how to divide the remainder up until I get the correct answer* (Appendix E: lines 73-75, PF).

In the interview excerpts, Xoli indicated that her subject matter knowledge had developed to the point where she was comfortable with teaching long division. The lesson observation was a contradiction to her statement. She began the lesson with 10 mental maths questions on doubling and halving, and then corrected them together with the learners. During her presentation, she explained to the learners that "*double means repeating 180 + 180 = 360 and half of 428*", but she did not specify how to find the half; she simply said "*half of four, two, and eight*," and stated that "*this is how we get half of 428*". The learners were confused, and they could not get the half sums correct. She did the mental corrections, and moved on to the day's topic, which was division. She showed the learners the division algorithms as examples on the board, using the breaking down method and long division. She could not explicitly explain to the learners what division is, or the special names of the numbers in division. When Xoli asked questions and the learners responded incorrectly, it appeared that the learners were bewildered, while she was unable to thoroughly explain the content; instead, she just asked another learner or gave the correct answer. Xoli did not thoroughly explain the concept of division to the learners in a way that would allow them to comprehend it. She kept asking the learners to look at the times table in their DBE workbook when she asked a question.

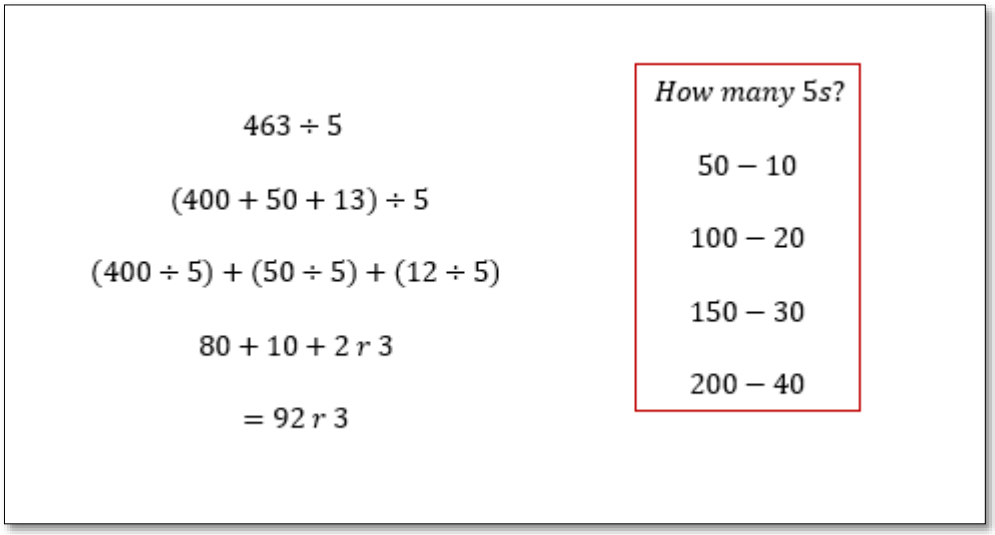

Figure 4.9*:* An example of Xoli showing learners division algorithms

When she wrote the above example on the board, she told the learners to look at the multiples of five in the multiplication table in their DBE workbook. She also counted and read aloud to them from the DBE workbook's multiplication table. She asked how many fives were indicated above, then she said they could guess how many fives fitted into 400. One learner said fifty times, which was incorrect. She did not expand on this, but instead told them the correct answer. She explained to them that five is a divisor, and three is a remainder, but not that division also includes the words 'dividend' and 'quotient'. She had only mentioned the divisor.

She was able to correctly perform the division algorithm using long division and breaking down, but she did not explicitly explain how learners could break the equation down, or the steps used in long division (that we start by dividing the dividend with a divisor, then write the quotient, then multiply the quotient with the divisor, and subtract it from the dividend and then drop the number down). Xoli did not make use of the learners' responses to explain or correct their misconceptions. She did not explain to the learners that division is the opposite of multiplication. Instead, she directed them to look at the times table in their DBE workbooks. It was clear that Xoli lacked knowledge of division. She also made mistakes when teaching, and was not confident in representing the topic as she kept looking at her textbook.

Lihle's subject matter knowledge

Lihle professed that she had no difficulty in teaching any concept. She said, *"I don't think there is a gap"* (Appendix E: line 21, PG). She further explained that her subject matter knowledge had developed a lot compared to when she started teaching mathematics:

> *It has developed a lot because now. Eehh… I am loving this subject I do not know whether one day the principal will say you do not teach this subject mathematics anymore. The way I like it now (Laughs) I love it. I like it like myself I enjoy teaching mathematics. Because you do not need to write notes, a lot of notes. You just write an equation or the problem on the board. Then try to explain to the how can do they solve that particular problem? Mmhh… Then after that, you are done* (Appendix E: lines 71-76, PG).

In the observed lesson, the above claims were disproved (Appendix F, Lihle, 31/05/21). She began the lesson with 10 mental maths questions on multiplication, and then corrected these together with the learners. After that, she asked the learners to take out their DBE workbooks and open to page 96, which was their previous homework. She started doing the corrections of the homework by asking the learners questions. The description of 3-D objects in her initial explanation was inadequate and difficult to follow: she said, *"the cylinder is curved only because it has got 2 circles on the sides which are curved, and the other side is curved"*. She kept referring to sides instead of faces.

Figure 4.10: A picture of Lihle showing learners the properties of a rectangular prism

Lihle displayed insufficient subject matter knowledge when explaining the properties of 3-D objects. She could not give real-life examples to assist learners to visualise the 3-D objects. Instead, she used a tabletop to demonstrate rectangular prism properties as in the picture above (Figure 4.10). In her presentation, the properties of 3-D objects' faces, edges, and vertices were not clearly explained. This was evident in the learners' incorrect responses to her questions. For example, when she asked how many faces were on a rectangular prism, some learners said 'two' in chorus, while others remained silent. She asked one of the learners to show the class the faces on the tabletop, but the learner only showed two of them. Lihle did not tell the learners to count all of the faces, or correct the learner; instead, she continued to ask other questions. She did not effectively use the tabletop to demonstrate the faces, vertices, and edges to the learners. She also incorrectly stated that a rectangular prism has four vertices. This also indicated that she had a limited idea of how manipulatives could be used to develop children's understanding. She incorrectly explained, *"the lines that form the shape is called edges where is a face",* which was difficult to understand, and she spoke of a *"corner"* instead of a vertex. She further explained, *"Hexagonal prism is formed by hexagons and six squares. The lines of the squares are the edge even line of hexagons is the edge".* She asked the learners to match the nets with the 3D objects in their DBE workbooks. She kept referring to shapes instead of 3-D objects. Lihle explained the difference between the prisms and pyramids as follows, *"Prisms are all the shapes that are flat on the top pyramid are all the shapes with triangles on top".* Her explanations were unclear, and the learners seemed to not understand what was being shown to them.

Lihle then asked the learners to open to page 98, a new topic: geometric patterns. She did not explain what patterns are, she simply read the DBE workbook descriptions and then asked

the learners questions from the DBE workbook. She encouraged the learners to read the description of patterns, as well as the corresponding questions from their DBE workbooks aloud. She displayed some difficulty in explaining how to find the rule or the difference between the terms. From the lesson observation (Appendix F, Lihle, 31/05/21), it was evident that she had insufficient subject matter knowledge, despite what she had claimed during the interviews. She used only the examples and activities in the DBE workbook, and did not explicitly explain the concept in a way that helped the learners to develop an understanding of the concept.

Thoko's subject matter knowledge

Thoko said that she did not experience any difficulties in teaching mathematics: *"Mmhh…I don't have any challenges with maths"* (Appendix E: line 23, PH). Referring to her subject matter knowledge, she explained:

> *It has developed by attending the workshops and also the curriculum implementers sometimes coming to our school and assist us. Or also go to our senior or colleagues in another school to assist* (Appendix E: lines 46-48, PH).

Her response was not confirmed in the observed lesson, where she demonstrated inadequate subject matter knowledge (Appendix F, Thoko, 02/06/21). Although she stated that they were going to learn patterns in the lesson, learners were only asked about the multiplication table. She did not explicitly explain to the learners what a pattern is, or how to find the rule to extend the pattern. She asked the learners low-level questions about multiplication tables and multiples. She instructed the learners to look at the multiplication table in their DBE books so that they could respond to her questions. It was evident that her subject matter knowledge was insufficient in terms of the concept she was presenting. Thoko did not explain patterns clearly to the learners, and as a mathematics teacher myself, I was also perplexed by what she was presenting because she deviated from the topic; she was unable to connect the multiplication table to patterns. She simply drew the times table on the board and asked the learners to complete the multiplication table on the board by asking them multiplication questions.

Buhle's subject matter knowledge

Buhle confessed that she did not have sufficient subject matter knowledge. She said,

> *No, there are content that I find difficult especially ratio and rate, pattern symmetry and time zone. Before I teach these topics, I first consult my other teachers who are doing mathematics in Grade 7* (Appendix E: lines 20-22, PI).

She mentioned that other topics were difficult for her to teach, requiring her to ask her colleagues who were Grade 7 mathematics specialists to assist her before she could teach other topics. She claimed that her subject matter knowledge had developed a lot compared to when she started teaching mathematics, *"It has developed a lot… aahh… a lot… a lot"* (Appendix E: line 40, PI). The observed lesson contradicted this assertion (Appendix F, Buhle, 03/06/21). Buhle taught the learners what a mixed fraction is, and how to add mixed fractions. However, she did not begin the lesson with the pupils' prior knowledge of fraction addition. She demonstrated the techniques for adding mixed fractions with the same and different denominators to the learners. She emphasised that we begin by adding whole numbers, then we check the denominators, and finally add the numerators if they are the same. She added that if the denominators are not the same, we change them and make them the same first, then add the numerators. She did not make it explicit how you make the denominators the same. She explained in an abstract way that did not help all of the learners to understand why we should multiply by three. She was supposed to create more examples of fractions with different denominators and explain how to make the denominators the same by finding the lowest common multiple.

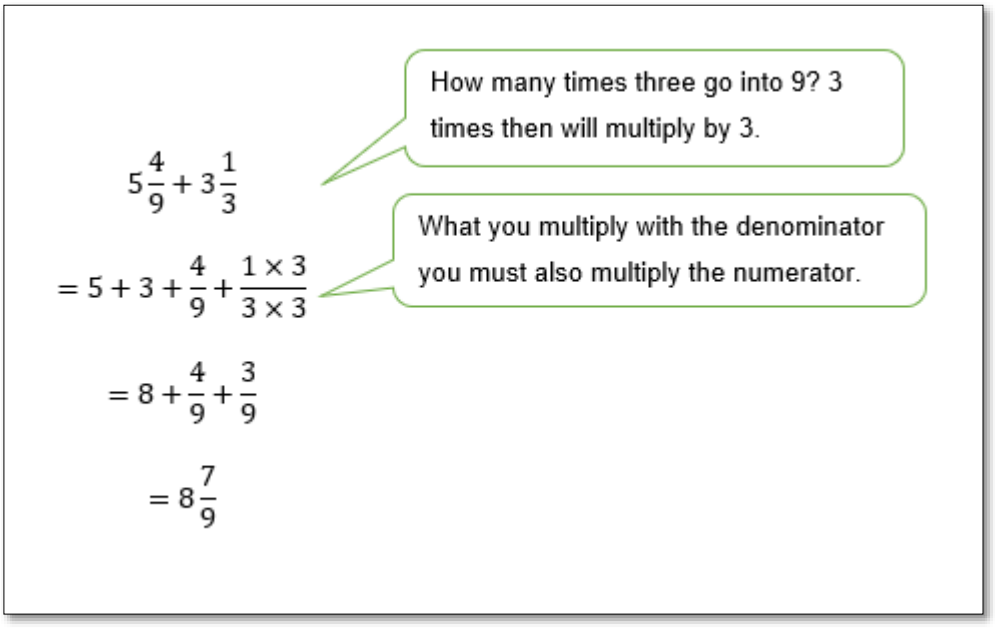

Figure 4.11: An example of Buhle showing learners algorithms for the addition of mixed numbers with different denominators

Mpho's subject matter knowledge

Mpho claimed that *"With the experience, nothing is challenging"* (Appendix E: line 48, PJ), thus asserting that she experienced no challenges in teaching any content in mathematics as

she had nine years of experience teaching mathematics. However, the above response is contradicted in the interview excerpts below. She explained:

> *Mathematics is quite an interesting subject. And there are few challenges when it comes… It depends on how much you know. So, you understand. So, in that instance, I enjoy it, but when I teach them few* (sic) (Appendix E: lines 24-26, PJ).

The observed lesson revealed that she lacked subject matter knowledge (Appendix F, Mpho, 03/06/21). Mpho explained only one example on the chalkboard, the algorithm of long division. She did not explain explicitly what division is, or how to do long division. She used one example, showing the learners the steps in long division calculations. She also instructed the learners to open their multiplication tables, which were pasted into their books, so that they could refer to them while she was teaching.

Mpho did not thoroughly explain the concept to the learners, and did not assess their understanding while teaching so that she could use their responses to further elaborate on the concept and identify any misconceptions the learners may have had. She finished the lesson by assigning the learners an activity from their DBE. A picture of Mpho teaching the concept of long division to learners is shown in Figure 4.12.

Figure 4.12: A picture of Mpho presenting a lesson on long division

4.4.2 Sub-theme 2:2: Didactical expertise

Category 1: Evidence of understanding

In this category, I discuss how the teachers assessed the learners' understanding of the content while teaching. All 10 participants used the question-and-answer method to assess

the learners' understanding while teaching. They asked low cognitive-level questions. Critical thinking, or problem-solving skills were not assessed. They concluded their lessons by giving the learners a written activity to complete. When they were asked how they assessed learners' understanding while teaching, Bonga answered as follows:

> *I do assess learners' understanding during teaching by asking questions and also giving questions verbally and also giving them classwork and we mark during the class. So, I understand that if aahh… most of the learners understand I will see by the raise of the hands and they will respond positively so that will indicate that they understand and even when I give them the classwork, they will write and get the correct answers. So that is how I assess the class and also give me knowledge do the learners understand or not* (Appendix E: lines 58-64, PE).

Zano said the same, *"In most of the time, I use classwork, question and answer"* (Appendix E: line 45, PB).

I also observed that the participants were not able to use the learners' responses to further explain the concept (see Appendix F). If the learner gave an incorrect answer, the teachers would just ask another learner, or tell learners the correct answer without asking them to explain the reasoning behind their answer to make sure they understood the concept and reasoning behind it. No problem-solving questions were implemented to monitor the learners' understanding while teaching. Instead, only a few knowledge recall questions were posed.

Category 2: Teaching approaches

During the semi-structured interviews, the participants described the teaching approaches and strategies that they used when teaching. Some showed knowledge of different teaching approaches, and that they understood that learners have different learning styles. However, during lesson observation, all the participants used a teacher-centred approach. The participants were asked to describe the approaches they used when teaching mathematics. Below are some of the participants' perceptions of the various teaching approaches, and the strategies that they claimed to use when teaching mathematics.

> *I am using the available approaches, the learners-centred approach. The learner-centred approach assists me to identify learners with challenges. It gives more opportunities to learners to self-discovery and more eehh… techniques of… of… eehh… teaching, so why I am using learner-centred is because I want learners to identify… and eehh find ways of solving problems by themselves not be feeding all the time. I am there as a teacher to guide and assist them. But most of the time, the*

> *learners themselves must be able to find new ways of calculating and find innovative solutions* (Bonga) (Appendix E: lines 48-56, PE).
>
> *I use the teacher-centred method. I only provide the learners with the knowledge and sometimes I use the learner-centred method. Because it helps me in gaining experience because some learners are very clever when they do some problems on their own. I also learn something from them* (Zano) (Appendix E: lines 39-42, PB).
>
> *We use the teacher and learner centred. This means involving me as well as the learners when you are teaching as a teacher you show them may be one example, then the second one you need to invite the class. This means we work together as a group* (Thando) (Appendix E: lines 54-57, PC).

During the interviews, Thando and Zano showed their awareness of the importance of using teacher- and learner-centred approaches for the effective teaching and learning of mathematics. They were conscious of the fact that learners have different learning styles. However, this knowledge did not lead them to using different teaching approaches, as was obvious in the observed lessons.

Buhle described her teaching approach as predominantly teacher-centred:

> *I am using the teacher-centred method because eehh… I see it is an easier method approach to the learners (Buhle) (Appendix E: lines 28-29, PI).*

Some participants described teaching strategies, not the teaching approaches used to teach. Plato said:

> *I use the old method which is chalk and talk. Aahh… I use the chalk to demonstrate sums on the board. And the learners that are [sic] how they learn. I also work with ehh… I work with the examples that are in the textbook. Then I work with the learners using the examples that are given in the textbook* (Appendix E, lines 66-69, PA).

Thoko explained why he preferred group work:

> *I group them, I take the clever one and I mix them with the slow ones to assist each other while busy writing* (Appendix E: lines 42-43, PH).

In contrast, Lihle explained that they were unable to implement group work because of COVID-19 regulations. She said:

> *Ok… the teaching approaches I usually use when teaching mathematics. The first one that I prefer is group work. But now due to COVID-19, no we are not allowed to… we must maintain the social distance. But it helps when the learners, look at the activities*

> *as a group and discuss them and help one another to solve the problem. But for now, we use the one-on-one question and answer* (Appendix E: lines 51-55, PG).

The teachers' claims in terms of their approaches and strategies were not necessarily evident during the lesson observations. This observation is consistent with the findings of van Putten et al. (2014), who found incongruence between prospective teachers' perceived and actualised PMTI in their classrooms. I can conclude that the teachers' views of mathematics as a subject, as well as their understanding of teaching and learning, influenced how they teach mathematics. The teachers all employed direct, teacher-centred instruction in explaining concepts. These teachers were predominantly behaviourists in the sense that they transmitted knowledge to learners, and the learners, as passive receivers, were required to learn algorithms to find solutions. These teachers did not provide opportunities for constructive learning where learners could construct new knowledge by building on what they already knew. Furthermore, it appeared that the teachers found it challenging to use a learner-centred approach to assist learners in understanding concepts. Moreover, the sitting arrangements facilitated a teacher-centred approach, as the learners were sitting individually or in pairs facing the teacher. The teachers did not implement any other teaching approach or learning strategy.

In an effort to gain deeper understanding of the teachers' approaches in terms of teaching-and-learning expertise, the teachers were asked how they accommodated the diverse needs of learners. Bonga and Lihle presented their thinking and practice in this regard as follows:

> *It is difficult to cater to different learners' needs. But I am trying to make sure that those learners who understand fast, I give them more work and for those who are left behind, I go to them to explain on their tables. But it is exceedingly difficult because we are having highly packed classes in this environment* (Bonga) (Appendix E: lines 70-74, PE).

> *Yahh this one is exceedingly difficult (laughs). But eehh… we are trying our level best maybe to communicate with them in English because we have a Venda or Tsonga learner inside the classroom. If we communicate in English, it becomes easier for them to understand* (Lihle) (Appendix E: lines 65-68, PF).

In the interview excerpts, Bonga and Lihle declared that it is extremely difficult to accommodate the diverse needs of learners because of the challenge of overcrowded classes, and language problems. These were evident in all of the lesson observations. The participants were not able to accommodate diverse learning styles, and only a few advanced learners responded when they asked questions, after which they continued teaching without identifying whether the other learners understood. In addition, none of the participants used

representations or real-life examples to enhance the learners' understanding. Only Thato used empty containers and water to demonstrate the difference between capacity and volume.

Category 3: Flexibility or rigidity in teaching

In the observed lessons, the teachers relied heavily on the DBE workbook, textbook, and lesson plan, which relates to rigidity of teaching. The teachers did not demonstrate flexibility in their lesson presentations as they did not encourage learners to ask questions. They used direct instruction where the learners only listened to them and responded to their questions. They used a question-and-answer strategy, and when the learners responded, they would either say yes or no, or tell the learners the correct answer. They did not pose follow-up questions to understand the reasoning behind the learners' answers. In addition, the participants did not use the learners' responses to further explain the concept or correct any misconceptions that they may have had; nor were any discussions created that would allow the learners to participate actively in gaining a deeper understanding of the concept (See Appendix F).

4.4.3 Summary of the findings of Theme 2: MTI and actualisation

During lesson observations, it appeared that the participants lacked subject matter knowledge as they made many mistakes, were uncertain about the concept they were presenting, relied heavily on the textbook and DBE workbook, and had difficulty explaining the concepts explicitly. The lesson observations confirmed what Spaull (2013b, p. 5), very simply, states, "teachers cannot teach what they do not know". The participants used a teacher-centred approach, and did not attempt the use of a learner-centred approach, real-life examples, representations, class discussions, or an exploration of mathematics concepts. The participants were not able to accommodate the diverse needs of learners while teaching. They demonstrated only traditional teaching with fixed rules - direct instruction with simple question-and-answer methods, resulting in few learners actively participating in the lessons. The development of problem-solving skills was not facilitated. It was also obvious that there was a lack of constructivist learning, including classroom discussions with questions posed on different cognitive levels. Quiet learners were not encouraged to answer (or ask) questions, which would have aided the teachers to determine if these learners understood the concept. The participants generally demonstrated both a lack of knowledge of the concepts they were teaching, and a lack of confidence in teaching mathematics. In each of the cases, there was unambiguous evidence of insufficient subject matter knowledge and didactical skills.

4.5 SUMMARY

During the inductive data analysis of the interviews, four categories emerged from the data. These were essential to provide a clear picture of the research phenomenon: the influencers of non-specialist MTI development through practice. In terms of sub-theme 1.1: Teacher beliefs, there were two categories that emerged - view of self as a mathematics teacher, and confidence. Furthermore, one category emerged in sub-theme 1.2. - contextual factors, which concerned the learners' background. A single category emerged from the inductive analysis of data on theme 2: MTI, and actualisation. In Sub-theme 2.1: subject matter expertise, one category, subject matter knowledge, emerged. It explained the teachers' subject matter knowledge in relation to their MTI development in this study.

4.6 CONCLUSION

This chapter presented an analysis of the data collected from 10 Grade 6 non-specialist mathematics teachers from rural schools in South Africa. The data obtained during the semi-structured interviews, lesson observations, and document analysis were presented based on the emergent categories. These were later grouped according to predetermined sub-themes and themes. The study's findings were substantiated with quotations from the semi-structured interviews with the participants, as well as the data collected from the lesson observation and document analysis of lesson plans. All of this was done with a view to enhancing the study's credibility. Detailed findings on the MTI development of each participant's visual representation summaries are presented in Appendix H. In Chapter 5, I give my interpretation of the findings against the backdrop of the existing literature. In addition, I provide answers to the research questions that guided this study, followed by the contributions thereof to the field of knowledge, as well as the limitations, recommendations, and the conclusion of the study.

CHAPTER 5 DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter, I first provide a summary of the chapters, followed by answers to the research questions that guided this study in line with the literature, and the contribution to existing knowledge from the data. Furthermore, this chapter presents the study's contribution to the field, as well as its limitations, and recommendations for practice and future research.

5.2 SUMMARY OF THE CHAPTERS

In Chapter 1, the background and context of the study were presented. This study explored the development of non-specialist mathematics teachers' subject matter knowledge and didactical expertise through practice. The research rationale was discussed, the main research question and three research sub-questions were formulated, and the key concepts were defined. The methodological considerations and possible contributions of the study to the body of knowledge were discussed.

In Chapter 2, I gave an in-depth review of the relevant literature underpinning this study, and critically reviewed the literature on PTI, MTI, the link between MTI and beliefs, MTI influencers, and the development of non-specialist mathematics teachers. I also discussed non-specialist mathematics teachers in general. Lastly, the theoretical frameworks on mathematics teacher identity, and this study's conceptual framework were discussed.

In Chapter 3, a description of the research methodology employed in this study was presented. The interpretive paradigm, as well as the use of a qualitative approach and case study design were discussed. I then shed some light on the sampling methods utilised, the sample being 10 Grade 6 non-specialist mathematics teachers. The data collection methods, which were semi-structured interviews, lesson observations, and a document analysis of lesson plans were then discussed. Finally, the data analysis, quality criteria, ethical considerations, and possible limitations of the study were discussed.

In Chapter 4, the data analysis was mainly deductive, and the findings were presented in accordance with the study's conceptual framework. Transcripts of the interviews were coded and analysed according to the predetermined themes and categories from the literature and the conceptual framework. As such, codes and other categories that emerged from the data obtained during the semi-structured interviews, lesson observations, and document analysis of the lesson plans were presented.

5.3 VERIFICATION OF THE RESEARCH QUESTIONS

The discussion of the results will be structured according to the research questions that guided this study. These answers describe the participating non-specialist mathematics teachers' subject matter and didactical expertise development.

5.3.1 Sub-question 1: How can the beliefs that non-specialist mathematics teachers have about mathematics as a subject, and its teaching and learning, change through practice?

The participants' beliefs regarding the nature of mathematics, and teaching and learning, did not change through practice. They clung to mathematics beliefs acquired during their schooling experiences as learners because they were not prepared to teach mathematics at post-secondary school level. During the interviews, the participants expressed their beliefs about the nature of mathematics as being a practical and difficult subject, requiring much practice and planning compared to other subjects. These beliefs were observed through their teaching practice where they used the chalk-and-talk method; direct instruction; explaining the concepts step-by-step; and concept learning through listening, memorisation, and drilling, with no connection between mathematics and real-world examples. The participants, unknowingly, applied the Behaviourist Theory of Learning in which they transmitted knowledge to the learners, who passively received it. The reason for this could be that, as the participants claimed, they did not see themselves as mathematics teachers, demonstrating a lack of interest in the subject despite having taught it for several years. These findings support those of Westaway and Graven (2019, p. 35), who find that teachers uphold their old beliefs about mathematics and its teaching and learning, such that "mathematics is 'difficult' or 'not for everyone', 'mathematics is about taught procedures', procedures are learned by 'listening and following clear explanations". Furthermore, it was discovered in the current study that the participants had two types of mathematical perspectives: seven teachers had an instrumentalist view, and three teachers had a Platonist view (Beswick, 2012; Ernest, 1989). These perspectives were thus in line with their practices.

The findings of this study show that the teachers' beliefs had a great influence on the teaching approaches and learning strategies used in their classrooms. During the interviews, the participants expressed their belief that mathematics is a difficult subject. This was evident in their lesson presentations as they simply used a teacher-centered approach and direct instruction, and taught mathematics as a set of rules that learners had to master. There was no emphasis placed on the development of understanding of the concept being taught. These findings are consistent with that of prior research claiming that there is congruence between

mathematics teachers' beliefs and practices (Polly et al., 2013; Stipek et al., 2001). The findings from the observed lessons confirmed those of Stipek et al. (2001), who show that teachers who hold traditional beliefs use traditional practices in their classrooms. As such, these teachers' practice emphasises performance, learning procedures, and getting correct answers, as well as learners' reliance on the teacher. The present study's findings also confirmed Ernest's (1988) claims that teachers' beliefs have a significant impact on mathematics teaching and learning. In addition, Zhang (2022) concurs, finding that teachers' beliefs influence their teaching approaches in the mathematics classroom, as well as their perceptions of learners' mathematical understanding.

The participants in this study can also be categorised as subscribing to transmissive learning, or possessing beliefs related to a content-focused approach. This was obviously the case as these teachers' teaching was based on imparting knowledge to learners, who should be able to repeat it (Voss et al., 2013). Furthermore, this study supports the findings of Westaway and Graven (2019), which indicate that many South African mathematics teachers are reluctant to accept the new teacher's roles by adopting a social constructivist approach. Instead, they continue to reproduce the old systemic roles through how they express their teacher identities while teaching mathematics.

Although it was not the objective of this research to explore whether non-specialist teachers are confident in their ability to teach mathematics, six participants (Plato, Zano, Xoli, Lihle, Thoko, and Mpho) demonstrated a lack of confidence during the lesson observations, and four participants (Thando, Thato, Bonga, and Buhle) demonstrated confidence in presenting their lessons. Nine participants were unable to accommodate the diverse needs of learners by using representations to thoroughly explain the concept to the learners, with the exception of Thato. The findings of this study are consistent with that of previous research, which has shown that non-specialist mathematics teachers lack confidence in their lesson presentations, and are unable to meet the diverse needs of their learners (Apau, 2022; Du Plessis, 2019; Hobbs & Quinn, 2021). The findings of this study corroborate those of Goos and Guerin (2022) and Lane and Ríordáin (2020), who find that non-specialist teachers use a teacher-centred approach when teaching because they lack confidence, and are less comfortable using other approaches that may invite learners to go beyond the teachers' subject knowledge.

Furthermore, three of the 10 participants claimed to have sufficient subject matter knowledge; nevertheless, the lesson observations contradicted their claims because they demonstrated a lack of subject matter expertise. Three participants reported using a teacher-centered method, four others said that they used a learner-centered approach. Thato claimed to use a demonstrative approach, and Thando and Zano stated that they used both learner-centered

and teacher-centered approaches. Although they described various methods of teaching, they all employed a teacher-centered approach in their practice. This research supports the findings of van Putten et al. (2014), who discovered a discrepancy between teachers' perceived and actualised MTI in the classroom.

In conclusion, the findings of this study show that the participating non-specialist teachers' beliefs about the nature of mathematics, as well as mathematics teaching and learning, were influenced by their own experiences as learners,. These beliefs had not changed, as they continued to view mathematics as a practical and difficult subject, and use traditional teaching methods in their classrooms. Furthermore, it was shown that these non-specialist teachers' MTI development was influenced by their beliefs about mathematics as a subject, and mathematics teaching and learning.

5.3.2 Sub-question 2: What contextual factors influence non-specialist mathematics teachers' MTI development through practice?

The findings of this study show that the MTI development of non-specialist teachers is influenced by several contextual factors, namely: the school context and resources, learners' background, and school leaders' support, which are discussed further below.

5.3.2.1 School context and resources

The findings of this study revealed that the context of rural schools was not conducive to the effective MTI development of non-specialist teachers. I also discovered that there is a shortage of mathematics teachers in schools as some teachers taught mathematics from Grade 4 to 7, owing to unequal distribution of teachers in rural or low socio-economic level areas (Long & Wendt, 2019; Motala & Carel, 2019). Some of the schools had old, broken furniture; a shortage of resources; and poor infrastructure and sanitation. The lack of necessary teaching and learning resources could be due to a lack of funds. The teachers only used the DBE workbooks, textbooks, and chalkboards for lesson representations; they did not use any teaching aids. Thato was the exception in this regard as he was inventive and brought empty bottles and water to represent capacity and volume. The findings of this study are consistent with those of previous research in that schools in remote rural areas of South Africa, particularly in the Mpumalanga province, have inadequate facilities, poor infrastructure, poor sanitation, overcrowding, and a lack of resources (Du Plessis & Mestry, 2019; Jele, 2022; Spaull, 2019).

Furthermore, I discovered in this study that the school context had a negative impact on the MTI development of these non-specialist teachers. This is in line with research conducted by

Van Lankveld et al. (2017), who claim that context plays a crucial role in the construction of teacher identities because it can either assist or hinder teacher identity development. In addition, this research supports Hobbs' (2013) conclusion that for non-specialist teachers to adapt to a new subject, the school environment must be conducive to them making the necessary adjustments to their subject knowledge and perception of themselves as mathematics teachers. Moreover, the outcomes of this study are congruent with Apau's (2022) statements that the surroundings and context of a school can influence the experiences of non-specialist teachers.

5.3.2.2 The learners' background

This category emerged from the participants' interview data analysis, and was confirmed through Thando and Lihle's lesson observation. The learners were disobedient and disruptive while the teachers were teaching; one learner even slept in class. Some of the participants raised the issue of learners not doing their schoolwork because of their family backgrounds and lack of parental support. This could be due to learners being neglected by their parents, being orphans, living with grandparents, and some growing up in child-headed families. This put a lot of pressure on these teachers, who had several roles to play in the lives of their learners, including a loco-parentis role. However, this study showed that teachers' MTI development was less affected by the learners' background than other factors.

5.3.2.3 Support from school leaders

It was discovered that three of the participants lacked assistance from school leaders (such as their mathematics HoDs), because the HoDs themselves were not mathematics specialists. This had a detrimental impact on their MTI development because they lacked subject matter expertise, as well as didactical skills. Furthermore, there was no mathematics HoD in Bonga, Buhle, Thoko, or Mpho's schools; instead, there was only a principal. As such, it was impossible for these principals acting alone to support the non-specialist mathematics teachers. Xoli, Thato, and Lihle, alternatively, had mathematics HoDs and claimed to have gotten support from them in developing subject matter knowledge. Additionally, all of the participants stated that they received support from curriculum implementers or subject advisers when they attended workshops. Nonetheless, this was insufficient because they only attended one session per term, with limited time allocated to each session. There are four terms per year, so the teachers attended four workshops per year in order to prepare them for the topics that would be covered in that term. Hobbs and Törner (2019) concur with this, explaining that rural areas have fewer support mechanisms available due to a lack of subject specialists. In support of the preceding findings, Hobbs' (2013) study asserts that a support mechanism is critical to the professional development of non-specialist teachers because it

increases the possibility of boundary-crossing. Apau's (2022) research highlights that providing non-specialist teachers with adequate support can help them to improve their teaching practices in the classroom. I agree with the previous research findings, emphasising the necessity for support from school leaders. Nanna et al. (2021) add that not only non-specialist teachers, but all primary school mathematics teachers require instructional support.

According to Du Plessis (2016), leadership actions and attitudes have been identified as important factors influencing the practice of non-specialist teachers. I discovered in this study that other school leaders provided little or no support to these non-specialist teachers because the leaders themselves lacked the necessary subject matter expertise. Furthermore, the study revealed that the participants were neglected by school leaders because they were aware of the difficulties they faced as non-specialist teachers, but did nothing to address them. In support of the findings of this study, Ní Ríordáin et al. (2022, p. 256) state that "professional isolation is a significant concern for out-of-field teachers if they do not have support from school leaders". Therefore, support from school leaders can be critical in the development of non-specialist teachers' MTI (Lane & Ríordáin, 2020; Ní Ríordáin et al., 2022). In conclusion, the findings of this study revealed that the school context, a lack of resources, and a lack of support from school leaders had a negative influence on the development of non-specialist mathematics teachers' MTI.

5.3.3 Sub-question 3: How does the practice of non-specialist teachers influence their MTI development?

The participants in this study did not prepare their lesson plans; instead, they used the lesson plans provided by the MPDE without making any modifications to meet the needs of their learners, or to demonstrate that they had studied the lesson plan. This was the case with exception to Thato and Buhle, who prepared their lessons; however, they had difficulty preparing their lessons because they lacked subject matter knowledge. Moreover, certain aspects of the lesson plan were missing, including the introduction, lesson goals, prior knowledge, and teaching approaches to be used. The findings of this study are consistent with those of Apau (2022), who maintains that non-specialist teachers have difficulty preparing lessons, assessing learners, and managing their classrooms. Chan and Yung (2018) reveal that teachers' lack of subject matter knowledge can influence the lesson planning of a new topic, possibly due to a lack of prior knowledge on which the new topic must be built. These results from the literature support the findings of this study, in particular, that these non-specialist mathematics teachers could not prepare effective lesson plans due to inadequate subject matter knowledge.

During the lesson observations, I discovered that the teachers only adopted a teacher-centered approach, despite some mentioning during the semi-structured interviews that they used both teacher and learner-centered approaches. The participants did not use teaching approaches that allowed the learners to actively participate in the construction of their mathematical knowledge and understanding of the content; they were also unable to engage the learners in high cognitive-level discussions. Additionally, I observed that the teachers spent little time explaining concepts, asked a few low cognitive-level questions, had limited interaction with the learners, and did not facilitate classroom discussion to improve learners' conceptual understanding. Additionally, they did not thoroughly explain concepts using different representations or real-life examples. They were merely conveying the topic to the learners and demonstrating how to solve mathematical problems. The interaction between the teachers and the learners was limited because they were using direct instruction, and had difficulty assessing the learners' understanding of the concept while teaching. The present study's findings are consistent with those of Goos and Guerin (2022), which state that non-specialist teachers are incapable of actively involving learners in developing conceptual understanding, engaging in problem solving, and providing opportunities for learners to learn at more than one cognitive level. This study's lesson observations support Caldis' (2017) claim that non-specialist teachers demonstrate poor classroom practices. Furthermore, these findings are aligned with Hughes et al.'s (2019) finding that primary school teachers who are anxious about mathematics are more likely to use traditional teaching methods and spend less time teaching mathematics. This is because they are afraid that learners may ask them about something to which they do not have the answers. This was confirmed in my interview with Zano as she told me that learners sometimes posed difficult questions that she was unable to answer.

Furthermore, the observed lessons corroborate Vale et al.'s (2021) findings that developing educational approaches that emphasise understanding and problem solving, as well as learner-centred approaches, is not something that a non-specialist teacher can do quickly or easily. However, it can be done over time with the assistance of colleagues. In addition, this study aligns with Bosse and Törner's (2015) explanation that when a teacher lacks professional knowledge, even if they are experienced non-specialist mathematics teachers, they focus on procedures and calculations as a practice strategy rather than conceptual knowledge development. This implies that subject matter knowledge is critical for MTI development.

Despite this, research has shown that practice is essential for the development of subject matter knowledge and didactical skills as part of MTI (Grootenboer & Edwards-Groves, 2019; van Putten et al., 2014). Studies have further shown that MTI develops in the school context

through interactions with learners, colleagues, and teaching and learning resources (Darragh, 2016; Pipere & Mičule, 2014; Richter et al., 2014). In this study, however, the non-specialist teachers' MTI did not develop through these interactions because they demonstrated a lack of subject matter knowledge and didactical skills during the lesson observations. It could be argued that the identity of non-specialist mathematics teachers cannot be developed purely through practice, especially when they lack the background knowledge and skills provided in mathematics teacher development programmes. Kovács and Kálmán (2022) claim that MTI development requires professional training and practice; this was observed in this study. Skott (2019) goes on to say that after teacher training, teachers can only continue to develop their MTI through practice and multiple engagements in practice. This includes when teachers prepare, present, and reflect on lessons and assessment tasks, as well as through professional interaction with learners and colleagues.

5.3.4 Main research question: How do non-specialist mathematics teachers' subject matter knowledge and didactical expertise develop through practice?

It was found in this study that non-specialist mathematics teachers' MTI does not develop meaningfully through practice since it was observed that the participants lacked subject matter knowledge and didactical expertise. This was confirmed in the observations as they made numerous errors during their explanations, were unable to explain concepts explicitly, only used a teacher-centred approach, were unable to assess the learners' understanding while teaching through meaningful questioning, and were incapable of accommodating the diverse needs of learners. Furthermore, it was clear during the lesson observations that they lacked a thorough understanding of the topics such as number patterns, comparing and ordering fractions, the addition of fractions and mixed numbers with a different denominator, 3-D objects, the division of three digits by one digit. The concepts were presented in an inadequate manner due to a lack of subject matter knowledge and didactical skills. Moreover, during the interviews, Plato, Zano, Thando and Bonga confessed to having insufficient subject matter expertise, and having difficulty teaching other topics such as those indicated above. These results support earlier findings in the literature that non-specialist teachers lack in-depth subject matter knowledge and didactical skills (Du Plessis, 2019; Hobbs & Törner, 2019; Lane & Ríordáin, 2020; Ní Ríordáin et al., 2022). Additionally, this study's findings support the findings of Ríordáin et al. (2017), who discovered that non-specialist teachers promote many conceptual errors, indicating inadequate subject matter knowledge and difficulties with curriculum content. Ní Ríordáin et al. (2022) claim that non-specialist mathematics teachers are unlikely to gain personal resources such as knowledge expertise or professional identity features on their own; this was confirmed in the present study. Thus, the findings of this study

allow the reader to understand the importance of in-service professional development programmes for non-specialist mathematics teachers for the effective development of their subject matter knowledge and didactical expertise. This is consistent with the research results of Crisan and Rodd (2017), Faulkner et al. (2019), Goos and Guerin (2022), and Goos et al. (2021).

The findings of this study also support the claim that mathematics is a specialised subject (Botha, 2011), and that mathematics specialist teachers obtain knowledge of the different instructional approaches through their teacher training. This is required to teach the content proficiently and support the learners' learning alongside their understanding of the content (Hobbs & Torner, 2019). Thus, mathematical knowledge and teaching skills cannot be acquired solely through practice (Ní Ríordáin et al., 2019), making it evident that knowledge is power. This implies that a professional development programme for mathematics teachers is necessary before MTI can continue to develop through practice (Skott, 2019). As a result, developing subject matter and didactical expertise through teaching necessitates in-depth knowledge (Cross Francis et al., 2018). The participants had been teaching mathematics for several years, but their MTI had not developed meaningfully. Furthermore, the current study's findings are consistent with those of Smith et al. (2022), who discovered that teachers' years of teaching did not help support their development of subject matter knowledge. Furthermore, as found by Nixon et al. (2017), subject matter knowledge does not change significantly from the first to the fifth year of teaching. In fact, Nixon et al. (2017) argue that subject matter knowledge may take a very long time to develop through practice. A reason for these teachers' deficit in this area could be that they lacked the interest to learn the subject, and had hoped that they would be assigned to teach their specialised subjects in the future. This was evident from my interview with Plato in which he told me that he was not pleased about teaching mathematics, and that he was promised that he would be changed back to teaching languages, but this did not happen.

The study's findings support the previously stated findings in the literature by demonstrating that non-specialist teachers' experiences vary depending on the number of years they have taught mathematics. In this study, I discovered that non-specialist teachers with two to five years of experience in mathematics appeared to struggle with subject matter knowledge and didactical skills, and had a lack of confidence in their abilities. Teachers with six to 15 years of experience in mathematics teaching began to gain confidence, and there was a bit of MTI development, but nothing meaningful as they still found it difficult to explicitly teach the concept and use different teaching approaches. Nonetheless, their practice was very different from that of those with two to five years of experience.

In this study, the teachers' beliefs were discovered to be a significant influencing factor in the development of their MTI. In the interviews, the participants expressed their beliefs regarding the nature of mathematics, as well as the teaching and learning of mathematics. The participants believed that mathematics is a challenging subject that needs more practise. Because of these beliefs, the participants had developed a negative attitude toward mathematics, and had lost interest in mastering subject matter knowledge and didactical skills. As indicated earlier, several studies have found a relationship between teachers' beliefs and practice (Polly et al., 2013; Stipek et al., 2001). Similar findings emerged in the current study, which is consistent with mathematics teacher's beliefs as described by Beswick (2005), Ernest (1988), and Van Zoest et al. (1994). Furthermore, the findings of the present study showed that the teachers' beliefs had a negative influence on the development of their MTI through practice.

5.3.5 Summary of answers to the research questions

Table 5.1: Summary of the answers to the research questions

	Questions	Answers
Main research question	How do non-specialist mathematics teachers' subject matter knowledge and didactical expertise develop through practice?	This study's non-specialist mathematics teachers demonstrated that subject matter knowledge and didactical expertise were not developed meaningfully through practice. Their lack of subject matter knowledge and didactical expertise were evident through their lack of confidence; lack of, or incorrect lesson planning; numerous mistakes while presenting the content; inability to explain the content explicitly; only asking low cognitive-level questions; and only using a teacher-centred approach.
Sub-questions	1. How can the beliefs that non-specialist mathematics teachers have about mathematics as a subject, and its teaching and learning, change through practice?	The non-specialist teachers' perspectives on mathematics were Instrumentalist and Platonist. The teachers' beliefs did not change through practice, and it influenced their teaching methods and understanding of mathematical teaching and learning. The teachers held onto their old beliefs that mathematics is a difficult subject, not only for them, but also for the learners. This caused it to take them more time to plan and practice than for their other subjects. They believed in teaching mathematics through direct

	Questions	Answers
		instruction, focus on procedural knowledge, and using fixed rules. The emphasis is therefore on knowledge transmission, learning mathematics through receiving knowledge and following steps or procedures, as well as memorizing facts, rote learning, and drilling. As a result, the teachers' beliefs had a negative impact on the non-specialist teachers' MTI development.
	2. What contextual factors influence the non-specialist mathematics teachers' MTI development through practice?	The study found that the school context and resources; the learners' background; and lack of support from school leaders had a negative impact on their MTI development. The school context was characterised by inadequate infrastructure; a scarcity of teaching and learning resources; and overcrowding. Six participants indicated that their HoD could not support them because they were not mathematics experts; three participants did not have an HoD, and only had a principal; and only three participants indicated that they received support from their school leaders. This study found that the school context; a lack of resources; a lack of support from school leaders; a lack of learners' discipline in class; and disruptive behaviour all had a negative influence on the development of these non-specialist teachers' MTI.
	3. How does the practice of non-specialist teachers influence their MTI development?	The participating non-specialist mathematics teachers only used a teacher-centred approach. They heavily relied on the DBE workbook and textbooks while teaching, simply following examples from the textbook to explain concepts to the learners, and showing them how to solve mathematics problems. Because the teacher used direct instruction, there was very little interaction between the teachers and their learners. They were concerned with learners memorising or mastering procedures rather than developing conceptual understanding. An inability to actively

Questions	Answers
	engage learners in active learning and accommodate the diverse needs of learners was also observed. The questions asked were of a lower cognitive level, and did not encourage critical thinking. The participants were unable to prepare their own lesson plans. Only two participants presented me with their own lesson plans, but other lesson plan aspects were missing; six participants presented me with MPDE provided lesson plans that had no evidence of modification; and the final two had no lesson plans at all.

5.4 CONTRIBUTION OF THE STUDY

The results of this study have shown that the non-specialist mathematics teachers' subject matter knowledge and didactical expertise had not developed meaningfully through practice. These results extend to the existing body of knowledge by providing empirical evidence that supports the notion that non-specialist mathematics teachers' subject matter knowledge and didactical expertise cannot develop solely through practice (Ní Ríordáin et al., 2022; Ní Ríordáin et al., 2019). Therefore, the study concludes that it is appropriate to consider in-service professional development programmes for effective subject matter knowledge and didactical expertise development. It is assumed that mathematics at intermediate level is easy, and anyone can teach it; however, this is not the case because mathematics teaching in this phase is crucial as it is where the foundation is laid for so many basic mathematics concepts.

It was also discovered that the teachers' beliefs about the nature of mathematics and about its teaching and learning cannot merely change through practice. These beliefs are developed and grounded over many years through their experiences as mathematics learners in school (Handal, 2003; Zakaria & Musiran, 2010). As a result, changing the teachers' beliefs is difficult (Westaway & Graven, 2019), and it has been found to have an influence on their MTI development (Grootenboer, 2006). Muhtarom et al. (2019) also indicate that pre-service teachers' beliefs influence their teacher development.

The results also add to the existing body of knowledge by providing empirical evidence that these teachers' beliefs had a negative influence on their MTI development. This further shows that there is a definite need for in-service professional development programmes that will focus on changing the non-specialist mathematics teachers' beliefs about the nature of mathematics

as a subject, and mathematics teaching and learning. Such training will also improve these teachers' subject matter knowledge and didactical skills.

In addition, this study has added to the existing body of knowledge regarding contextual factors that have a negative impact on non-specialist mathematics teachers' subject matter knowledge and didactical expertise development through practice, namely: the shortage of resources; and the lack of support from school leaders. It clarifies how the lack of support from school leaders negatively influenced their MTI development. Furthermore, there is a need for an in-service professional development programme for school leaders on how to support the non-specialist teachers in their schools (Apau, 2022; Hobbs, 2013; Lane & Ríordáin, 2020; Ní Ríordáin et al., 2022), with a focus on subject matter knowledge and didactical expertise development. Moreover, it is concluded that this study has contributed to the body of knowledge on the exploration of factors that influence non-specialist teachers' MTI development, particularly within Mpumalanga rural primary schools.

5.5 LIMITATIONS OF THE STUDY

The first limitation of this study is that the findings cannot be generalised because it is a case study with a small sample size of teacher participants. The small sample size was intentional in order to obtain in-depth data. This proved to be valuable in gathering rich information, and developing a thorough understanding of the research phenomenon. However, this small sample size cannot give a picture of the situation pertaining to other non-specialist mathematics teachers across South African schools. Secondly, there was a limitation in the theoretical framework; this study only focused on the two aspects of subject matter expertise, and didactical expertise instead of three aspects, as according to the Beijaard PTI model (Beijaard et al., 2000). This was done as the interest of the study lay in the teachers' development of mathematical knowledge for teaching.

Thirdly, there was a further limitation in terms of the way in which I collected the data and how I analysed it. The teachers' subject matter knowledge and didactical expertise were based on self-reports from the participants in one semi-structured interview, one lesson observation, and a document analysis of one lesson plan per teacher. In addition, the fact that only one lesson was observed per participant does not give a full picture of the teachers' subject matter expertise and didactical expertise. The document analysis of the lesson plans did not provide enough data because only two participants had planned their lessons. Six participants presented me with the lesson plans they had received from the MPDE, and two participants did not present any lesson plan at all. In addition, the learners' understanding of what was

taught, and learner performance, per se, were not investigated since the purpose of the study was to understand the MTI development of Grade 6 non-specialist teachers.

The participants expressed their fear of being audio and video recorded as they felt that they would be exposed, despite my assurances to the contrary. It was thus difficult to find non-specialist mathematics teachers who were willing to participate and be recorded. As a result, for the lesson observations, I only recorded the part where they were presenting the content, and had to stop recording after that because they were uncomfortable with the recordings. I was unable to observe all of the participants teaching Grade 6 mathematics due to the arrangement of learners' rotations in compliance with COVID-19 regulations, and due to time constraints for me to collect the data. The Grade 6 non-specialist mathematics teachers were teaching all of the grades in the intermediate phase (Grade 4 to 6), and Grade 7 as there was a shortage of mathematics teachers, and the learners were not going to school every day. However, three participants were observed teaching Grade 5, and one participant was teaching Grade 7, while six participants were observed teaching Grade 6 classes. Those participants who happened to be teaching Grade 5 and 7, and not Grade 6, on the observation day that we had agreed upon were nevertheless observed. This was based on the assumption that their professional identity would also be manifested in the Grade 5 and 7 classes. Despite adjusting the data collection plan, this study took longer than was planned because I was not able to collect in-class observation data during the COVID-19 lockdowns. Other factors that contributed to the limitations of this study were the distance between the schools located in the province. Additionally, because of the constraints imposed by the COVID-19 pandemic situation, the classes were divided into small numbers of learners due to social distance regulations and the resulting seating arrangements. If this was not the case, I could have possibly observed teachers using other teaching approaches where learners were more involved in the lessons.

Lastly, I was subjectively involved in analysing the data, and my personal experience and knowledge may have influenced the findings. This, however, was mitigated by using different data collection techniques to enhance the credibility of the study through triangulation. Despite the limitations of the study, below, I discuss the recommendations for practice and further research based on the study's findings.

5.6 RECOMMENDATIONS FOR PRACTICE

This study has revealed that there is a limited possibility that non-specialist mathematics teachers can develop their MTI through practice. During the lesson observations, the participants displayed insufficient subject matter understanding by making several errors and

failing to explain the concepts explicitly and adequately. I recommend that when teachers are allocated to teach mathematics, and they have not trained for this at a tertiary level, they should be provided with in-service professional development programmes so that they can develop their subject matter expertise and didactical expertise. Ní Ríordáin et al. (2019) recommend that non-specialist mathematics teachers should be provided with the appropriate professional development opportunities to acquire mathematics knowledge and skills (Ní Ríordáin et al., 2019), thus confirming my recommendation. Furthermore, for effective MTI development, the professional development programme should also focus on the integration of teachers' beliefs into professional development programmes. This will support the change in teachers' beliefs since the current study indicated the impact of the teachers' beliefs on their development of MTI, which also influenced their attitude. A mathematics teacher must be passionate about his/her subject to motivate learners and get them passionate about it.

This study showed that non-specialists mathematics teachers do not receive support from their HoD or school leaders in rural schools. I recommend that it is essential that non-specialist mathematics teachers receive support from school leaders who are mathematics experts to continuously support them with the challenges that they experience. In addition, school leaders should be trained on how to support non-specialist teachers so that they do not work in isolation. The HoD or school leaders should be aware of the difficulties that non-specialist mathematics teachers encounter, and provide the necessary support to ensure that they develop their MTI.

5.7 RECOMMENDATIONS FOR FURTHER RESEARCH

This study was only conducted in the Mpumalanga province in rural primary schools. It might be of interest for future researchers to explore the development of non-specialist mathematics teachers' MTI at secondary school level in a South African context. This would allow them to see how the phenomenon works similarly or differently from that of primary school non-specialist mathematics teachers. This would allow learners to benefit from the education system in this country. It should also be considered to implement systematic and development programmes for the upskilling of non-specialist mathematics teachers. Essentially, this study gives room for further research or the possibility of adding a new face to the existing literature. This includes investigation into:

- How the MTI of non-specialist teachers continues to develop after an in-service professional development programme, and through practice ?
- How can a professional development programme influence non-specialist mathematics teacher's beliefs in order to improve their MTI development ?

- In case of specialist mathematics teachers, what aspects of MTI do or do not develop through practice ? and why? Researchers have discovered that their MTI begin to develop through teacher training and continue to develop through practice.
- The influence of learners' background on the MTI development of non-specialist teachers through practice.
- This study should be replicated to investigate, what aspects of PTI could develop through practice in terms of other subject domain (e.g. language or social sciences)?

5.8 CONCLUSION

"The quality of an educational system cannot exceed the quality of its teachers" (Barber & Mourshed, 2007, p. 16). This statement emphasises the significance of non-specialist teachers' MTI development because of its direct impact on mathematics teaching and learning. This study's findings show that non-specialist mathematics teachers lack subject matter knowledge and didactical skills. As a result, it can be concluded that the participants' MTI was not developed meaningfully through practice. Additionally, their beliefs about mathematics, and the teaching and learning thereof, as well as contextual factors, have a negative influence on these teachers' MTI development. In conclusion, this research recommends in-service professional development programmes for non-specialist mathematics teachers to improve their subject matter knowledge and didactical expertise, and attempt to change their beliefs and attitudes towards the subject.

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APPENDICES

APPENDIX A1: MPDE APPROVAL LETTER AND INFORMED CONSENT

education
MPUMALANGA PROVINCE
REPUBLIC OF SOUTH AFRICA

Ikhamanga Building. Government Boulevard. Riverside Park,
Mpurnaianga Province Private Bag X11341, Mbombela. 1200.
Tel: 013 766 5552!5115. Toll Free line: 0800 203 116

Litiko le Tcmfundvo Umnyango wemfundo Department van Onderwys. Ndzawulo ya Dyonczo

Ms.Zanele Dibane
67Xubeni Section
TEMBISA
1632

RE: APPLICATION TO CONDUCT RESEARCH: MS. ZANELE DIBANE (zdibane@gmail.com) 072 890 0248

Your application to conduct research study was received and is therefore acknowledged. The title of your study reads thus: **"The mathematics teacher identity development of non- specialist Grade 6 teachers in rural schools."** Your request is approved subject to you observing the provisions of the departmental research policy which is available in the departmental website and available on request. You are also requested to adhere to your University's research ethics as spelt out in your research ethics document. We trust that the aims and the objectives of the study will benefit the department, especially the learners and the teaching staff and all officials in the department of education.

In terms of the research policy, data or any research activity can only be conducted after school hours as per appointment with affected participants. You are also requested to share your findings with the relevant sections of the department so that we may consider implementing your findings if that will be in the best interest of the department. To this effect, your final approved research report (both soft and hard copy) should be submitted to the department as soon as you complete your research project. You may be required to prepare a presentation and present at the department's annual research dialogue. For more information kindly liaise with the department's research unit @ 013 766 5476 or a.baloyi@education.mpu.gov.za.
The department wishes you well in this important project and pledges to *give* you the necessary support you may need.

MR. J.R. NKOSI
ACTING HEAD: EDUCATION
DATE: 22/07/2020

APPENDIX A2: LETTER OF NOTIFICATION: HEAD OF DEPARTMENT

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

Dr A.H Baloyi
The Head of the Department
Private Bag X 11341
Nelspruit
1200

LETTER OF NOTIFICATION: HEAD OF DEPARTMENT

Dear Dr A.H Baloyi

I am a PhD student studying through the University of Pretoria and I would like to collect data at your schools for a research project titled: ***"The mathematics teacher identity development of non-specialist Grade 6 teachers in rural schools"***.

The purpose of this study is to explore how rural Grade 6 non-specialist mathematics teachers' beliefs and contextual factors influence their MTI development through practice. Although much research has been done on MTI, very little is known about the MTI development of non-specialist mathematics teachers through classroom practice. The non-specialist Grade 6 mathematics teachers will be chosen in consultation with the school mathematics head of department.

The Grade 6 non-specialist mathematics teachers will be invited to participate in an interview, which will not last more than 30 minutes, in order to determine how the teachers view their identity as mathematics teachers. The interviews will be completed during Terms 2 and 3 in the teachers' normal mathematics classrooms in the afternoon or in the school whenever the teacher is free and is not attending any classes.

Based on this information, I will ask teachers to further participate in this study by allowing me to video record and observe two of their mathematics lessons. The video recording will take place during Term 2 or 3, in their normal Grade 6 mathematics classes and will not last more than 60 minutes each. These video recordings are necessary to make my analysis as detailed as possible. I will sit quietly at the back of the teachers' classes and take notes. Only the actions of the teachers will be recorded. The video will also record any interaction that the teachers have with their learners, but the learners will not be included in the video recordings.

For the recordings, the teachers will be asked to teach their normal mathematics classes. As the research is focused on studying the professional identity of Grade 6 mathematics teachers, it will not in any way comment on the teachers' or learners' mathematical competence. I will also ask the teachers to make copies of their assessment tasks in order to determine the teachers' mathematics knowledge and pedagogical skills.

This study will not attempt to evaluate the quality of teaching but aims to describe the MTI development of Grade 6 non-specialist mathematics teachers. The data collected for this study will be handled in strict confidentiality, and neither the schools nor the participants will be identifiable in any report. The teachers who are participants may withdraw anytime without any penalty. The teachers, parents and learners will be provided with letters that will elicit their informed consent and the researcher will only commence with data gathering once all these have been granted. The video recording, document analysis transcripts and interview transcripts will only be used for research purposes and the content will remain confidential.

The results of this study may be presented at conferences or published in scientific journals. On completion of the study, an electronic copy of the thesis will be available at the University of Pretoria's library. If it is required, I will be available to provide short presentations on the purpose, findings and recommendations of my research to both Mpumalanga Department of Education officials and the schools concerned.

Participation is subject to the Ethics Committee of the Faculty of Education at the University of Pretoria's regulations, and the following will apply:

1. The names of the school and identities of the participants will be treated confidentially and will not be disclosed.
2. The video recording, document analysis transcripts and interview transcripts will be treated confidentially. Only the researcher (Ms Zanele Dibane) and the supervisors (Prof. Sonja van Putten and Dr Hanlie Botha) will have access to the video recordings and the transcribed data.
3. Only the researcher (Ms Zanele Dibane) will know the identity of the teachers who agreed to participate in the study.
4. Pseudonyms for schools and teachers will be used in all spoken and written reports.
5. The information provided by the teacher and learners will be used for academic purposes only.
6. Participation in this project is entirely voluntary. Participants have the right to withdraw at any time without any penalty.
7. The teachers and learners will not be exposed to acts of deception at any point in the research study.
8. The teachers and learners will not be placed at risk of any kind.
9. No incentives will be offered to any of the research participants.

For any further queries, you are more than welcome to contact the researcher or her supervisor.

Your support in this matter will be appreciated.

Ms Zanele Dibane
072 890 0248
zdibane@gmail.com

Prof. Sonja van Putten (supervisor)
(012) 420 5657
Sonja.vanPutten@up.ac.za

APPENDIX A3: LETTER OF NOTIFICATION: PRINCIPAL

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

LETTER OF PERMISSION: PRINCIPAL

Dear Sir / Madam

I am a PhD student studying through the University of Pretoria and I would like to collect data at your school for a research project titled: ***"The mathematics teacher identity development of non-specialist Grade 6 teachers in rural schools".***

The purpose of this study is to explore how rural Grade 6 non-specialist mathematics teachers' beliefs and contextual factors influence their MTI development through practice. Although much research has been done on MTI, very little is known about the MTI development of non-specialist mathematics teachers through classroom practice. The non-specialist Grade 6 mathematics teachers will be chosen in consultation with the school mathematics head of department.

The Grade 6 mathematics teachers will be invited to complete an interview, which will not last more than 30 minutes, in order to determine what influence their professional identity development as mathematics teachers. The interviews will be completed during Term 2 and 3 in the school after school hours or when the teacher is free has no class to attend.

Based on this information, I will ask teachers to further participate in this study by allowing me to video record and observe two of their mathematics lessons. The video recording will take place during Term 2 or 3, in their normal Grade 6 mathematics classes and will not last more than 60 minutes each. These video recordings are necessary for accurate analysis. I will sit quietly in the back of teachers' classes and take notes. Only the actions of the teachers will be recorded. The video will also record any interaction that the teachers have with their learners, but the learners will not be included in the video recordings.

For the recordings, the teachers will be asked to teach their normal mathematics classes. As the research is focused on studying the identity of Grade 6 mathematics teachers, it will not in any way comment on the teachers' or learners' mathematical competence. This study will not attempt to evaluate the quality of teaching but aims to identify mathematics teachers' professional identity development of Grade 6 non-specialist mathematics teachers. I will also ask the teachers to make copies of their assessment tasks in order to determine the teachers' mathematical knowledge and pedagogical skills.

The data collected for this study will be handled in strict confidentiality, and neither the schools nor the participants will be identifiable in any report. The teachers who are participants may withdraw anytime without any penalty. The teachers and learners will be provided with letters that will elicit their informed consent and the researcher will only commence with data gathering once all these have been granted. The video recording, document analysis transcripts and interview transcripts will only be used for research purposes and the content will remain confidential.

The results of this study may be presented at conferences or published in scientific journals. On completion of the study, an electronic copy of the dissertation will be available at the University of Pretoria's library. If it is required, I will be available to provide short presentations on the purpose, findings and recommendations of my research to both GDE officials and the schools concerned.

Participation is subject to the Ethics Committee of the Faculty of Education at the University of Pretoria's regulations, and the following will apply:

1. The names of the school and identities of the participants will be treated confidentially and will not be disclosed.
2. The video recording, document analysis transcripts and interview transcripts will be treated confidentially. Only the researcher (Ms Zanele Dibane) and the supervisors (Prof. Sonja van Putten and Dr Hanlie Botha) will have access to the video recordings and the transcribed data.
3. Only the researcher (Ms Zanele Dibane) will know the identity of the teachers who agreed to participate in the study.
4. Pseudonyms for schools and teachers will be used in all spoken and written reports.
5. The information provided by the teacher and learners will be used for academic purposes only.
6. Participation in this project is entirely voluntary. Participants have the right to withdraw at any time without any penalty.
7. The teachers and learners will not be exposed to acts of deception at any point in the research study.
8. The teachers and learners will not be placed at risk of any kind.
9. No incentives will be offered to any of the research participants.

For any further queries, you are more than welcome to contact the researcher or her supervisor.

Your support in this matter will be appreciated.

Ms Zanele Dibane
072 890 0248
zdibane@gmail.com

Prof. Sonja van Putten (supervisor)
(012) 420 5657
Sonja.vanPutten@up.ac.za

Should you be willing to grant me permission to conduct the study at your school, please fill in the details on the next page:

I, _____ (your name only), give permission for the research project titled, *The mathematics teacher identity development of non-specialist grade 6 mathematics teachers in rural schools,* to be conducted at my school.

…… ……..
Signature Date

APPENDIX A4: LETTER OF NOTIFICATION - TEACHER

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

LETTER OF INFORMED CONSENT: TEACHER

Dear Teacher

I am a PhD student studying through the University of Pretoria and would like to collect data at your school for a research project titled: ***"The mathematics teacher identity development of non-specialist Grade 6 teachers in rural schools"***.

As a Grade 6 mathematics teacher, you will be invited to complete an interview, which will not last more than 30 minutes, in order to determine how you view your identity as a mathematics teacher and how it is developed through practice. These interviews will be completed during Term 2 and 3 in the school after school hours or whenever the teacher is free is not attending any classes

Based on this information, I will ask you to further participate in this study on lesson observation and allow me to video record and observe two mathematics lessons and will not last more than 60 minutes each. The video recording will take place during Term 2 or 3, during your normal Grade 6 mathematics classes. This video recording is necessary to allow me to do a detailed analysis. I will sit quietly in the back of your class and take notes. I will have a video camera that will only record your actions as a teacher. The video will also record any interaction that you have with your learners, but the learners will not be included in the video recordings.

For the recordings, you will be asked to teach your normal mathematics classes. You should not teach mathematics any differently than you are used to. As the research is focused on studying the identity of Grade 6 mathematics teachers, it will not in any way comment on your competencies as a teacher. This study will attempt to explore their professional mathematics teacher identity development. I will also ask you to make some copies of your assessment tasks in order to determine how you actualize your identity as a mathematics teacher.

The results of this study may be presented at conferences or published in scientific journals. On completion of the study, an electronic copy of the dissertation will be available at the University of Pretoria's library. If it is required, I will be available to provide short presentations on the purpose, findings and recommendations of my research to both GDE officials and the schools concerned.

Participation is subject to the Ethics Committee of the Faculty of Education at the University of Pretoria's regulations, and the following will apply:

1. The names of the school and identities of the participants will be treated confidentially and will not be disclosed.
2. The video recording, document analysis, transcripts and interview transcripts will be treated confidentially. Only the researcher (Ms Zanele Dibane) and the supervisors (Prof. Sonja van Putten and Dr. Hanlie Botha) will have access to the video recordings, audio recordings, lesson plans and the transcribed data.
3. Only the researcher (Ms Zanele Dibane) will know the identity of the teachers who agreed to participate in the study.
4. Pseudonyms for schools and teachers will be used in all spoken and written reports.
5. The information provided by the teacher and learners will be used for academic purposes only.

6. Participation in this project is entirely voluntary. Participants have the right to withdraw at any time without any penalty.
7. The teachers and learners will not be exposed to acts of deception at any point in the research study.
8. The teachers and learners will not be placed at risk of any kind.
9. No incentives will be offered to any of the research participants.

For any further queries, you are more than welcome to contact the researcher or her supervisor.

Your participation will be appreciated.

Ms Zanele Dibane	Prof. Sonja van Putten (supervisor)
072 890 0248	(012) 420 5657
zdibane@gmail.com	Sonja.vanPutten@up.ac.za

Should you agree to participate in the study under the above-stated terms, please fill in the following details:

I, _____ (your name only), agree to take part in the research project titled, "*The mathematics teacher identity of non-specialist Grade 6 teachers schools*".

…… ……..
Signature Date

APPENDIX A5: LETTER OF NOTIFICATION - PARENT

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

LETTER OF INFORMED CONSENT: PARENTS

Dear Parent(s)/Guardian(s),

I am a PhD student studying at the University of Pretoria and would like to collect data at your child's school for a research project titled: ***"The mathematics teacher identity development of non-specialist Grade 6 teachers in rural schools"***.

The purpose of this study is to investigate how Grade 6 non-specialist mathematics teachers subject matter knowledge and teaching skills has developed through practice. Your child's mathematics teacher has agreed to partake in this study where I will observe and video record them teaching mathematics during two lessons. Only your child's teacher will be recorded. The video camera will not record your child's face. If your child's face has been recorded, I will personally use software to hide their face. The recording will only be used for me to check the teachers subject matter knowledge and teaching skills. I will observe and record your child's mathematics teacher during Term 2 and 3 during your child's normal mathematics lessons. The video recordings will take place in your child's normal mathematics classroom. The results of this study may be presented at conferences or published in scientific journals. On completion of the study, I will supply the Director of Knowledge Management & Research at the Mpumalanga Department of Education with one electronic copy of a research report. If it is required, I will be available to provide short presentations on the purpose, findings and recommendations of this research to both Mpumalanga Department of Education officials and your school. The video recording will only be used for research purposes and the content will remain confidential.

Participation is subject to the Ethics Committee of the Faculty of Education at the University of Pretoria's regulations, and the following will apply:

1. The names of the school and identities of the participants will be treated confidentially, and the teacher nor learners' identities will not be disclosed.
2. Only the researcher (Ms Zanele Dibane) and the supervisors (Prof. Sonja van Putten and Dr Hanlie Botha) will have access to the video recordings and the transcribed data.
3. Only the researcher (Ms Zanele Dibane) will know the identity of the teachers who agreed to participate in the study.
4. Pseudonyms for schools and teachers will be used in all spoken and written reports.
5. The information provided by the teachers will be used for academic purposes only.
6. Participation in this project is entirely voluntary. Participants have the right to withdraw at any time without any penalty.
7. The teachers and learners will not be exposed to acts of deception at any point in the research study.
8. The teachers and learners will not be placed at risk of any kind.
9. No incentives will be offered to any of the research participants.

For any further queries, you are more than welcome to contact the researcher or her supervisor.

Your support in this matter will be appreciated.

Ms Zanele Dibane
072 890 0248
zdibane@gmail.com

Prof. Sonja van Putten
(012) 420 5657
Sonja.vanPutten@up.ac.za

Should you agree to allow your child to participate in the study under the above stated terms, please fill in the details below:

I, _____(your name only), agree that my child may take part in the research project titled, "*The mathematics teacher identity of non-specialist Grade 6 teachers in rural schools*".

…… ……..
Signature Date

APPENDIX A6: LETTER OF NOTIFICATION - LEARNER

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

LETTER OF INFORMED ASSENT: LEARNERS

Dear Learner

Why am I here?

Sometimes when we want to find out something, we ask people to join something called a project. What you are taught in your class and how your teacher teaches it is often based on research. To continue to improve on what you are taught and how you are taught, there are research projects that look at what happens in a mathematics classroom. This is such a research project. In this project, I will be looking at how your teacher is teaching you mathematics. This project will give me a chance to look at different ways that teachers teach mathematics.

What will happen to me?

I will be video recording your teacher during two of your lessons. You should work and behave just as you always do in class. The camera that I will use to record your teacher will not record your face. The recording will only be used for me to check what you and your teacher have said, so there is no need to worry about what others may think about you or how you might look or act in the class. These recordings will not be shown to anyone (except your teacher, and my supervisors). If you do not want to say anything you do not need to.

Will the project help me?

This project is a bit like cleaning up a river, building houses in poor areas, or protecting rhinos; it will not necessarily help you immediately, but it may help to improve how mathematics is taught in future.

What if I have any questions?

You can ask your teacher or me any questions you have about this research. If you have questions later you can phone Ms Zanele Dibane at 072 890 0248, or you can ask her next time you see her at school.

Do I have to be in the project?

You do not have to be in this project if you do not want to. No one will be upset if you do not want to participate. You will not lose any marks for mathematics if you do not participate. If you do not want to be in the video recordings, you just have to tell us, and we won't use any of your words. You can say yes or no and if you change your mind later, you do not have to be part of the project anymore. It is up to you.

Writing your name on this page means that you agree to be in the project and that you know what will happen when we do the project. If you decide to quit the project at any time, all you have to do is tell me or your teacher.

…… ……

Signature of the learner **Date**

Open Rubric

.....	.....
Signature of the researcher	**Date**
.....	.....
Signature of the supervisor	**Date**

DATA COLLECTION INSTRUMENTS

APPENDIX B: INTERVIEW PROTOCOL

Interview questions
1. Please provide some background to your teaching career.
2. How do you view mathematics as a subject?
3. How do you see yourself as a mathematics teacher?
4. Do you believe that you have sufficient subject matter knowledge to teach mathematics effectively? or is there any content you find it difficult?
5. How confident are you in teaching mathematics?
6. Which teaching approaches do you employ when teaching mathematics? why?
7. How do you assess learners understanding while teaching?
8. How do you accommodate the diverse needs of learners while teaching?
9. How has your mathematical knowledge developed since you started teaching mathematics?
10. Which teaching resources do you use when teaching?
11. How do you plan your lessons?
12. Is there anything that influences your teaching and learning of mathematics?
13. What support did you receive from the school leaders?

APPENDIX C

LESSON OBSERVATION SCHEDULE

Date of the observation	
The school (pseudonym)	
Name of the teacher (pseudonym)	
Subject	
Grade 6	
Number of learners	
Period number and time	
Lesson topic	

Checklist for lesson observation

Elements of classroom practice to be observed	**Question guiding observation**	**Comments**
Practice (subject matter knowledge)	Is the content presented adequately?	
	How is the content presented?	
	How the teacher uses real-life examples to explain the concepts thoroughly.	

	Is the teacher able to respond to the learner's questions correctly?	
	Is the teacher asking enough questions for the learners to develop critical thinking?	
	Can the teacher encourage classroom discussion?	
Practice (didactical skills)	What teaching approaches employed in the classroom?	
	Does the teacher accommodate the diverse needs of the learners when teaching?	
	Does the teacher ask the questions while teaching to ensure that learners understand the content being taught?	
	Does the teacher use the learners' questions and responses to further elaborate on content being taught?	
	How does the teacher encourage learners' participation throughout the lesson?	
	What teaching resources does the teacher use when teaching?	

	How does the teacher assess learners understanding content?	
Teachers' beliefs	How confident is the teacher in teaching mathematics?	
Contextual factors	How is the classroom sitting arrangements?	
	Does the teacher have mathematics resources for teaching?	
	What supports the teacher receive from the school leadership?	
	How is the school environment?	

Adapted from Kekane (2016)

APPENDIX D

Document analysis guide for lesson plans

Teacher (pseudonym)	
School (pseudonym):	
Documents analysis: teachers' lesson plan	
Date:	

Criteria	**Comments**
Introduction	
Teachers' goals what learners should know and be able to do at the end of the lesson.	
Assessing the learner's prior knowledge of the content.	
Explanation of the lesson content (concept development).	
Resources the teachers' used in class for teaching and learning.	

What teaching strategies were used in the lesson.	
Conclusion of the lesson (question and answer/classwork/ homework or group work)	

APPENDIX E: INTERVIEW TRANSCRIPTION

Transcription interview scripts

Interview with Plato (School A, Participant A)

1. Zanele: Good afternoon
2. Plato: Afternoon
3. Zanele: Thank you for your time, I have got few questions which I would like you to share
4. with me your experience of teaching as a non-specialist mathematics teacher. The first
5. question, may you please provide some background to your teaching career.
6. Plato: Ok…thank you…thank you for the question…mm…ahhmm…firstly I am going to
7. take you through my background when and how I started my teaching. Ehh…I am a
8. qualified teacher, I qualified to be a teacher in 2013. I did a bachelor's degree in
9. education I am specialising in the languages in the intermediate and senior phase.
10. Ehm... when started working I started working in a primary school. Where I was
11. teaching the languages because I am a qualified language teacher, and then as time
12. goes Ehh…one of our mathematics teachers in the school left the school. He got a
13. promotion. So…the school management team requested me to come and assist
14. in mathematics. Because the school did not qualify for a teacher by then so from
15. there, I have been teaching mathematics. I think it's my third year now. So…that's
16. what….that's what I can say about the background of my teaching. Thank you.
17. Zanele: Thank you very much, the second question, how do you view mathematics as
18. a subject?
19. Plato: Ok…ehh…mathematics from where I see it. Ehh…mathematics is aa…, it's a
20. very difficult subject, not only to me, to the learners as well. Because most of the
21. learners see mathematics as a monster. They complain about passing all the
22. subjects but struggling with mathematics. So, I also see it as a subject that is
23. challenging, that is why we always have a emm…extra classes for maths, also
24. always come on Saturday sometimes. Because mathematics is not an easy subject,
25. so it needs more time and it needs more dedication. I think that is how I view it.
26. Zanele: Ok thank you, sir. The third question is, how do you see yourself as a
27. mathematics teacher? Since now you are teaching mathematics.
28. Plato: Yaahh…now that I am teaching mathematics, I do not know that I am a
29. language teacher. I see myself as a language teacher as I am qualified to teach
30. languages. But now because I am also teaching mathematics. I always try to be a

mathematics teacher but deep down I know that I am not a maths teacher. Ehh… firstly I am not happy to teach the subject because they promised me that they will be changing me back to languages but still, it's not happening so…yahh… that's how I see myself not a mathematics teacher. I am teaching it but I am a language teacher. Zanele: Ok, thank you. The fourth question, do you believe that you have sufficient subject matter knowledge to teach mathematics effectively? or is there any content you find it difficult? Plato: Ehmm…as a teacher who has specialised in languages at a tertiary, obviously I do not have enough knowledge or content as far as mathematics is concerned but aahh…I try my level best to make sure that I learn so that I improve every day. But I do not have the… enough knowledge in the subject. For example I am still struggling to date to teach probability the last chapter in Grade 6. So for me, it is very difficult to teach the subject. Ehh… At some point, I only teach it aahh…half of the content I am supposed to cover. Ehhm…and as a result my learners are not performing well on the topic. . It's not only probability because I don't have enough content in mathematics as a whole. aahhmm most of the content or topic I do not cover fully. Because some of the things I do not cover fully. Because some of the things I do not know. Yes, I do consult sometimes but eehh…you know I won't be able to get all the information that I want. Yahh…I think I still need Ehh… to learn a lot in the subject. Thank you. Zanele: Ok, thank you very much. The fifth question, how confident are you in teaching mathematics? Plato: Ehhmm…ehh… when I am with the learners because this are kids they are young they do not know the subject, just like me I do not know much. So, I am with them its fine I do teach. But there are times whereby eehhm…maybe a colleague comes in for lesson observation, then I do not have confidence. ehh I am even scared to teach in front of them. Sometimes my senior will come and observe my lesson, so I feel very much intimidated. And ehh… I do not have enough confidence even ehh… the learners are having a homework some of the parents they will call me and ask how this is supposed to be done. And at the time I had to be defensive and tell them that I cannot work while I am not at school. It's not really that I don't want to assist them but it's because some of the parents are teachers, they know more than me, so I am not much confident in the subject. Yahh… that's all I can say. Zanele: Ok, thank you. Question six, which teaching approaches do you employ when teaching mathematics? Why? Plato: Ok…ahmm… the approach that I use when I am teaching the subject. Eehh… I use the old method which is chalk and talk. Aahh… I use the chalk to demonstrate

67. sums on the board. And the learners that are how they learn. I also work with ehh…I
68. work with the examples that are in the textbook. Then I work with the learners
69. using the examples that are given in the textbook. Following all the steps that are there.
70. Aahh…so I think that is the approach that I am using yahh…thanks.
71. Zanele: Ok, thank you. Question number seven, how do you assess learners
72. understanding while teaching?
73. Plato: Ok, eehh…thank you. Mmmm…I assess my learners as I teach, I asked them
74. informal questions and then they will raise their hands .to answer whatever that I
75. am asking them. I also write sums on the board and then ask the learners to come
76. and demonstrate or answer them in front so that the other learners can also see.
77. Eehhmm…I also give the informal test and I also give formal test during eehh…the
78. end of the term So yah… it's the informal assessment is when I ask them questions,
79. then they answer back by raising their hands or they go to the board. And during the
80. test, they write the test formally.
81. Zanele: Ok, thank you. Question 8, how do you accommodate the diverse needs
82. of learners when teaching?
83. Plato: Yes, I have got different learners in my classes, some learners, they are gifted,
84. they are very fast and some they are very slow. So, to accommodate the needs of the
85. slow ones, I aahh…I let the learners who are good to help each other. So, I make
86. sure that aahh…those who are good sit with the ones who are struggling so that they
87. will be able to assist them. I also go the extra mile in assisting the ones that are…aah
88. struggling by staying with them after school and try to assist them so that will be able
89. to catch up. Eehh… but I also communicate with their parents to help them with some
90. of the work at home. Yes…, thank you.
91. Zanele: Ok, thank you. Question 9, How is your mathematical knowledge has
92. developed since you started teaching mathematics?
93. Plato: Ehhm… I can say my…my knowledge has developed because now is no
94. longer, it's not like the first time when I started to teach the subject. But it has
95. developed very slow because eehh…we do not have time; we don't have enough
96. time. It has developed but not much. Aahhm…I still believe that there is a gab or
97. there is a lot that I need to 97. learn up to date. Aahhmm…Yes, I do attend the
98. school, eehh… support teams,
99. whereby our HODs are developing us, but eehh… I still believe that there is a lot that
100. still needs to be done. So, it has developed compared to when I started but I still
101. have a lot to do. I still have a lot to learn. Aahh…yah…I am taking slowly by slowly,
102. day by day. Thank you.

103. Zanele: Ok, mmhh…Question 10, which resources do you use when teaching?
104. Plato: Eehhmm…when teaching aahhmm…I used the prescribed textbooks. In the
105. school, we are using the platinum, so it is the prescribed textbook that we are using.
106. The learners are also having this book. So I sorely rely on this book. I get
107. aahh…resources from the book so that I will make sure that I share the information
108. with the learners. I also use, question papers or previous question papers so that I
109. can refer to what was asked previously then I can assist them. Thanks.
110. Zanele: Ok, how do you plan the lessons?
111. Plato: Mmmm…when planning the lessons, the
112. the department has provided the lesson plans for all of the schools. But you know
113. that the context of the school is not the same. Some schools are different from
114. others and the learners are also different. So to adapt I use the very same textbook
115. which is platinum to prepare for the lessons and make sure that my learners
116. understand. Yahh… Thanks.
117. Zanele: Ok. Is there anything that influences your teaching and learning of
118. mathematics?
119. Plato: A lot I can say. eehh… there is a lot that is influencing my teaching. Eehh…
120. for example some of the learners that I teach they are having parents who are well
121. equipped in the subject so they know mathematics. Sometimes if I give them some
122. work to do at home go the extra mile and bring more than I give them. So that
123. motivates me, gives me the allowance to go the extra mile as I teach. But at the
124. same time, it also intimidates me because some of the things they bring I don't know
125. so it becomes a challenge when the learners know more than me. And another the
126. thing that is influencing me here at school our leaders or the education specialist 127.
they come and monitor our work so they want to see all the learner's books
128. marked. They want to check and see if the learners are progressing
129. eehh….nicely. So I think that is influencing my teaching in a good way, though
130. because I always improve so that I impress. Thank you.
131. Zanele: Ok, thank you very much. The last question. Is there any support you
132. receive from the school leaders?
133. Plato: Aahh…from the school leaders I do receive support but its aahh…it's not
134. sufficient. It's not sufficient because aahh…like the person that I am reporting to is
135. also, not a maths specialist is just a HOD for an intermediate phase so is not a
136. specialist for maths. So the support that I am getting is very limited as far as the
137. content is concerned. For me to get the support I must contact eehh…other
138. teachers from neighbouring schools who are teaching the subject so in the

139. school, I don't receive much support. Yah…I think that's it.
140. Zanele: Ok, thank you very much, Sir, for your time. I appreciate it. Thank you.

Interview with Zano (School B, Participant B)

1. Zanele: Good afternoon mam
2. Zano: Afternoon
3. Zanele: How are you?
4. Zano: am good and yourself
5. Zanele: I am good. I am here to interview you., actually to get you to share with me
6. your experience in teaching mathematics. Since you indicated that you are a
7. non-specialist teacher. The first question which would like to hear from you. Can you
8. please provide
9. some background to your teaching career.
10. Zano: Ohh…right I am a qualified teacher. I have got a degree, specialised in
11. foundation phase. I have taught the foundation phase since 2010-2014. Then from 12. 2015 aahh…they SMT decided to move me to intermediate phase mathematics due 13. to the shortage of mathematics teachers, and now I have 3 years experience in
14. mathematics (she said started in 2015 to teach intermediate phase,
15. meaning she has got 7 years to experience teaching mathematics in Grade 6).
16. Zanele: Ok, thank you very much mam. The second question, how do you view
17. mathematics as a subject?
18. Zano: Mmmm…Since I am a foundation phase teacher. I view mathematics as a
19. simple subject cause its where learners have to learn operations signs and adding 20. and so on. But…now since I am teaching intermediate phase it's a very difficult
21. subject because it involves a lot of topics that have different kinds of methods.
22. Zanele: Ok, thank you. Question 3, how do you see yourself as a mathematics
23. teacher?
24. Zano: Mmhh…I don't see myself as a mathematics teacher because it is very difficult.
25. But since…I have been teaching the intermediate phase I am trying to develop myself
26. in mathematics.
27. Zanele: Ok, thank you. Do you believe that you have sufficient subject matter?
28. knowledge to teach mathematics effectively? or is there any content you find difficult?
29. Zano: No…I don't believe that I have sufficient subject matter knowledge to teach
30. mathematics. And…I find the content difficult. Eehh…I found the content long division

31. method difficult. It's very difficult to teach and also difficult for the learners to master
32. because it is very long it involves all the operations signs.
33. Zanele: Ok, thank you very much, mam. The fifth question, how confident are you in
34. teaching mathematics?
35. Zano: Mmhh…Less confident (laughs)…No confidence at all. Due to challenges from
36. learners and some topics are very difficult. I can't deliver them properly even if I
37. can try I see that this is difficult and also the learners are very challenging on asking
38. questions and so on. Yahh…
39. Zanele: Ok, thank you. Question 6, which teaching approaches do you employ when
40. teaching mathematics? Why?
41. Zano: Alright… most of the time, I use the teacher-centred method. I only provide the
42. learners with the knowledge and sometimes I use the learner-centred method.
43. Because it helps me in gaining some experience because some learners are very
44. clever when they do some problems on their own. I also learn something from them.
45. Zanele: Ok, thank you very much. How do you assess learners understanding while
46. teaching?
47. Zano: In most of the time, I use classwork, question and answer.
48. Zanele: Ok, thank you. How do you accommodate the diverse needs of learners
49. when teaching?
50. Zano: Aahh…I accommodate the diverse learners by mixing them. By doing group
51. work taking few learners who are most clever and few average learners and those
52. who are experiencing difficulties and mix them to work in groups. In that way, I think
53. will be able to learn from each other and share some ideas accordingly to their
54. abilities.
55. Zanele: Ok, thank you mam. How is your mathematical knowledge has developed
56. since you started teaching mathematics?
57. Zano: Eehh…it is developing, yah …it is developing but still struggling. It's developing
58. but still struggling. As…aahh…as I am still teaching the intermediate phase. I do
59. master some of the content but some, it is very difficult.
60. Zanele: Thank you very much, mam. Which resources do you use when teaching?
61. Zano: I use textbooks and most of the time I follow the textbooks steps to teach in
62. class. To teach in class I use chalkboard and chalk that is all.
63. Zanele; Ok, thank you very much, mam. How do you plan your lessons?
64. Zano: mmhh…we do not plan lessons; the subject specialists provide us with lesson
65. plans. I only go through them, prepare myself and go to class.
66. Zanele: Ok, thank you mam. Is there anything that influences your teaching and

67. learning of mathematics?
68. Zano: Yes, there is. The first one is the average performance. If my learners have
69. performed for example in a test, if they have performed better. It influences me
70. positively so I to continue to put more effort and improve my teaching styles and
70. method. And the other one that influences me, is the challenges from the learners. 71.
The challenge on the lesson, during lesson presentation they ask questions that
72. sometimes I am…(laughs) not able to answer so I have to branch. So yeah… it's very
73. difficult.
74. Zanele: Thank you very much, mam. The last question, is there any support you
75. receive from the school leaders?
76. Zano: No, there is no support that we are receiving from the school leaders. They
77. only do the workshops from the department of education. The subject specialists
78. help us. Here at school, they only do IQMS, and but in the end, they don't implement
79. it. They only go to class observe your lesson and identify your challenges but, in the
80. end, they won't help you.
81. Zanele: Ok, thank you very much mam for your time, I appreciate it.

Interview with Thando (School C, Participant C)

1. Zanele: Good afternoon mam, thank you for this opportunity and your time to allow me
2. to come and interview you. Just to share your experience of teaching mathematics as a
3. non-specialist teacher. the first question is, please provide some background to your
4. teaching career.
5. Thando: I am teaching Grades 6 and 7.I have a Bed degree, I completed in 2007 and
6. started teaching in 2013. I am sure it was April. The subject that I majored in is
7. languages, unfortunately in my school, I was in the maths and physics department. So,
8. when I start teaching, I started with the languages 2013, 2014,Grade 4, 5 and 6. In
9. 2016 I moved to mathematics and social science Grade 6 and 7. Yahh…that's all.
10. Zanele: Ok, thank you. The second question is, how do you view mathematics as a
11. subject?
12. Thando: Ok…aahh…when I am teaching mathematics, I see it as a challenging subject
13. because it needs more practice, it needs more knowledge, so the children we have in
14. this generation. They are not serious with counting especially when you give them
15. problem-solving number. The sums that have high numbers, they are very lazy.
16. Mathematics is very important because aahh…most skill, more careers need the
17. science and maths department.

18. Zanele: Ok, thank you, mama. How do you see yourself as a mathematics teacher?
19. Thando: Eish…aahh…Ok ngitibona ngifanela kuba nguThishela weMaths ngisase
20. sikoleni bengifisa kutsi ngisebente kuma careers we Maths and Science, macareers
21. kufana nabo Engineering bo Doctors. But unfortunately, angikakhoni we certain
22. reasons. Imaths yona ikahle like kutsi ube nayo, ngoba utholakala cishe nje misebenti
23. leminingi nje le nje lekahle iku maths and science. So, mina ngitibona…ngibalulekile
24. kule position lengikuyo. Ngibona ngibalulekile kusita bantfwana batholakale babe
25. nguloku labakudzingako nalaba kufisako. Kutsi ekugcineni kungatholakali sesi nema
26. careers layi one kuphela kufuna nalawa aku demand bakhone kugena kuwo.
27. Translated to English (I see myself as a maths
28. teacher, While I was still at school I wished to work on careers in maths and science
29. stream like engineers and doctors. But unfortunately, I couldn't because of certain
30. reasons. It is important to have maths and science because it has got a lot of job
31. opportunities. So, I see myself in an important position as I am teaching maths. I am
32. important because I am helping learners to become what they want to be in future. So,
33. that at the end we don't find ourselves with only one the type of career but the learners
34. should be able to do careers which are currently on market demand).
35. Zanele: Ok, thank you very much. Do you believe that you have sufficient subject matter
36. knowledge to teach mathematics effectively? Or is there any content you find difficult?
37. Thando: Ohh…when teaching mathematics some content is difficult because
38. now we are teaching a new curriculum that we didn't do previously. But fortunately, we
39. do have our coordinators which develop us to teach certain content. Yahh…there are
40. many challenges like time, the topic about time, the topic about long division, the topic
41. about the multiplication of 4 digits numbers by 3 digits. Those are the topics that are
42. difficult for me as well as the learner. Because now we do not use the old methods that
43. they used to do at our schools, now they use the new methods. Also, as teachers we
44. are trying to fit in the new methods and also need to apply those methods to the
45. children.
46. Zanele: Ok, thank you very much. Question 5, how confident are you in teaching
47. mathematics?
48. Thando: Aahh…I am very confident; I don't doubt myself because this subject I have
49. learnt it for many years at school. So, when I am teaching aahh…I just feel confident
50. in my school trying to teach them other methods which they do not know and also other
51. methods which are not in their textbook content and lesson plans and whatsoever.
52. Zanele: Ok, thank you. Question 6, which teaching approaches do you employ when
53. teaching mathematics? Why?

54. Thando: Usually we use the teacher and learner-centred. Which means involve me
55. as well as the learners when you are teaching as a teacher you show them maybe one
56. example, then the second one you need to invite the class. This means we work
57. together as a group.
58. Zanele: Ok, thank you. Question 7, how do you assess learners understanding while
56. teaching?
57. Thando: Ok…after the lesson sometimes I give them classwork maybe two sums
58. because short of time. After we do corrections orally. When I say orally like in class,
59. each learner is supposed to come in front of the class and write some of the steps on
60. the chalkboard, so that every learner can see where they got it wrong or get it right.
61. Zanele: Ok, thank you very much mam. Ehh…Question 8, how do you accommodate
62. the diverse needs of learners when teaching?
63. Thando: We have different learners; some are smart, and some are slow. When they
64. teach us the curriculum advisors, they say if you teach the lesson if it's understood you
65. will see with the clever learners. Then the slow learners you put them in the middle of
66. the smart learners you choose as leaders to assist the slow learners. Maybe if you
67. divide the class into four groups and you have three smart learners. I will be the fourth
68. one and assist the slow learners. We accommodate the slow learners all of us and in
69. the end will be understanding the content.
70. Zanele: Thank you. Question 9 how your mathematical knowledge is has developed
71. since you started teaching mathematics?
72. Thando: Ok,I can say I have developed a lot. I have learnt a lot which I didn't know.
73. as I have indicated earlier that the curriculum we are teaching currently, even the
74. calculation methods that are currently using are not the same as the old ones. I have
75. learnt a lot especially fractions, like equivalent fractions. How do you identify that this
76. is equivalent to this or that one, without using the fraction boards to count the squares
77. to find out how are they equal. Also, the time zones, I have learnt a lot, only a few things
78. which I am still struggling with. I was still learning just that the COVID-19 started so
79. there was no. more workshops.
80. Zanele: Ok, thank you. Question 10, which resources do you use when teaching.
81. Thando: We are using the DBE workbook a lot as a primary resource. They use it to
82. write it as classwork and homework. There is no need to write the classwork aside.
83. There are activities in the workbook unless space is little to write the work or if I want
84. to add for them extra activities to do, that is when they write in another book. We are
85. using the DBE workbook, solution for all textbooks. and also, the Viva. The viva

86. textbook is good and different. from the other textbooks. Also, other resources we do
87. Have, for example, when we are teaching shapes, we do have shape, length we 88.
Use measuring tapes. We do. have a mathematics kit because our school is a combine
89. so, we use it in both primary and secondary school.
90. Zanele: Ok, that you. Question 11, how do you plan your lessons?
91. Thando: Ok…our lesson plans we plan every week. This means every Friday we
92. prepare for next week. But we receive the lesson plans from our CI , then check on the
93. ATP if they are aligned with the ATP. But we do not teach everything in their lesson
94. plans, because we are not used to their lesson planning. Their lesson plan has got
95. activities and they have advised us that since they have prepared the lesson plans for
96. us we should use them.
97. Zanele: Ok, thank you. Question 12, is there anything that influences your teaching and
98. learning of mathematics?
99. Thando: Yes…There is and there is more of the negative influence. We don't work
100. together with the learners, like when you give them a project to go and do it at home
101. they don't do it. For example, you can give them a project in February and other kids
102. bring it in April not done, saying he/she doesn't know what to do. It is one of the
103. challenges. even if you can say you will stay with them in the afternoon and help them
104. to write some don't stay behind. Or if you ask them to come on Saturday a few will
105. come and the other ones won't come. So, you'll have to teach the same thing again
106. on Monday to assist those who were absent. aahh nje…
107. Zanele: Mmhh…Ok. The last question is there any support you receive from the
108. school leaders?
109.Thando: Yes…in my school…the problem with the learners we assisted by the HODs.
110. And another thing is there is a topic which you do not understand since other topics
111. are difficult or I don't know it. We use teamwork. where the teacher from another
112. Grade come and help you and teach the topic for me and I go and teach in her/
113. his class. Also, the subject advisors are assisting us where we are struggling and also
114. by following the ATP.
115. Zanele: Ok, thank you very much mam for your time.

Interview with Thato (School D, Participant D)

1. Zanele: Good afternoon, Sir. Thank you very much for your time. I have few questions
2. which I will like you to share with me your experience on teaching mathematics. The first
3. question can you please provide some background to your teaching career.

4. Thato: Ok, while I was eehh…in Secondary school doing Grade 8 and 9. Ehh…I have a
5. passion of becoming a teacher. Since my life orientation teacher eehh…she was a very
6. friendly woman. she used to share the…the career of teaching and she was a passionate
7. teacher. She used to share the career choices and advice and also support. So that is
8. when I fell in love with the teaching career. So…as for a mathematics teacher, I have
9. done mathematics in a primary level in the GET level until Grade 9. And then when I
10. was in Grade 10 due to the pressure that I was in, in terms of the people around me,
11. the peers and also the fear of maths. Then I decided to take the stream of geography
12. and tourism. So, I was not a Maths fan or an enthusiast that is what I can say. So that's
13. when I did the geography and tourism up to Grade 12. And then when I went to
14. tertiary. I had an opportunity to continue with my choice of subject. And then I was
15. doing a bachelor's degree and specialization in geography and tourism. And then I
16. obtained my qualification in geography and tourism. So, when I reach the teaching field.
17. Eish…the story changed. There was no teacher at my school for mathematics and I
18. have to code switch and move everything from geography and tourism to mathematics.
19. So I started teaching Grade 4 for two years that was in 2006-2007. I taught Grade 4 for
20. two years. I started attending workshops and seminars for mathematics. I then joined
21. AMESA and then aahh…I started to relate eehh…the teaching the didactic situation
22. versus the content, the subject matter that is when I started gaining the little experience.
23. Then I started falling in love with mathematics. And then as the school needs, they
24. depend on the situations and the enrolment, that's when I was placed aahh…for
25. teaching intermediate phase Grade 4, 5 and 6. So currently I am teaching Grade 6
26. mathematics. Eehh…that's its mam.
27. Zanele: Ok, thank you very much Sir. Ok, question 2, how do you view mathematics
28. as a subject?
29. Thato: Mmhh…Yahh…mathematics it's a very challenging. subject. Actually, it is more
30. practical. Aahh…I remember while I was teaching 3-D objects. I had to start from a
31. brick to relate a content to me mathematics is a challenging subject before you go to
32. class, you have to tackle what you have, especially moving from the bathroom to the
33. kitchen, trying to relate the example so that your lesson can be effectively. So, for an
34. example aahhmm…in the morning when you wake up. you have to follow procedures,
35. you have to follow steps. You have to bath after bathing you have to wear clothes. The
36. sequence of teaching maths it goes like that. You prepare yourself before you teach.
37.So I take mathematics as a challenging subject. But as…as a practical subject, that
38. whatever organisation that you organise yourself in especially in preparation then you
39. have to relate everything into practical subject which is more experimental. Thanks

Zanele: Ok, thank you very much Sir. Question 3, how do you see yourself as a mathematics teacher?
Thato: Yahh…since I am a lifelong learner if you take back my history aahh…as a mathematics teacher. I was not in love with maths at all. I was a…aa…actually I was almost a frightener when talking about maths. Also, aahh…I was like not even thinking that one day I was going to be a maths teacher. So, I see myself as a challenger eehh…a fighter actually a lifelong learner, because before I go to class as I said in your previous question. I prepare myself in a way that I want to become that teacher that my learners can understand and fall in love with maths and not to do the way I did not to fall in love with maths while I was in high school. I want to make this maths a habit so that this learner can even have a variety of choices in terms of careers and approaches in the broader world when they reach the…the field of career stage so I see myself as a challenger aahh…and the lifelong learner. Thank you.
Zanele: Ok, thank you sir. Question 4, do you believe that you have sufficient subject matter knowledge to teach mathematics effectively? or is there any content you find it difficult?
Thato: I cannot say that I have a sufficient subject matter, eehh…since while I was eehh…doing my first year of teaching as a maths teacher. Yahh…I was even afraid to go to class. Coming to the next year, that was in 2007. Yahh…it was a challenge after a challenge. Eehh…since even the issue of curriculum was ever changing you get use to this tomorrow it changes to another approach. So, I cannot say that I have sufficient subject matter. Since this content, the content on its own its changes now and then. Even the approaches, the strategies and also the diversity of learners that that I am dealing with. It changes year to year. Also, you can also check the issue of the current technologies issues and the innovations that are going on. So, all this eehh…things that surrounds the subjects on its own. It impacts or hinders some of the opportunities of becoming a specialist in the subject. So, I cannot say I have sufficient information or quantity of matter but I can say due to the passion that I am having yes, I am getting there. So, in terms of the second question that you are saying that is there any content I find it difficult? Yahh…there are some concepts especially when you go to the eehh go word sums to Grade 6, eehh…yahh division using the other method. We used to use the long division method eehh…it is very difficult because aahh…because I have lost some basics yahh…while I was in Secondary school and also while I was at tertiary level. Since I have never done maths. I have a gab there, then aahh it's a challenge I have to make research every day, I have to

75. consult everyday. I have to approach even my younger…, those once are coming after
76. me, the specialists in maths. Especially the new teachers to assist me. Thank you.
77. Zanele: Ok, thank you very much sir. Question 5, how confident are you in teaching
78. mathematics?
79. Thato: Yahh…as a lifelong learner, I have said it that on the previous
80. question. Yahh…before I go to class, I prepare so since the story begins therein
81. preparation then, I am a little bit confident yahh…I am getting there yahh thank you.
82. Zanele: Ok, thank you very much, sir. Question 6, which teaching approaches do you
83. employ when teaching mathematics? why?
84. Thato: Mmhh…I have got very few. The first one I can say is the investigating approach.
85. Eehh… before I introduce a lesson I go wider and investigate more information on that
86. concept to assist in various teaching approaches and strategies to my learners, so
87. eehh…the most approach that I am using is the discovery approach. Before I go to
88. class. I practice the concepts and then aahh…I made a summary of what I am going
89. to teach and then apply the demonstration approach and with the demonstration
90. approach and with the demonstration approach, it assists me to relate the concept
91. since I have said that maths its practically start from the bathroom going to the kitchen.
92. So, with this the demonstrating method, before I introduce the lesson, I use the
93. demonstration, and then since the learners will have the primary background of what
94. they have done in the morning whenever they are while they are at the school. The
95. pattern of or the sequence of the basics of what they have done. So, it assists me while
96. I was teaching, while I am teaching in terms of the demonstration. So, I am using,
97. actually, I am using more demonstration and practically eehh…approaches. Thank you.
98. Zanele: Ok, thank you so much Sir. Question 7, how do you assess learners
99. understanding while teaching?
100. Thato: Mmhh…in this case aahh…when I am teaching, I teach maybe I give 3
101. examples of concepts in the same concepts and then, lets take maybe it is aahh…it
102. is multiplication. I know that learners they don't have confidence when coming to
103. multiplication. So…what I am doing I will introduce maybe I will start from the first digit
104. multiplication. Then I give them and opportunity by writing maybe a sum in a
105. chalkboard, then I allow them to respond in a form of answering a question. And then
106. I move to the second maybe the two digit and i teach I give examples and give them
107. an opportunity to answer eehh…and from there that is when I prepare an activity. In
108. my activity I am going to list maybe five sums, then we do one sum, I give them an
109. opportunity to answer in their activity books and then we give corrections. They don't
110. write on the chalkboard the first sum. I will write for them trying to emphasise the

concept, then in the second sum I am going to write the sum in the chalkboard, give them an opportunity to come forward and answer in terms of the corrections. In term of the…the sum at the chalkboard. Eehh…while the child answers, then I will also check the quantity of learners that got the sum correctly then I will fine now, they are grapping the concept. Then I give them a question they respond we do together. Secondly, I give them a question, they respond. I give the learner to answer. Aahh…thirdly I give them a sum not to the learner to answer. I am answering the concept. They are writing, then I am answering the concept, they got it right. So then assist me to say ok now they are fully equipped. And the last sum, the fifth sum it will be a bonus to them. If they got maybe 90 per cent of the classroom, they got it correctly. Then I can say that the lesson was successful, that's when I will give them the. homework. Thank you.

Zanele: Ok, thank you very much, Sir. Question 8, how do you accommodate the diverse needs of learners when teaching?

Thato: Mmhh…aahh…I got an opportunity to do a certificate in LSEN (Learners with Special Educational Needs). In that certificate aahh…I got an opportunity to get a background on how to identify a learner who needs support. Any support can be aahh…hearing support, visual support maybe the…the slow learners all the this diversity of learners. So, with this course it has assisted me to identify the main challenges before the learner becomes a learner. So, to assist learners with different diversity I have said, I am more practical. Eehh…I am more eehh…experimental. I am more eehh. Background extraction in prior of the lesson like to relate what the learner has equipped from home to school. So actually, those two they assist me very well to identify and finding an approach that will be suitable for the learners. For example, eehh…in the background at home. You will find that eehh…a parent calls a child hheyi wena Sibusiso comes here, maybe to take something from the kitchen, maybe a spice Sibusiso goes and takes a piece in the kitchen then Sibusiso will run and say eish I have forgotten, Sibusiso now has forgotten what the parent asked him to do. It is a challenge even if you go to the classroom assisting the same learner will say I have forgotten and then you are not moving. So that is when I identify ok, this learner is a slow learner and he easily forget. I will call the parent we sit down , I will ask the background of the learner from birth. How did you give birth to the learner like a child? Then the parent will say Ok, I was delayed by cramps. I got the child in operation, the child was tired. The child is always tired, growing tired, reaching primary level tired. I am taking this child now as a learner. Then I have to put content inside. Then the learner since, the learner has been affected from birth, it won't

148. change. It is in me
149. patience to assist the learner and in that way, I can identify and group these learners
150. according to their needs and diversity. Thank you.
151. Zanele: Ok, thank you very much, sir. Question 9, how is your mathematical
152. knowledge has developed since you started teaching mathematics.
153. Thato: Mmhh since I am a 10 plus teacher neh…By 10. plus, teacher I am saying I
154. have moved from eehh….I a just a teacher now I a little bit senior. Not senior in terms
155. of qualification but senior in terms of content knowledge. A little bit of understanding
156. in terms of maths concept. Then I can say now, I have developed a little bit. I can say
157. I am moderate. Thank you.
158. Zanele: Ok, thank you, sir. which resources do you use when teaching?
159. Thato: Eehh…in this case, it differs from concept to concept, the most concept they
160. are practical. So, for example when I do addition and subtraction in terms of word
161. problems. I…I will…with the learners we will analyse the concept and try to break the
162. concept, then from breaking the concept that's when I will experiment with the
163. learners. So that they fit into the practical. And then in this case Eehh…it will be based
164. on the concept that I am teaching. So maybe aahh…3D-objects I will be using
165.the…the…resources that they demonstrate the 3D objects. and if it is an addition
166. maybe I will have some money coins. I put them in place and demonstrate how we
167. add subtract. Even if it's multiplication also then maybe apply a bag of maize meal,
168. with a bag of rice then you put a little then it will multiply and get better. In that way, I
169. can say it differs from concept to concept. But I am more practical. I use practical
170. resources. Yaahh…improving what I have. Thank you.
171. Zanele: Ok, thank you very much, sir. Question 11, how do you plan your lessons?
172. Thato: Mmhh…in this case, I use the CAPS documents since you know that we are
173. guided by policy. So I use CAPS document, from CAPS document Aahh I will have
174. my textbook ready, my workbook ready. Then for more concept eehh… more
175. information from other teachers. That's when I will use Youtube videos on how are
176. other teachers around the world aahh…are extracting information and how they teach
177. the concept. I am more ICT and yaahh practical when it comes to planning.
178. Yaahh…Thank you.
179. Zanele: Ok, thank you very much, sir. Is there anything that influences your
180. teaching and learning of mathematics?
181. Thato: Yaahh…since I was not a maths lover. Yaahh…I am influenced by the learners
182. that I am teaching. Since aahh…the generation of technology that we are in. It pushes
183. us from the world of geography and tourism to an ICT and engineering field

184. aahh…which is more scientific and then in this case I…I influence my kids positively
185. so that they can be able to do maths. And they can be able to further their studies in
186. the field of studying in mathematics. So, in this way that is how I approach the
187.situation Thank you.
188. Zanele: Ok, thank you very much, sir. The last question is there any support you
189. receive from the school leaders.
190. Thato: Yaahh…my HOD is very supportive. You know she is very supportive and she
191. understand my qualification very well. So, if is there anything that eehh…that doesn't
192. go right. Eehh she will approach me and then she will make one on one with me.
193. Yaahh in that way yaahh I receive support very well and also my principal she
192. understand my qualification and also understand my passion that I have currently
193. eehh…when coming to maths and teaching maths. So, she is very supportive
194. whenever there is a session, MST will inform and if there is any support financially
195. from the SGB then she will assist and request the SGB to assist. I am also part of the
196. group that is attending Pandridge college. Eehh…in that way the HODs, deputy
197. principal and also the principal are very supportive. Thank you.
198. Zanele: Ok, thank you very much Sir for your time I appreciate it. Thank you.

Interview with Bonga (School E, Participant E)

1.Zanele: Good morning, Sir.
2. Bonga: Morning mam
3. Zanele: Thank you very much for your time to allow me to come and interview you so
4. that you can share with me your teaching experience. For the first question, please
5. provide some background to your teaching career.
6. Bonga: Eehh I started teaching back in 2005, eehh I was teaching at high school. I was
7. teaching geography. I taught eehh…for five years. Then I moved to Emagcekeni primary
8. school. From that school, I was given mathematics as a subject to teach. So that is how
9. it is…So but eehh…in my teaching expertise and the experience. I majored in geography
10. in tertiary. But coming to primary I was given mathematics to teach as a subject.
11. Zanele: Ok, thank you very much, Sir. Question two, how do you view mathematics as
12. a subject?
13. Bonga: Eehh…mathematics as a subject…eehh it requires most of your time in terms
14. of planning and teaching, using different strategies so that you accommodate most of
15. the learners. So, it is very challenging because eehh…in tertiary or university I was not
16. equipped with such skills or tools which were going to assist me but currently. I am

17. trying and I am managing, but somewhere somehow, I still face challenges because it
18. was not my major subject. Thank you.
19. Zanele: Thank you very much, sir. Question 3, how do you see yourself as a
20. mathematics teacher?
21. Bonga: Eehh…I am a very dedicated teacher, and I am trying even though I encounter
22. challenges. Because ehh…you find that there are learners who encounter challenges
23. but eehh…it is difficult for me because I don't have the necessary skills and tools which
24. I must use in terms of assisting learners who are having challenges and barriers to
25. learning. But I am trying my level best, eehh…I am working very hard. Thank you.
26. Zanele: Thank you very much, sir. Question 4, do you believe that you have sufficient
27. subject matter knowledge to teach mathematics effectively or is there any content you
28. find it difficult?
29. Bonga: Eehh…aahh…I am using my knowledge of mathematics from high school and
30. primary school. And I am using that to teach and…aahh…there are other contents that
31. I find difficult for example, time zones because those require eehh…you to
32. measure with other subjects so it is somewhere somehow difficult. So, when I venture
33. into that particular content. I am usually requesting my Grade 7 teacher to come and
34. teach but with other content, I think I am now having the expertise to teach Grade 6
35. learners.
36. Zanele: Ok, thank you very much, sir. Question 5, how confident are you in teaching
37. mathematics?
38. Bonga: In the beginning, I was not confident enough eehh…because eehh…this is not
39. my area of specialisation. I tried my level best to align myself currently I am teaching
40. very well. So, I think that aahh…I am gradually I am getting there in terms of boosting
41. my confidence but in the beginning, I was a little bit eehh…shaky in terms of teaching
42. because you will find that there are learners with more knowledge and expertise more
43. than you. So, as you proceed you will realise that you need more experience than what
44. you have in class. But currently, I am working very hard, so I think I am getting there. I
45. am trying my level best to be a good teacher.
46. Zanele: Ok, thank you very much, sir. Question 6, which teaching approaches do you
47. employ when teaching mathematics? why?
48. Bonga: Eehh…aahh…I am using the available approaches the learners-centred
49. approach. The learner-centred approach assists me to identify learners with
50. challenges. It gives more opportunities to learners to self-discovery and more
51. eehh…techniques…of…eehh…teaching, so why I am. using learner-centred is
52. because I want learners to identify…and eehh find ways of solving problems by

53. themselves not me feeding all the time. I am there as a teacher to guide and assist
54. them. But most of the time, the learners themselves must be able to find new ways of
55. calculating and find new solutions.
56. Zanele: Ok, thank you very much, Sir. Question 7, how do you assess learners
57. understanding while teaching?
58. Bonga: I do assess learners understanding during teaching by asking questions and
59. also giving question verbally and also giving them classwork and we mark during the
60. class. So, I understand that if maybe aahh…most of the learners understand I will see
61. by the raise of the hands and they will respond positively so that will indicate that they
62. understand and even when I give them the classwork, they will write and get the correct
63. answers. So that is how I assess the class and also give me knowledge do the learners
64. understand or not.
65. Zanele: Ohh ok sir. Question 8, how do you accommodate the diverse needs of
66. learners when teaching?
67. Bonga: Mmhh…Yaahh most of our classes are overcrowded, so it is difficult to cater
68. different learners need. But I am trying to make sure that those learners who
69. understand fast I give them more work and those who are left behind I go to them to
70. explain on their tables. But it is very difficult because we are having highly packed
71. classes in this environment. Thank you.
72. Zanele: Ok, thank you very much, sir. Question 9 how is your mathematical knowledge
73. has developed since you started teaching mathematics?
74. Bonga: It has developed quite a lot. Aahh…exponentially or automatically because I
75. have been attending workshops and seminars where other teaching methods and
76. techniques, they were explained and the support from the curriculum implementers (CI)
77. and subject advisors. So currently, I developed, I am no longer the same as I have
78. started. So I have a lot of knowledge and a lot of skills which I can use in terms of
79. teaching. But you will understand since it's not my area of learning. I do have some
80. shortfalls but I am trying somewhere and somehow, I am going to gain knowledge. And
81. make sure that my knowledge is developed every time.
82. Zanele: Ok sir, thank you. Question 10. which resources do you use when teaching?
83. Bonga: Eehh…I am using a workbook, textbooks, and teaching aids. So…we don't
84. have the technical teaching materials, such as smart boards, eehh…or TVs,
85. smartphones or laptop. So, I am currently focusing a lot on using the textbooks and the
86. workbooks from the department of basic education (DBE), those are the ones that I am
87. using currently.
88. Zanele: Ok, thank you very much, sir. How do you plan your lessons?

89. Bonga: I plan my lessons by consulting my ATP annual teaching plan versus the
90. workbook and the textbooks. So, I know that this week teaching these topics and this
91. sub-topics. So, they assist me. I plan I write them on my laptop and then print them and
92. then I make sure that they are available. Even my HOD and my deputy principal when
93. they come to visit me they will find them in my class and also in my file.
94. Zanele: Ok, thank you very much, Sir. Question 12, is
95. there anything that influences your teaching and learning of mathematics?
96. Bonga: Eehh…mmhh…Yes eehh…I want to see eehh…learners become leaders of
97. tomorrow and I also I want to be urgent of change that one influences me
98. positively. Because I am trying my level best to make sure learners get good at the
99. the foundation of mathematics. So, I want to lay a good foundation in mathematics.
100. So I want aahh…to lay a good foundation of mathematics in the intermediate phase.
101. So that's what influences me in teaching mathematics.
102. Zanele: Ok, thank you very much, sir. Question 13 is there any support you receive
103. from the school leaders?
104. Bonga: eehh…Yes…even though it's not enough but we do have the teacher
105. development programmes and also, we do have eehh…eehh. Subject advisors who
106. are gradually invited by the principal and the deputy principal to come and assist in
107. terms of making sure that what we teach is in line with that in the Annual Teaching
108. Plan (ATP). I am being assisted so the deputy principal is assisting but should
109. understand that even he is not the expert in the subject, so he is using what is at her
110. disposal. Thank you.
111. Zanele: Ok, thank you very much sir. We came to the end of the interview. Thank you
112. so much for your time. Thank you.

Interview with Xoli (School F, Participant F)

1. Zanele: Good afternoon mam, thank you very much for your time. I appreciate it. I have
2. got few questions that I want you to share with me about your experience in teaching
3. mathematics. The first question, please provide some background to your teaching
4. career.
5. Xoli: Thank you very much mam…eehh… I hold a National Diploma in teaching. Eehh…
6. majored in English. And also hold an Advanced Certificate in Teaching (ACT) majored
7. in science and technology.
8. Zanele: Ok mam, how do you view mathematics as a subject?

9. Xoli: Eehh…mathematics provides opportunities for learners to share mathematical
10. ideas and problem-solving.
11. Zanele: Ok mam, on the background as well how many years you have been teaching
12. mathematics?
13. Xoli: Aahh… it's not so long. It's been two years since I have started teaching maths.
14. Zanele: Ok, you also had maths in high school?
15. Xoli: yes, I did.
16. Zanele: Ok, thank you very much, mam. Let us go to question three. How do you see
17. yourself as a mathematics teacher?
18. Xoli: aahhmm…hopefully I will be teaching maths the next coming five years. And I am
19. planning to upgrade myself in my profession. I want to major in maths do yaahh…
20. Zanele: Ok, thank you very much mam: Do you believe that you have sufficient subject
21. matter knowledge to teach mathematics effectively? or is there any content you find it
22. difficult?
23. Xoli: I don't find any difficulties in teaching maths aahh…yes before I have difficulties
24. but for now, I can't. I am even able to teach long division of 3 digits by 1 that's all.
25. Zanele: Ok, thank you very much, mam. How confident are you in teaching
26. mathematics?
27. Xoli: Very confident, eehh…I feel confident and proud.
28. Zanele: Ok, thank you very much mam which teaching approaches do you use when
29. teaching mathematics? Why?
30. Xoli: Aahh…I use Aahh images, visuals, real objects as my student will come across
31. countless images graphs in their textbooks.
32. Zanele: Ok, so in class how do you teach the learners or interacting with them? Do you
33. group the learners to work together or you are the ones who present the lesson and
34. do learners write by themselves?
35. Xoli: I usually present the lesson due to COVID we no longer group them.
36. Zanele: So, you present the lesson, and they write by themselves.
37. Xoli: Yahh…
38. Zanele: Ok thank you very much, mam, how do you assess the learners understanding
39. while teaching?
40. Xoli: I ask them questions to test their knowledge. if they haven't
41. understand what I have been teaching, I will then try to explain it again.
42. Zanele: Ok, thank you very much, mam. How do you accommodate the diverse needs
43. of learners when teaching?

44. Xoli: Aah…mmhh…firstly I will have to identify the learners' learning needs from there
45. I will apply the IEP of which is individual education need. For instance, those who have
46. impairments problem, maybe it can be sight or hearing I make sure that I place them
47. in front of the classroom.
48. Zanele: Ok, how is your mathematical knowledge has developed since you started
49. teaching mathematics?
50. Xoli: Aahh…I have developed a lot, my mentor played a huge role and making me a
51. maths teacher.
52. Zanele: Ok, thank you very much, mam. Which resources do you use when teaching?
53. Xoli: mmhh…I use aahh…Viva mathematics textbook, workbook, ATP, and CAPS
54. document.
55. Zanele: Ok, thank you very much. I there anything that influences your teaching and
56. learning of mathematics?
57: Xoli: Yahh…Yes yahh…the positive influence in that most of my learners enjoys
58. mathematics the way I present my lesson to them, it makes them want more. Aahh the
59. negative influence is that some of the learners do not do their homework due to,
60. they don't have parents they are staying with grannies. Their grannies can't help
61. them with my homework.
62. Zanele: Ok, you said that the learners come once a week or after how long?
63. Xoli: it's a very…very, I mean its very challenge because they come once a week due
64. to COVID.
65. Zanele: Ok, thank you. Is there any support you receive from the school leaders?
66. Xoli: Yes, I do from the principal and the departmental head. Mmhh…they provide me
67. with aahh…teaching aids they even help me and disciplining learners.
68. Zanele: Ok, thank you very much, mam. Is there anything which you would like to share
69. based on the teaching experience since you haven't specialised in mathematics, how
70. have you been teaching or any challenges you experienced and how you have
71. overcome them?
72. Xoli: Eehh…As I said earlier on. The challenges I came across was teaching the long
73. division but now I am covered with it. The challenge I had was teaching long division.
74. My mentor plays a huge role in how to explain it to my learners. And how to divide the
75. remainder up until I get the correct answer.
76. Zanele: Ok, thank you very much mam, for your time. I appreciate your time. Thank
77. you:

Interview with Lihle (School G, Participant G)

Zanele: Good morning mam, thank you very much for your time, I appreciate it. Aahh…I have got few questions which I would like you to share with me your experience of teaching mathematics. Aahh the first question can you please provide some background to your teaching career.

Lihle: Ok, morning mam.

Zanele: Morning

Lihle: Ok, I can say mathematics to me it's like a language subject because it uses symbols, a notation to describe the relationship in geometric and graphic activities,

Zanele: Ok, aahh can you please tell us more about your qualification, when did you start teaching what were you teaching and what are you currently teaching?

Lihle: Ok, I started teaching mathematics eehh…in 2007 so it's plus or minus 10 to 12 years. So, I didn't do mathematics as a major subject. My major subject was English mmhh…and eehhh school library.

Zanele: Ok, thank you very much, mam. Question 2, how do you view mathematics as a subject?

Lihle: Ok…mmhh…mathematics as a subject…aahh according to my own opinion, it is a very easy subject for all of them. If I look at the experience that I have been teaching with the learners is an easy subject. Because in mathematics once you master the four basic operations that are multiplication, division, eehh…subtraction and addition you cannot go wrong. You can't say you don't know mathematics if you know the four basic operations. Zanele: Ok, thank you very much, mam. Question 3, how do you see yourself as a mathematics teacher?

Lihle: Ok…as a mathematics teacher aahh…I see myself as someone who has the confidence to help the learners to understand that mathematics it's not a difficult subject like we use to know. We used to know that mathematics is difficult. That if you pass maths, you are a genius. Mathematics is a normal subject, it's like the other subjects. It's like English, it's like Siswati, it's like life skills.

Zanele: Ok, thank you very much mam. Question 4, do you believe that you have sufficient subject matter knowledge to teach mathematics effectively? or is there any content you find it difficult?

Lihle: Aahh…For now I cannot say that there is a content that I find difficult because we normally use the DBE workbooks that we are provided by the government. So

34. they state clearly what we must do inside the classroom with the learners. Even if you
35. don't understand, even if you didn't even major in mathematics but you can also teach
36. mathematics using that DBE workbook.
37. Zanele: Ok, meaning that the activities are clearly explained in the workbook.
38. Lihle: Yes, they are clearly explained. They are not that much difficult.
39. Zanele: And you don't have any subject matter problem, or do you think you have a
40. knowledge gap in any topic?
41. Lihle: No…I don't think there is a gap. I think maybe the problem it's the teaching
42. aids. Yahh…Because this subject needs you to involve the things that are happening
43. in real life. Even if you make examples, you make examples using the children inside
44. the classroom. Using their chairs and tables and also the cars of their teachers inside
45. the school. So, for now, there is no gab.
46. Zanele: Ok, thank you very much mam. How confident are you in teaching
47. mathematics?
48. Lihle: I am very confident in teaching mathematics.
49. Zanele: Ok, thank you very much mam. Question 6, which teaching approaches do you
50. employ when teaching mathematics? Why?
51. Lihle: Ok…the teaching approaches I usually use when teaching mathematics. The first
52. one that I prefer it's a group work. But now due to COVID-19, no we are not allowed
53. to…we must maintain the social distance. But it helps when the learners, look at the
54. activities as a group and discuss it and help one another to solve the problem. But for
55. now, we use the one-on-one question and answer.
56. Zanele: Ok, thank you very much, mam. How do you assess the learners understanding
57. while teaching?
58. Lihle: Ok, I can say that I assess them by asking questions based on the topic of that
59. day so that I…I can see that they understand me, or they are left behind. Also, by giving
60. their activities when we mark the activities and asking them. What is the answer here?
61. When they respond I can see that they didn't understand that topic. So that is how I
62. assess my learners. Whether they do understand, or they didn't understand that topic.
63. Zanele: Ok, thank you very much, mam. Question 8, how do you accommodate the
64. diverse needs of learners while teaching?
65. Lihle: Mmhh…Yaahh this one is very difficult (laughs). But eehh…we are trying our
66. level best maybe to communicate with them in English because maybe we have a
67. Venda or Tsonga learner inside the classroom. If we communicate in English, it
68. becomes easier for them to understand.
69. Zanele: Ok, thank you very much, mam. How is your mathematical knowledge has

70. developed since you started teaching mathematics?
71. Lihle: Eehh…it has developed a lot because now. Eehh I am loving this subject I
72. don't know whether one day the principal will say you don't teach this subject
73. mathematics anymore. The way I like it now (Laughs) I love it. I like it like myself I enjoy
74. teaching mathematics. Because you don't need to write notes a lot of notes. You just
75. write an equation or the problem on the board. Then try to explain to the how can
76. do they solve that particular problem? Mmhh…Then after that you are done. Even
77. if…when it comes to exams when we are marking. We teachers of mathematics we are
78. the first ones to submit. It's very easy to mark it. I don't even need to memorise the
79. memo. Because I love this subject, I just look at the problem and see that this is correct.
80. I don't need to stress very much.
81. Zanele: Ok, thank you very much, mam. Question 10, which resources do you use
82. when teaching?
83. Lihle: Ok, eehh…the first resources that I use when teaching, I consult the policy
84. document because I am teaching Grade 6. I look at the policy that is written
85. intermediate. That it's Grade 4 to 6 because the grades they intergrade. What is done
86. in Grade 4, it's also done in Grade 5 and also be done in Grade 6. So, I use the
87. policy document, the DBE workbook the government is providing us and learners they
88. have DBE workbooks. Mmhh…Also I use the lesson plans. Because the lesson plans
89. even if you don't know mathematics, they clearly state what you must do. What you are
90. expected to do inside the classroom. You don't need to go inside the classroom. You
91. don't need to go and ask someone that Eehh…I don't understand this topic. In the
92. lesson plan clearly states that you are doing this now, you are doing this after you are
93. given an activity then you are done. It also clearly indicates the resources that you must
94. use. That is based on that particular topic in that way becomes easier.
95. Zanele: Ok, thank you very much, mam. Do you have teaching aids here at school?
96. Lihle: Yes, we do have teaching aids, but they are not enough. They are not enough
like 97. for example, when we are doing measuring eehh…the department usually say they
98. don't have money to buy the scales, the different types of scales. So that you can show
99. the learners if you talk about the bathroom scale, kitchen scale and whatsoever so that
100. they can see what you are talking about. So, we have the teaching aids, but they are
101. not enough.
102. Zanele: Ok, thank you very much, mam, how do you plan your lessons?
103. Lihle: In my lessons, I plan them according to the terms because we have four terms.
104. I have lessons for term 1, for term 2, for term 3 and term 4. But they are categorised

105. daily, daily lesson plans. Some take even 2 hours so if they take 2 hours it means it's
106. for two days but I plan them according to the term.
107. Zanele: Ok, thank you very much, mam. Question 12, anything that influences your
108. teaching and learning of mathematics?
109. Lihle: Mmhh…
110. Zanele: Can either be positive or negative anything that influences your teaching.
111. Lihle: Yahh…I can eehh…say that teaching mathematics can be…to me it influences
112. me positively. Because eehh…when I was still studying at the secondary level. I didn't
113. know that one day I will be a maths teacher because they use to say that mathematics
114. it's difficult. But when I am teaching, I can see that mathematics is the easiest subject
115. of them all. So, it positively influences me.
116. Zanele: So, you don't have a problem with maybe overcrowding or discipline in
117. classes and so forth that can. influence your teaching? Parental involvement.
118. Lihle: Eehh…
119. Zanele: Parental involvement.
120. Lihle: Eish that one, I won't say I don't have overcrowding because eehh…it's
121. easier because they don't come in large numbers. But when there is no COVID-19 it
122. is a problem because you'll find that the class is overcrowded you can't even move
123. to assist the learners that are having learning barriers. So…so in that way, it influences
124. me in a negative way the overcrowding. Yahh it is a contextual factor that one.
125. Zanele: Ok, so the learners do they write their work or do their parents assist with
126. helping their children as well.
127. Lihle: aahh…most of them write only a few that they don't write. And if you look at
128. the background of the child who comes to school didn't write the home activity. You
129. will find that the children are staying with the brothers. He or she doesn't have parents,
130. so, it becomes a problem and also those who stay with grandparents or grandmothers.
131. Some of them are illiterate so it becomes a problem for that child to write the
132. home activity.
133. Zanele: Ok, thank you very much, mam. The last question is there any support you
134. receive from the school leader?
135. Lihle: Yes, there is a support that we receive from our leaders. They normally conduct
136. meeting maybe twice a term so that they can develop us. Let's say maybe I have
137. a problem with my learners in calculating the number. So, they give me strategies
138. what can I do so that the learners can understand easily.
139. Zanele: Ok, do you also attend workshops.
140. Lihle: Yes…The curriculum implementers set the dates we attend the workshop.

141. then they give us activities to write about. And if they see that you don't copy on that
142. problem. Then they assist you, they come and visit at school. Look at the paper
143. you have written they look at the name of the school and they come and give support
144. and develop you.
145. Zanele: Ok mam. Do you perhaps also receive the support from your HOD or the
146. school principal.
147. Lihle: Ok, we usually get the support from the HOD, not the principal. Yahh…we
148. usually get the support from the HODs', like aahh…when he or she is conducting the
149. the meeting, or when we are analysing the results of the learners. He checks the SIP
150. the School Improvement Plan and see where the challenges are for my learners. She
151. come to my classroom and observe my teaching then after that she calls me to the
152. office and to develop me. Ok, thank you very much mam for your time. We have come
153. to the end of the interview. I appreciate your time.
154. Lihle: Ok.

Interview with Thoko (School H, Participant H)

1. Zanele: Good afternoon mam, thank you for your time. I appreciate it. I will like you to
2. share with me your experience of teaching mathematics. I have got few questions which
3. I would like you to answer. For the first question, please provide some background to
4. your teaching career.
5. Thoko: I do have experience in the subject. It's almost 12 years or more teaching this
6. subject.
7. Zanele: Ok can you please tell us about your qualifications for your teaching career.
8. Thoko: My qualifications its aahh…SPTD stands for Senior Teachers Diploma, and I do
9. have ACE in management and also a participant certificate for natural science for grade
10. 7 and 9.
11. Zanele: Ok, on your SPTD, what did you measure with?
12. Thoko: I have measured with Xitsonga and Geography.
13. Zanele: Ok thank you very much, mam. Question 2, how do you view mathematics as
14. a subject?
15. Thoko: Maths need a lot of time to practice every day when you go to class. It's not
16. difficult for me. It needs time.
17. Zanele: Ok, thank you very much, mam. Question 3, how do you see yourself as a
18. mathematics teacher?
19. Thoko: Hard worker, allowing learners to participate in class and as a teacher at the

20. end give them feedback as corrections.
21. Zanele: Ok, thank you very much. Do you believe that you have sufficient subject matter
22. knowledge to teach mathematics effectively? Or is there any content you find difficult?
23. Thoko: Mmhh…I don't have any challenges with maths.
24. Zanele: Ok thank you very much. Question 5, how confident are you in teaching
25. mathematics?
26. Thoko: I do have confidence in this subject because I know maths since from the
27. beginning when I was learning in primary school and also in Secondary school
28. I was learning mathematics up to Grade 12. So, I don't have a problem.
29. Zanele: Ok, thank you very much, mam. Question 6, which teaching approaches do
30. you employ when teaching mathematics? Why?
31. Thoko: When I am busy teaching, I am allowing the learners to ask questions. If they
32. don't understand then I do have a strategy to help them to understand.
33. Zanele: Ok thank you very much. How do you assess learners understanding while
34. teaching?
35. Thoko: I have to repeat a question or lesson while I am busy teaching for
36. them to understand and after school, I will remain with the learner are not able.
37. Zanele: Ok mam question 8, how do you accommodate the diverse needs of learners
38. when teaching?
39. Thoko: As equally.
40. Zanele: How do you accommodate them because we have those slow learners and
41. the clever ones who learn very fast, how do you accommodate them in class?
42. Thoko: Ok…I group them, I take the clever one and I mix them with the slow ones in
43 order to assist each other while busy writing.
44. Zanele: Ok thank you very much, mam. Question 9, how is your mathematical
45. knowledge has developed since you started teaching mathematics?
46. Thoko: It has developed by attending the workshops and also the curriculum
47. implementers sometimes coming to our school and assist us. Or also go to our senior
48. or colleagues in another school to assist.
49. Zanele: Ok thank you very, mam. Which resources do you use when teaching?
50. Thoko: We are using the textbook and also the workbook. And all the pictures when
51. it's needed like when you are teaching the 2-D shapes and 3-D it needs some pictures,
52. the objects like when you teach 3D, there are polygons hexagons. So, you have to
53. show the learners what is a hexagon, then even the net when doing 3D how to find the
54. net there. More especially the cubes and also the cylinder you must be done have an
55. object. The picture and the object, the tools that we are using to find the learners to

56. understand what you are teaching like a roll of tissue of paper that rolls its cylinder.
57. You can easily show the learner the sides.
58. Zanele: Ok thank you very much, mam. How do you plan your lessons?
59. Thoko: I am planning the lesson before I go to class.
60. Zanele: Ok, question 12. Is there anything that influences your teaching and learning
61. of mathematics?
62. Thoko: Yes…learners must be getting better marks to show that I am teaching.
63. Zanele: Ok thank you very much, mam. The last question is there any support you
64. receive from the school leaders?
65. Thoko: Yes, our school assist us and also the curriculum implementers when coming
66. to school for moderation, they assist us.
67. Zanele: Ok thank you very much mam for your time we come to the end of the interview.
68. Thank you very much.

Interview with Buhle (School I, Participant I)

1. Zanele: Good morning mam
2. Buhle: Morning Mam
3. Zanele: Thank you very much for your time. I would like you to share with me your
4. teaching experience in teaching mathematics. I have got few questions. First, please
5. provide some background to your teaching career.
6. Buhle: Ok…I started…Aahh…I have got a diploma teaching foundation phase. I have
7. started teaching in 2007 at Grade 3 and after the death of my colleague the principal.
8. We got the challenge of a teacher and the principal asked me to go to the intermediate
9. phase. Then I started teaching Grade 4 to 6 in 2010 if I am mistaken until now.
10. Zanele: In those Grades, you were teaching what?
11. Buhle: I was teaching maths and life skills.
12. Zanele: Ok, thank you very much. How do you view mathematics as a subject?
13. Buhle: I view mathematics as a challenging subject and need more practice.
14. Zanele: Ok thank you very much, mam. How do you see yourself as a mathematics
15. teacher?
16. Buhle: I see myself as a maths teacher now because I am used to it.
17. Zanele: Ok thank you very much, mam. Question 4, do you believe that you have
18. sufficient subject matter knowledge to teach mathematics effectively? or is there any
19. the content you find difficult?

20. Buhle: No, there are content that I find difficult especially rate and rate, pattern
21. symmetry and time zone. Before I teach these topics, I first consult my other teachers
22. who are doing mathematics in Grade 7.
23. Zanele: Ok, thank you very much, mam. How confident are you in teaching
24. mathematics?
25. Buhle: I am confident in some and I am not in some other topics.
26. Zanele: Ok, thank you very much, mam. Question 6, which teaching approaches do
27. you employ when teaching mathematics? Why?
28. Buhle: Eehh…I am using the teacher-centred method because eehh…I see it is an
29. easier method approach to the learners.
30. Zanele: Ok thank you very much, mam. How do you assess learners understanding
31. while teaching?
32. Buhle: Aahh…I ask questions in class and give them class and home activities.
33. Zanele: Ok thank you so much, mam. How do you accommodate the diverse needs of
34. learners while teaching?
35. Buhle: Ok…learners who have barriers to learning I assist them individual and those
36. ones who are clever I give them more work to do while I am assisting other learners
37. who have barriers. Ok, thank you very much, mam. How is your mathematical
38. knowledge has developed since you have started teaching mathematics?
39. Buhle: It has developed a lot…aahh…a lot…a lot.
40. Zanele: Ok, thank you very much, mam. What resources do you use when teaching?
41. Buhle: I use maths lab teaching aids, workbooks and textbooks and the board.
42. Zanele: Ok thank you very much, mam. How do you plan your lessons?
43. Buhle: Mmhh…currently I am using the ones that the government has provided us.
44. Zanele: Ok, thank you very much, mam. Is there anything that influences your teaching
45. and learning of mathematics?
46. Buhle: Yes, because I got assistance from other colleagues especially the topics that I
47. am struggling with. And there is no parental involvement, the parents when I give the
48. learners' homework they do not assist them. So, it gives me a challenge.
49. Zanele: Ok thank you very much, mam. Is there any support that you receive from the
50. school leaders?
51. I receive support especially from the workshops from the CI who are workshopping us.
52. Zanele: Ok mam, you don't receive support from the school HOD or Principal?
53. Buhle: We don't have a HOD in our school so…I got the support from other teachers
54. when I have got problems, or when I have got challenges in other topics, I consult with

55. they and they assist me. And I also phone my CI, he is always available. When I phone
56. him when I got a problem, he also assists me.
57. Zanele: Ok thank you very much, mam. We came to the end of the interview.
58. Thank you for your time.
59. Buhle: Thank you.

Interview with Mpho (School J, Participant J)

1. Zanele: Good afternoon mam.
2. Mpho: Ohh sorry (laughs)
3. Zanele: Good morning mam
4. Mpho: Morning
5. Zanele: How are you?
6. Mpho: I am ok and how are you dear.
7. Zanele: I am good thank you. Thank you very much mam for your time and the
8. opportunity you allowed me to come
9. and interview you to share with me your experience of
10. teaching mathematics. I have got few questions, the first question can you please
11. provide some background to your teaching career.
12. Mpho: Ok, I have been teaching since 1996. So you can count. Yeah, as the years
13.pass by instead of it to become simpler and simpler. It becomes tougher and tougher.
14. Looking at our education system in the olden days. It was easy because the learners
15. were taking tasks as important, but these days it's not like that. Even if they don't write
16. their work, their homework or classwork. Discipline it's a problem since there is no
17. corporal punishment. It is very difficult because even the bible says that spare the rod
18. and spoil the child. This means how I can teach a child when she knows that she has
19. got right. It doesn't matter whether he does her work, or she doesn't do her work. So,
20. we are teaching nevertheless what else can we do.
21. Zanele: Ok mam. Can you please tell us about the background of your qualification and
22. how many years you've been teaching maths?
23. Mpho: Ok, like I said I have been teaching since 1996. I have been teaching maths for
24. the past 9 years. Aahh...mathematics is quite an interesting subject. And there are
25. few challenges when it comes…Maybe it depends on how much you know. So, you
26. understand. So, in that instance, I enjoy it but when I teach them a few. They
27. understand some they don't because of their different IQs as you know. They have got
28. different IQs. As I have said we teach nevertheless because it's a job.

29. Zanele: Ok mam, what qualification do you have.
30. Mpho: I have a degree in family and consumer sciences with education. With education
31. you know the principle of teaching learners, of addressing learners and everything.
32. Zanele: Ok, thank you very much, mam. How do you view mathematics as a subject?
33. Mpho: It is a necessity, there is nothing you can do without mathematics.
34. Yaahh…because even if you are working for maybe in the farms, they will ask you to
35. count the number of tomatoes, so if you do not have a mathematics
36. the background then it's a problem. So, you need to have mathematics.
37. Zanele: Ok thank you very much, mam. How do you see yourself as a mathematics
38. teacher?
39. Mpho: Aahh…with the younger ones, I think it's (laughs)… it's ok for them to pursue
40. the mathematics. But with me where I am I think I am comfortable because at the end
41. of the day, there are no challenges and I do not need much.
42. Zanele: Ok thank you very much, mam. Do you believe that you have sufficient subject
43. matter knowledge to teach mathematics effectively? or is there any content you find it
44. difficult?
45. Mpho: At this level nothing.
46. Zanele: Ok thank you very much, mam. How confident are you in teaching
47. mathematics?
48. Mpho: With the experience, nothing is challenging.
49. Zanele: Ok, thank you very much, mam. Which teaching
50. approaches do you employ when teaching mathematics? Why?
51. Mpho: So, we use different techniques when teaching
52. learners. If this one doesn't work, you try another one. But with this type, we use the
53. teaching aids and chalkboard. We do not have sophisticated staff. It is the simplest one
54. for this level.
55. Zanele: Ok, thank you very much, mam. How do you assess learners understanding
56. while teaching?
57. Mpho: With the experience, you can tell by looking at them on their faces, that there is
58. the trouble here, there is no problem. So, like I said with time you learn to understand
59. them with their facial expressions. Even before you even go to their book, you get it
60. from your teaching. You get it that this ones eehh…let me try another method for
61. those once.
62. Zanele: Ok thank you very much, mam. How do you accommodate the diverse needs
63. of learners' when teaching? Since our learners are different, we have slow learners,
64. the clever learners as you indicated that learners have different IQs.

65. Mpho: Mmhh…Yahh…Aahh…Ok may you please repeat the question.
66. Mpho: Yahh…that one is a very big challenge as I have said that the system is
67. becoming tougher and tougher.
68. Because they tell you that you cannot teach as a child for more than 3 years in one
69. Grade. This means that even if the learner has not assimilated the content that he/she
70. was taught. She has to be progressed. This means you are teaching
71. learners who are diverse in the fact that the learner knows nothing, but we push him or
72. her to the next grade. So, in that way how can we do that in 50 minutes assisting the
73. ones that can't assimilate what you are teaching them at the same time, you have to
74. move forward, because the content is scheduled there is no way that you can say that
75. you will see them next week. I am still pushing those who can't learn or do not
76. understand. So sometimes you bypass that not directly. You try what you try but if you
77. see that this one I am wasting my time. I can't win this battle; you move forward with
78. this one who understands. We give them what we give them per day because of this
79. the thing it's scheduled, there is a teaching plan, a topic must be covered in two
80. days. So, if you have a slow learner, you give them what you give them, but you know
81. very well that this one I am just wasting my time the time that I do not have.
82. Zanele: Ok thank you very much, mam. How is your mathematical knowledge has
83. developed since you started teaching mathematics?
84. Mpho: how, please read that one.
85. Zanele: How is your mathematical knowledge has developed since you started
86. teaching?
87. Mpho: how has it developed? Ok actually in the older days they were using whatever
88. it was available for you. For instance, stones etc. as for this grade, they are allowed to
89. use calculator. Us we are still using the olden methods as we use their thinking
90. capacity, we rely on it mmhh…So that's how we do it. It's not about developing
91. ourselves. It's about developing the learners. As long you know that they understand
92.the topic. then you become happy. We have done our part. We are pushing it further to
93. our learners. Mmhh…so there is no need for us to develop in the lower level. I think I
94. can understand with the higher standards. Yes…Because with them you have to
95. expose them to A and B. So, with us, we attend workshops Yes, the workshop they are
96. not benefiting us much because we simply address, tackling problems concerning
97. certain methods or calculating mathematical problems you see. It not helping us much,
98. maybe with the learners as they go further but with these learners, there is no
99. much is done.
100. Zanele: Ok, you mean that not much is done to help teachers develop.

101. Mpho: Eehh…like I said with the lower level it's about providing teaching aids
102. and addressing the issue of the learners that one it's for higher grades, not us.
102. Zanele: Ok
103. Mpho: Yes
104. Zanele: Ok thank you very much, mam. which resources do you use when teaching?
105. Mpho: Aahh…I use the textbooks, I use the workbooks, I use the teaching aids
106. whatever I need for that particular topic. Whatever it's available.
107. Zanele: Yes…do you the resources in the school?
108. Mpho: Yes, we do have even though we are sharing so you need to tell whoever your
109. partners like in our thing we have mathematics group. So, you report before that I will
110. be needing this maybe someone is using it so that they can prepare them for me. I
111. tell them that tomorrow I will need them so that they can make it ready. If it's not there
112. then it's not there you use what you can do, you do what you can do.
113. Zanele: Ok, thank you very much, mam. How do you plan your lessons?
114. Mpho: Ok our lessons we plan prior like right now our department has given us their
115. own lessons. So, what you do before you take learners abroad you refer to the lesson
116. plans that are provided.
117. Zanele: Ok thank you very much mam is there anything that influences your teaching
118. and learning mathematics? It can influence you positively or negatively for instance
119. as you've indicated learners' discipline can influence your teaching and also them
120. learning. Or overcrowding anything that influences your teaching.
121. Mpho: Yahh…Yahh…I can say there is, aahh…what is it that influencing the
122. teaching. The time is given, whatever time that we are given. I strongly believe that
123. it's enough time but the content is too much. Because you'll find that you are given a
124. a lot of activities that need to be done yet the time is not enough. Yes, it is enough
125. because they can learn something. If they can reduce the number of activities that are
126. given in the workbooks instead of having about 20 problems a day, maybe if we can
127. focus on 5 questions so that you can know very well that these learners heard
128. you…you have done justice yourself as a teacher. Mmhh…if that can be done it can
129. be fine. I tell them to select one problem per group. In that way, it works but with all
130. the problems in front of them it becomes discouraging even to the learners. So…that
131. is what we have decided at our school as maths teachers that now we give them
132. enough because it depends on their IQs as I have said, the level of their IQ
133. assimilation is low. So, you can't be feeding them too much in the process of trying to
134. make them learn. No, you are discouraging them because at the end of the day they

will look at you and not write and even if they do write, they write one because they can see themselves that this is too much. There is just too much work we are overloading the young ones which are not fair. So that is why we opt for choosing a few aahh…problems to be done in each day as a way of trying to make sure that at least they benefit something. Even if the CI they come we tell them the same thing, that it's just too much work on the workbooks, it's too much even if you can give it to whoever is coming to check to do the activity, they cannot do it in one hour.

Mmhh…there is just too much to be done.

Zanele: Mmhh…when they take the work at home do they complete it?

Mpho: Some do some don't because when you look at the fact that some mothers they leave the house at 3 in the morning and when they come back, they have no Time. Some they are not even learned. So, you need to make sure that you do justice at work. you give them work that they can do. You give them maybe one problem to go and do at home which they don't do. So, you rely on what they can do. So that is how we play the game.

Zanele: Ok thank you very much, mam. The last question is there any support you receive from the school leaders?

Mpho: Yahh…we do get support like I said, sometimes they organise workshops. Whereby we discuss A, B, C, D but most of the time we end up talking about the same problems every time. Which doesn't make much sense when you look at it but at the end of the day you have to do it for compliance's sake. Otherwise, it's not benefiting us much. Because if we report a problem, the problem is not attended like this one of the workbooks and next year they will bring the same workbooks and with the same load of problems. Which they expect teachers to give to the learners, no it's just too much. You can look at it yourself and look at the level of these learners.

Zanele: Mmhh I know…

Mpho: It doesn't make sense what else can we do? we are just teachers?

Zanele: So, do they support you maybe with content.

Mpho: content is fine like I said the problem is there is too much workload per day for these learners, not us teachers because the people who are writing this sum there are learners, not teachers. I teach them I give them examples they write but the work it's too much. Sometimes in the workbook, they mix the topics. No…the learners need to be taught one thing a day. You can't say we are going to do multiplication and number patterns in one day. You understand, today we are doing maybe addition, tomorrow subtraction, multiplication then division, they are going to understand but if you bring two topics in one day you are confusing the small ones, No. then if it's

171. division then maybe you give it two days eehh…because you are going to use
172. this method if it doesn't work. You do the other method then you are teaching
173. learners but if it is the division with all these problems in front of them at the same
174. time, you have to do number patterns with them it's confusing, it's just confusing
175. learners If they can be taught one topic or one topic in two days depending on the
176. subject matter…mmhh it becomes easier but what can we do, we take it as we are
177. given. We do justice and then that's it.
178. Zanele: Ok thank you very much mam for your time I appreciate it, thank you.

APPENDIX F: LESSON OBSERVATION

Date of the observation	24 May 2021
The school (pseudonym)	School A
Name of the teacher (pseudonym)	Plato
Subject	Mathematics
Grade	6
Number of learners	27
Time	11:00-12:00
Lesson topic	Addition and subtraction of fractions with different denominators

Elements of classroom practice to be observed	**Question guiding observation**	**Comments**
Subject matter knowledge	Is the content presented adequately?	The content was incorrectly presented
	How is the content presented?	The content was presented incorrectly, the teacher was confusing the multiples with factors. He also incorrectly showed them how to find the lowest common denominator by finding the factors instead of LCM. The teacher wrote factors and said are multiples, and he also explained that multiples are numbers that go into another number without leaving a remainder.

	How the teacher uses real-life examples to explain the concepts thoroughly.	The teacher did not use practical examples to explain the concept.
	Is the teacher able to respond to the learner's questions correctly?	The learners did not ask any questions.
	Is the teacher asking enough questions for the learners to develop critical thinking?	No, the teacher was just asking simple recall knowledge questions and he did not ask enough questions.
	Can the teacher encourage classroom discussion?	The classroom discussion was not encouraged. When the learners respond to the teachers question the teacher just say yes or no.
Didactical skills	What teaching approaches are employed in the classroom?	Teachers-centred approach. He was doing the sums on the board showing them step-by-step how to calculate.
	Does the teacher link content to the learners' previous knowledge?	The teacher started the lesson on the learners' previous knowledge of common fractions. He started the lesson by asking learners to give examples of common fractions. and reminding them that a fraction has two numbers, a numerator, and a denominator. But he did not ask them how we add or subtract fractions of the same denominators, to determine the prior knowledge of addition and subtraction of fractions.
	Does the teacher accommodate the diverse needs of the learners when teaching?	No, the teacher always asking questions to the clever learners. Only the learners sitting in front were pointed by the teacher to respond to the questions.

	Does the teacher ask the questions while teaching to ensure that learners understand the content being taught?	Yes, but only knowledge low cognitive level questions.
	Does the teacher use the learners' questions and responses to further elaborate on the content being taught?	The teacher was not using the learners' responses to further explain the content.
	How does the teacher encourage learners' participation throughout the lesson?	The teacher was not encouraging learners to participate, few learners were responding when he asked questions.
	What teaching resources does the teacher use when teaching?	Whiteboard, textbook, and workbooks.
	How does the teacher assess learners understanding of content?	He was asking learners questions while teaching. He also gave them a class activity to complete. He asked one of the learners to come in front and write the answer on the board.
Teachers' beliefs	How confident is the teacher in teaching mathematics?	The teacher lack confidence. The teacher taught the concept as fixed ruled and the learners need to master the procedures. He relies heavily on his textbook when teaching and asked few questions and was not using the learners' responses to thoroughly explain the content.
Contextual factors	How is the classroom sitting arrangements?	The learners were sitting individually adhering to the COVID regulations of social distance.
	Does the teacher have mathematics resources for teaching?	I only saw the textbook and a DBE workbook.

	How is the school context?	The school have good classrooms, pit toilets and water tanks.

Adapted from Kekana (2016)

LESSON OBSERVATION CHECKLIST

Date of the observation	28 May 2021
The school (pseudonym)	School B
Name of the teacher (pseudonym)	Zano
Subject	Mathematics
Grade	7
Number of learners	34
Time	07:30-08:30
Lesson topic	Integers (commutative and Associative property to prove the equations whether the right hand and left-hand side are equal)

Elements of classroom practice to be observed	**Question guiding observation**	**Comments**
Subject matter knowledge	Is the content presented adequately?	The teacher presented the concept incorrectly. The lesson was not presented correctly, the teacher was making mistakes as she was teaching. She explained that they would do the commutative and associative property, instead of saying that they will prove that the left-hand side is equal to the right-hand side.
	How is the content presented?	Incorrectly said that they the lesson is on commutative and associative property and the lesson was not on that concept. The teacher was making many mistakes and was corrected by the learners. She relied on the learners' responses, and she was not

		using the learners' responses to further explain how they got the answer. She also did not explain to the learners that when working with a problem with brackets, they should apply the BODMAS rule. Also, she did not explain to the learners or remind them that if you add, multiply or divide a positive and a negative number what will be the sign of the answer since they are working with integers.
	How the teacher uses real-life examples to explain the concepts thoroughly.	The teacher did not use real-life examples to explain to the learners the content.
	Is the teacher able to respond to the learner's questions correctly?	One learner asked when calculating proving that the left-hand side is equal to the right-hand side the steps need to be the same as well. The teacher responded correctly and said what matters is the answer that they must be equal.
	Is the teacher asking enough questions for the learners to develop critical thinking?	The teacher wrote the questions on the board and the learners work on the problems individually and then after the teacher work out the answers together with the learners.
	Can the teacher encourage classroom discussion?	She was interacting with the learners by asking them questions.
Didactical skills	What teaching approaches are employed in the classroom?	Teacher-centred approach
	Does the teacher link content to the learners' previous knowledge?	The teacher started the lesson with an example of problem-solving, but she did not link the lesson to the learners' previous knowledge.

	Does the teacher accommodate the diverse needs of the learners when teaching?	No, she was interacting with the clever learners. The other learners were not participating.
	Does the teacher ask the questions while teaching to ensure that learners understand the content being taught?	She gave them the problems to calculate then they work on the solutions together.
	Does the teacher use the learners' questions and responses to further elaborate on the content being taught?	No, she was just saying yes or no when the learners respond and then proceed to the next questions.
	How does the teacher encourage learners' participation throughout the lesson?	She was asking questions while teaching.
	What teaching resources does the teacher use when teaching?	DBE workbook, chalkboard, and a whiteboard.
	How does the teacher assess learners understanding of content?	While teaching she asked questions and also gave the learners a class activity to complete.
Teachers' beliefs	How confident is the teacher in teaching mathematics?	The teacher lack confidence she relies on the DBE workbook examples for teaching and was assisted by learners when she made mistakes. She used direct instruction with emphasis on mastering the procedures.
Contextual factors	How is the classroom sitting arrangements?	The learners are sitting individually adhering to COVID-19 rules of social distance. There was a number of learners in the classroom was more than the required number by the COVID-19 regulations.

	Does the teacher have mathematics resources for teaching?	She did not use any manipulatives.
	How is the school context?	It is a well-built school with running water from the taps and pit toilets. The school other classes have whiteboards. I did not see textbooks; they were using DBE workbooks.

Adapted from Kekane (2016)

LESSON OBSERVATION CHECKLIST

Date of the observation	02 June 2021
The school (pseudonym)	School C
Name of the teacher (pseudonym)	Thando
Subject	Mathematics
Grade	6
Number of learners	55
Time	07:30-08:30
Lesson topic	Common fractions (comparing and ordering)

Elements of classroom practice to be observed	**Question guiding observation**	**Comments**
Subject matter knowledge	Is the content presented adequately?	The content was presented correctly using the fraction wall to compare and order the fractions. Also used cross multiplication to find the bigger fraction when comparing.
	How is the content presented?	The content is presented correctly. She explained what a fraction is, comparing and ordering fractions. She also explained how to compare fractions without using the fraction wall. You cross multiply the fractions. She was code-switching to SiSwati.

	How the teacher uses real-life examples to explain the concepts thoroughly.	She uses a practical example to explain the content. For example, the loaf of bread being divided equally to a certain number of children.
	Is the teacher able to respond to the learner's questions correctly?	The learners did not ask any questions.
	Is the teacher asking enough questions for the learners to develop critical thinking?	Few questions were asked and only knowledge recall questions. No critical thinking questions were asked.
	Can the teacher encourage classroom discussion?	No. The smart learners were responding to her questions, other learners were seated quietly, and the teacher did not encourage them to respond.
Didactical skills	What teaching approaches are employed in the classroom?	Teacher-centred approach.
	Does the teacher link content to the learners' previous knowledge?	The teacher just introduced the new topic and was not linking it to the learners' previous knowledge.
	Does the teacher accommodate the diverse needs of the learners when teaching?	The diverse needs of learners were not accommodated since the teacher uses direct instruction.
	Does the teacher ask the questions while teaching to ensure that learners understand the content being taught?	Yes, she asked questions but only low cognitive level questions not encouraging critical thinking.

	Does the teacher use the learners' questions and responses to further elaborate on the content being taught?	The teacher was not using the learners' responses to further explain the content. She just says yes or no and carries on.
	How does the teacher encourage learners' participation throughout the lesson?	The clever learners were the ones participating and the other ones were just listening.
	What teaching resources does the teacher use when teaching?	DBE workbook, chalkboard, and textbook.
	How does the teacher assess learners understanding of content?	She asked questions while teaching to check their understanding.
Teachers' beliefs	How confident is the teacher in teaching mathematics?	The teacher had confidence.
Contextual factors	How is the classroom sitting arrangements?	The learners were sitting in pairs. The class was overcrowded they did not adhere to the COVID-19 regulations and social distance.
	Does the teacher have mathematics resources for teaching?	She used the textbook, DBE workbooks and the chalkboard.
	How is the school context?	The school's is an old school with cracked floor tiles and falling ceilings. Shortage of desks and the learners sharing the desks, and overcrowded classrooms. The school is a combined school consisting of primary and secondary school.

Adapted from Kekane (2016)

LESSON OBSERVATION CHECKLIST

Date of the observation	26 May 2021
The school (pseudonym)	School D
Name of the teacher (pseudonym)	Thato
Subject	Mathematics
Grade	6
Number of learners	32 learners
Time	08:00-09:00
Lesson topic	Capacity and Volume

Elements of classroom practice to be observed	**Question guiding observation**	**Comments**
Subject matter knowledge	Is the content presented adequately?	The teacher presented the content adequately, but he did not explicitly explain the concept of capacity and volume.
	How is the content presented?	The teacher explains how to convert between the millilitres and litres. He explains why you cannot add a litre with millilitres, and that you should you convert it first and use the same standard units.
	How the teacher uses real-life examples to explain the concepts thoroughly.	In the introduction of the lesson, he used a practical example using the empty bottle with different capacities namely a bottle of 1,25 litres of cold drink and 500 millilitres of juice. The teacher also

		brought water to explain the difference between capacity and volume.
	Is the teacher able to respond to the learner's questions correctly?	The learners did not ask the teacher any questions.
	Is the teacher asking enough questions for the learners to develop critical thinking?	No, the teacher asked the low cognitive level questions, and the learners responded as a class.
	Can the teacher encourage classroom discussion?	No, when the learners respond to the questions, he either say yes or no.
Didactical skills	What teaching approaches are employed in the classroom?	The teacher-centred approach
	Does the teacher link content to the learners' previous knowledge?	The teacher did not link the new topic with the learners prior knowledge.
	Does the teacher accommodate the diverse needs of the learners when teaching?	The diverse learning needs were not accommodated in the lesson since the teacher only used direct instruction.
	Does the teacher ask the questions while teaching to ensure that learners understand the content being taught?	The teacher asked questions while he was teaching.
	Does the teacher use the learners' questions and responses to further elaborate on the content being taught?	The learners did not ask any questions, and the teacher was not using the learners' responses to further elaborate on the content.

	How does the teacher encourage learners' participation throughout the lesson?	He was just asking knowledge low cognitive level questions and not all the learners were encouraged to participate in the lesson. The clever learners were the ones who were participating.
	What teaching resources does the teacher use when teaching?	Objects, chalkboard, and textbook.
	How does the teacher assess learners understanding of content?	Asking questions and gave the learners a classwork to complete.
Teachers' beliefs	How confident is the teacher in teaching mathematics?	He was confident and he used practical examples to explain the content.
Contextual factors	How is the classroom sitting arrangements?	The learners sit one learner per table adhering to the COVID regulations of social distance.
	Does the teacher have mathematics resources for teaching?	Yes, he was using his objects to explain the capacity and volume concept practically.
	How is the school context?	The school have well-built classrooms, but the classrooms do not have charts on the walls. They are having running water in taps, and also water tanks.

Adapted from Kekane (2016)

LESSON OBSERVATION CHECKLIST

Date of the observation	27 May 2021
The school (pseudonym)	School E
Name of the teacher (pseudonym)	Bonga
Subject	Mathematics
Grade	6
Number of learners	34
Time	10:00-11:00
Lesson topic	Percentage

Elements of classroom practice to be observed	**Question guiding observation**	**Comments**
Subject matter knowledge	Is the content presented adequately?	He presented the content correctly.
	How is the content presented?	The content was accurately explained. The teacher explained what percentages mean. Explained how to convert the percentage to fractions and how to write in the simplest by looking at the number that is the factor for both numbers. He thoroughly explained the concept by making several examples in different cognitive levels. He was also code-switching to SiSwati.

	How the teacher uses real-life examples to explain the concepts thoroughly.	He used a practical example to explain the equivalent concept for example money, 1 note of R20 is equal to 2 notes of R10 and 4 coins of R5 and 10 coins of R2 all are equivalent to R20.
	Is the teacher able to respond to the learner's questions correctly?	The learners did not ask any questions.
	Is the teacher asking enough questions for the learners to develop critical thinking?	The teacher asked several questions at a low cognitive level.
	Can the teacher encourage classroom discussion?	No, he asked learners questions and if they say an incorrect answer, he asks another question related to the previous one and if they respond incorrectly, he will explain the concept to the learners again.
Didactical skills	What teaching approaches are employed in the classroom?	Teacher-centred approach.
	Does the teacher link content to the learners' previous knowledge?	Yes, he links his lesson to the equivalent fractions and simplifying fractions and the inverse operations. The teacher started the lesson by doing corrections of previous work together with the learners and further explaining where the learners gave an incorrect answer.
	Does the teacher accommodate the diverse needs of the learners when teaching?	The diverse needs of the learners were not accommodated in the lesson since the learners were just listening to the teacher and answering questions asked by the teacher as he was teaching. Not all the learners were responding to the questions. Some of the learners were sitting quietly.

	Does the teacher ask the questions while teaching to ensure that learners understand the content being taught?	Yes, he asked some questions on one cognitive level.
	Does the teacher use the learners' questions and responses to further elaborate on the content being taught?	Yes, if the learners' response is incorrect, he explains again or further elaborate on the content being taught.
	How does the teacher encourage learners' participation throughout the lesson?	By asking questions while teaching and the learners were kept actively involved throughout the lesson.
	What teaching resources does the teacher use when teaching?	DBE workbook and chalkboard
	How does the teacher assess learners understanding of content?	Asking questions verbally and also giving them classwork and homework.
Teachers' beliefs	How confident is the teacher in teaching mathematics?	The teacher had confidence.
Contextual factors	How is the classroom sitting arrangements?	There are sitting individually adhering to the COVID-19 regulations.
	Does the teacher have mathematics resources for teaching?	The topic needs practical calculations, not manipulatives or real-life objects.
	How is the school context?	The school is a well-built infrastructure and have resources. The classrooms have mathematics charts on the walls. They are using the pit toilets and have running water in the taps and water tanks.

Adapted from Kekane (2016)

LESSON OBSERVATION CHECKLIST

Date of the observation	26 May 2021
The school (pseudonym)	School F
Name of the teacher (pseudonym)	Xoli
Subject	Mathematics
Grade	5
Number of learners	27
Time	12:00-13:00
Lesson topic	Division of 3 digits by 1

Elements of classroom practice to be observed	**Question guiding observation**	**Comments**
Subject matter knowledge	Is the content presented adequately?	The breaking apart method was explained correctly but the long division method was not explained correctly.
	How is the content presented?	The teacher started the lesson with mental maths. The teacher was not able to explain the content thoroughly and explaining it in a simpler way to make it understandable to the learners. In the long division she did not explain explicitly the concept, and the way she drops the numbers down and it was incorrectly. The teacher was encouraging learners to copy answers from the multiplication table

		pasted in their workbooks not to practice calculating it by themselves. She was also code-switching.
	How the teacher uses real-life examples to explain the concepts thoroughly.	No, the teacher did not use real-life examples to explain the content.
	Is the teacher able to respond to the learner's questions correctly?	The learners did not ask the teacher any questions.
	Is the teacher asking enough questions for the learners to develop critical thinking?	The teacher was asking only low cognitive level questions and the learners were lazy to count just copy from their times table.
	Can the teacher encourage classroom discussion?	No, it was just questioned, and answer and she moved on to the next question.
Didactical skills	What teaching approaches are employed in the classroom?	Teacher-centred approach.
	Does the teacher link content to the learners' previous knowledge?	The teacher did not link the days' topic to what the learners already know about multiples and division. She just started by introducing the topic to the learners. She did not link division to multiplication or multiples which they have already covered.
	Does the teacher accommodate the diverse needs of the learners when teaching?	No, the teacher only used the direct instruction method and the learners listened and answer when she asked a question.
	Does the teacher ask the questions while teaching to ensure that learners understand the content being taught?	Yes, she asks questions to check the learners understanding of the content taught.

	Does the teacher use the learners' questions and responses to further elaborate on the content being taught?	The learners did not ask any questions and the teacher just said yes or no to the learners' responses. If the learners respond incorrectly, she doesn't correct them and explains. She moves on and ask another learner.
	How does the teacher encourage learners' participation throughout the lesson?	She asked questions to check the learners understanding. Only clever learners were responding to the questions. Few learners were participating in the lesson the other ones were silent.
	What teaching resources does the teacher use when teaching?	DBE workbook and chalkboard.
	How does the teacher assess learners understanding of content?	She asked questions and gave the learners classwork.
Teachers' beliefs	How confident is the teacher in teaching mathematics?	The teacher lack confidence. She tells the learners to check answers from their multiplication table in their books and not showing them how to calculate in multiples of that divider.
Contextual factors	How is the classroom sitting arrangements?	The learners sitting individually adhering to the COVID regulations of social distance.
	Does the teacher have mathematics resources for teaching?	The teacher used a textbook, DBE workbook and chalkboard.
	How is the school context?	The school have a well-built infrastructure. The classrooms don't have the charts on the wall. The school have resources for teaching. They have water tanks, and they are using the pit toilets.

Adapted from Kekane (2016)

LESSON OBSERVATION CHECKLIST

Date of the observation	31 May 2021
The school (pseudonym)	School G
Name of the teacher (pseudonym)	Lihle
Subject	Mathematics
Grade	6
Number of learners	32
Time	10:00-11:00
Lesson topic	3-Dimensional objects

Elements of classroom practice to be observed	**Question guiding observation**	**Comments**
Subject matter knowledge	Is the content presented adequately?	The teacher explained the content incorrectly or presented the content inadequately.
	How is the content presented?	The teacher started with the corrections of 3-D objects. She explained that in a prism all those shapes that are flat on top and pyramid have a triangular shape on top. She described the incorrectly saying it's curved only. And incorrectly said the vertices of a rectangular prism are 4. She couldn't explain to the learners how to determine if the object it's flat, curved or both flat and curved or both flat and curved. She couldn't explain thoroughly the

		properties of 3-D objects couldn't explain what the face, vertex and edges is. The teacher relies heavily on the DBE workbook to explain the content. She incorrectly said the hexagon has got 6 squares instead of saying rectangles. She was code-switching.
	How the teacher uses real-life examples to explain the concepts thoroughly.	The teacher couldn't use the practical example or real-life objects as examples of 3-objects. Also, couldn't use a good example to explain the face, edge, and vertices.
	Is the teacher able to respond to the learner's questions correctly?	The learners didn't ask any questions.
	Is the teacher asking enough questions for the learners to develop critical thinking?	Few questions were asked and only questions on recall knowledge questions.
	Can the teacher encourage classroom discussion?	No, she was reading the DBE examples and questions and explain to the learner.
Didactical skills	What teaching approaches are employed in the classroom?	Teacher-centred approach.
	Does the teacher link content to the learners' previous knowledge?	The teacher did not start the lesson by linking the lesson to the learners' previous knowledge, what they already know about the 3-D objects.
	Does the teacher accommodate the diverse needs of the learners when teaching?	The diverse learning needs of learners were not accommodated in the lesson since only direct instruction was used.

	Does the teacher ask the questions while teaching to ensure that learners understand the content being taught?	Yes, the teacher asked the questions from the DBE workbook.
	Does the teacher use the learners' questions and responses to further elaborate on the content being taught?	Yes, she used the learners' responses if there are incorrect to correct them.
	How does the teacher encourage learners' participation throughout the lesson?	Asking questions and the learners answering from the DBE questions.
	What teaching resources does the teacher use when teaching?	DBE workbook and chalkboard.
	How does the teacher assess learners understanding of content?	She keeps on asking questions while teaching and also give learners class activities.
Teachers' beliefs	How confident is the teacher in teaching mathematics?	Lack of confidence just reading and following the DBE workbook activities.
Contextual factors	How is the classroom sitting arrangements?	The learners are sited individually adhering to the COVID regulations of social distance.
	Does the teacher have mathematics resources for teaching?	No, the other teacher doesn't have the teaching aids as the topic needed the 3-D objects so that the learners can visualise and see the properties of the 3-D objects physical not on the workbook pictures.
	How is the school context?	The school have a built classroom, but the floor has got cracks. Pit toilets and they are using water tanks.

LESSON OBSERVATION CHECKLIST

Date of the observation	02 June 2021
The school (pseudonym)	School H
Name of the teacher (pseudonym)	Thoko
Subject	Mathematics
Grade	5
Number of learners	33
Time	11:00-12-00
Lesson topic	Numeric patterns

Elements of classroom practice to be observed	**Question guiding observation**	**Comments**
Subject matter knowledge	Is the content presented adequately?	The content was presented incorrectly.
	How is the content presented?	The teacher taught the multiplication table instead of number patterns. She didn't explain to the learners what patterns are and how to find the rule, which you need to find to complete or extend the patterns. It seems as if the teacher doesn't know what patterns are, as she didn't teach the patterns.
	How the teacher uses real-life examples to explain the concepts thoroughly.	The teacher did not use real-life examples to explain the content.

	Is the teacher able to respond to the learner's questions correctly?	The learners did not ask any questions.
	Is the teacher asking enough questions for the learners to develop critical thinking?	No. She asked about the multiplication table.
	Can the teacher encourage classroom discussion?	No. When the learners respond to the questions, she says either yes or no.
Didactical skills	What teaching approaches are employed in the classroom?	Teacher-centred approach.
	Does the teacher link content to the learners' previous knowledge?	The teacher did not link the topic of the day to what the learners already know. The lesson critical thinking questions are asked all the questions were knowledge recalling questions.
	Does the teacher accommodate the diverse needs of the learners when teaching?	The diverse learning needs of learners were not accommodated in the lesson since only direct instruction was used.
	Does the teacher ask the questions while teaching to ensure that learners understand the content being taught?	The teacher asked the learners about the multiplication table.
	Does the teacher use the learners' questions and responses to further elaborate on the content being taught?	No, she didn't use the learners' responses to further elaborate on the content. She just continues with teaching.

	How does the teacher encourage learners' participation throughout the lesson?	She asks the learners questions, and they respond verbally. She also asks other learners to come and write on the board the multiples of 4 and 5.
	What teaching resources does the teacher use when teaching?	DBE workbook and chalkboard.
	How does the teacher assess learners understanding of content?	Asking questions while teaching and class activity.
Teachers' beliefs	How confident is the teacher in teaching mathematics?	The teacher lack confidence she doesn't know what numeric patterns are.
Contextual factors	How is the classroom sitting arrangements?	The learners were sitting individually adhering to the COVID regulations of social distance.
	Does the teacher have mathematics resources for teaching?	No, she only uses the DBE workbook and chalkboard.
	How is the school context?	The school have poor physical facilities and it is a small school but has many learners. The classrooms don't have charts on the wall. They have pit toilets and tank water.

Adapted from Kekane (2016)

LESSON OBSERVATION CHECKLIST

Date of the observation	03 June 2021
The school (pseudonym)	School I
Name of the teacher (pseudonym)	Buhle
Subject	Mathematics

Grade	6
Number of learners	24
Time	11:00-12:00
Lesson topic	Addition and subtraction of mixed numbers

Elements of classroom practice to be observed	**Question guiding observation**	**Comments**
Subject matter knowledge	Is the content presented adequately?	The content was inadequately presented.
	How is the content presented?	She explained what a mixed fraction is. It has got a whole number and a fraction. We add fractions with the denominators are the same. Just add numerators if the denominators are not, we must make them the same when adding mixed numbers. We start by adding the whole numbers then you add fractions. She did not explain thoroughly how to change the denominators to be the same, find the LCM then multiply the denominator and numerators with the LCM. She did it correctly, but the learners may get confused on how they make denominators the same, which number should they multiply with and how do they know.
	How the teacher uses real-life examples to explain the concepts thoroughly.	The teacher did not use real-life examples to explain the concept and so that the learners can understand it easily.

	Is the teacher able to respond to the learner's questions correctly?	The learners did not ask any questions.
	Is the teacher asking enough questions for the learners to develop critical thinking?	The teacher kept asking the same questions as she was doing the practical examples on the board.
	Can the teacher encourage classroom discussion?	No, she was asking low-level questions and when the learners respond will say yes or no and explain to the learners. Not all the learners were participating during the lesson.
Didactical skills	What teaching approaches are employed in the classroom?	Teacher-centred approach.
	Does the teacher link content to the learners' previous knowledge?	The teacher introduces the lesson by asking the learners their prior knowledge of fractions that is a number that has a numerator and denominator. She also reminded the learners about the fraction wall which they have done on Monday.
	Does the teacher accommodate the diverse needs of the learners when teaching?	No, the diverse needs of learners were not accommodated in the lesson since learners were listening and answering questions as the teacher was teaching. Only that not all learners were responding to the teachers' questions.
	Does the teacher ask the questions while teaching to ensure that learners understand the content being taught?	Yes, the teacher was asking questions while teaching.

	Does the teacher use the learners' questions and responses to further elaborate on the content being taught?	The teacher further explains if the learner response it's incorrectly. Repeat for them so that they can understand the content.
	How does the teacher encourage learners' participation throughout the lesson?	By asking the questions while teaching and also ask the learners to come on the board and explain how they have worked out the problem and find the answer.
	What teaching resources does the teacher use when teaching?	For the lesson topic, she only used the textbook, DBE workbook and chalkboard.
	How does the teacher assess learners understanding of content?	She was assessing the learners understanding by continuously asking questions also gave them the class activity.
Teachers' beliefs	How confident is the teacher in teaching mathematics?	The teacher has confidence.
Contextual factors	How is the classroom sitting arrangements?	The learners were sitting individually adhering to the COVID regulations of social distance.
	Does the teacher have mathematics resources for teaching?	Yes, the school have mathematical resource textbooks, DBE workbooks, teaching aids and maths lab the teacher showed me.
	How is the school context?	The school have good physical and technological facilities. They have all the mathematical teaching resources and mathematics lab. They have pit toilets and borehole and water tanks.

Adapted from Kekane (2016)

LESSON OBSERVATION CHECKLIST

Date of the observation	03 June 2021
The school (pseudonym)	School J
Name of the teacher (pseudonym)	Mpho
Subject	Mathematics
Grade	5
Number of learners	31
Time	08:00-09:00
Lesson topic	Division of 3 digits by 1

Elements of classroom practice to be observed	**Question guiding observation**	**Comments**
Subject matter knowledge	Is the content presented adequately?	The content was correctly presented.
	How is the content presented?	The teachers showed the learners' the long division method one example. When teaching she told the learners to refer to their multiplication table. She did not thoroughly explain to the learners how to do long division and made the learners rely on the multiplication table they have pasted in their workbooks. She was teaching in their home language siSwati.
	How the teacher uses real-life examples to explain the concepts thoroughly.	The teacher did not use real-life examples to explain the content.

	Is the teacher able to respond to the learner's questions correctly?	The learners did not ask any questions.
	Is the teacher asking enough questions for the learners to develop critical thinking?	No, she was asking simple recalling knowledge questions.
	Can the teacher encourage classroom discussion?	No.
Didactical skills	What teaching approaches are employed in the classroom?	Teacher-centred approach.
	Does the teacher link content to the learners' previous knowledge?	The teacher did not relate the new lesson with what the learners already know she did not start the lesson by asking questions base on the topic.
	Does the teacher accommodate the diverse needs of the learners when teaching?	No, the diverse needs of learners were not accommodated in the lesson since direct instruction was used. The learners were listening and answering questions as the teacher was teaching.
	Does the teacher ask the questions while teaching to ensure that learners understand the content being taught?	Yes, the teacher was asking simple knowledge recall questions.
	Does the teacher use the learners' questions and responses to further elaborate on the content being taught?	No. when the learners' respond the teacher just say yes or no.

	How does the teacher encourage learners' participation throughout the lesson?	She did not encourage learners' participation.
	What teaching resources does the teacher use when teaching?	DBE workbook and chalkboard.
	How does the teacher assess learners understanding of content?	Asking questions while teaching and give learners classwork.
Teachers' beliefs	How confident is the teacher in teaching mathematics?	The teacher lack confidence. She couldn't show learners different examples of how to calculate. Learners learn by referring to the multiplication table.
Contextual factors	How is the classroom sitting arrangements?	The learners are sitting individually adhering to the COVID-19 regulations of social distance.
	Does the teacher have mathematics resources for teaching?	The teacher uses the DBE workbook only.
	How is the school context?	It's a well-built school but has pit toilets and running water in the taps and the tank water.

Adapted from Kekane (2016)

APPENDIX G: LESSON PLAN ANALYSIS

Document analysis of lesson plan

Teacher (pseudonym)	Thato
School (pseudonym):	School D
Documents analysis:	Teachers' lesson plan
Date:	26 May 2021

Criteria	**Comments**
Introduction	No introduction.
Teachers' goals what learners should know and be able to do at the end of the lesson.	The teacher did not indicate on the lesson plan the goals which he wants to achieve at the end of the lesson.
Assessing the learner's prior knowledge of the content.	The prior knowledge is not mentioned.
Explanation of the lesson content (concept development).	The lesson content has been explained and how the teacher will present the lesson to the learners. Firstly, use demonstration to define and differentiate between the two concepts. Indicated the conversions between $l\ to\ ml$. Also, how to add the volumes. The volumes with different units, convert the units to be the same then add or subtract
Resources the teachers' used in class for teaching and learning.	On the lesson plan the teacher did not indicate the teaching resources he will use.

What teaching strategies used in the lesson.	The teaching approach is not stated.
Conclusion of the lesson (question and answer / classwork/ homework or group work)	The lesson plan concluded by giving the learners a classwork.

Document analysis of lesson plan.

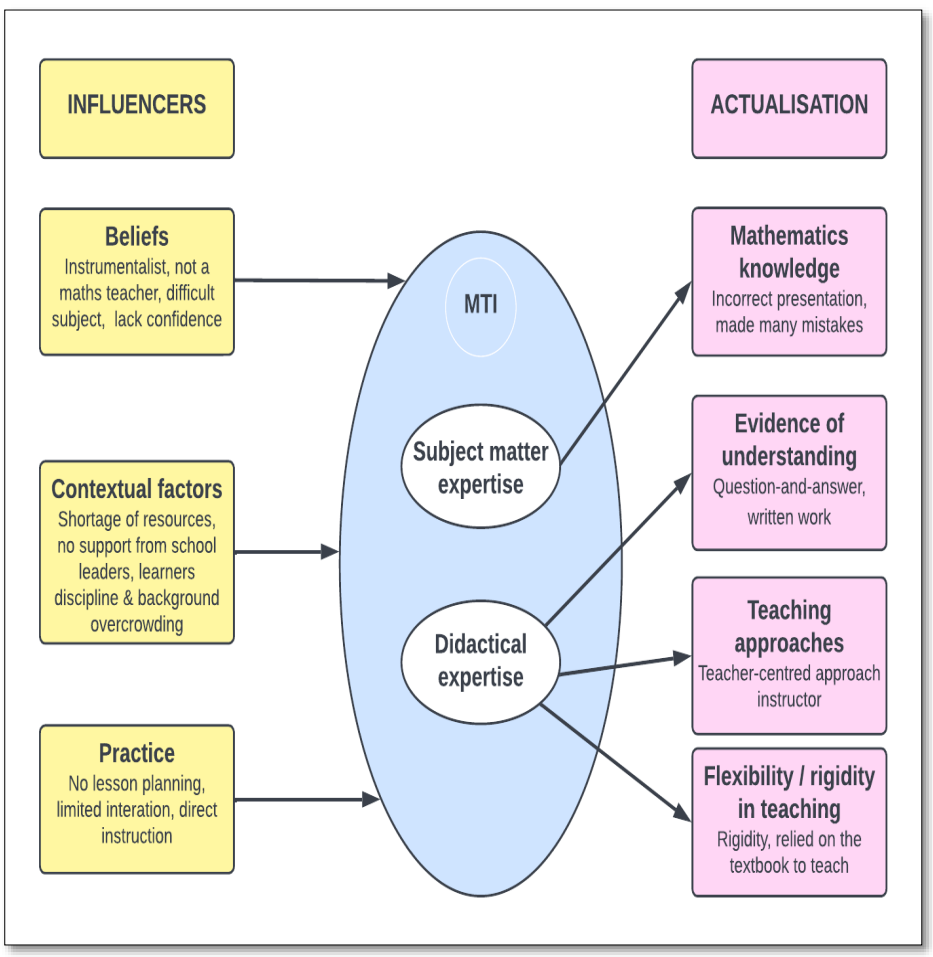
Teacher (pseudonym)	Thando
School (pseudonym):	School C
Documents analysis:	Teachers' lesson plan
Date:	02 June 2021

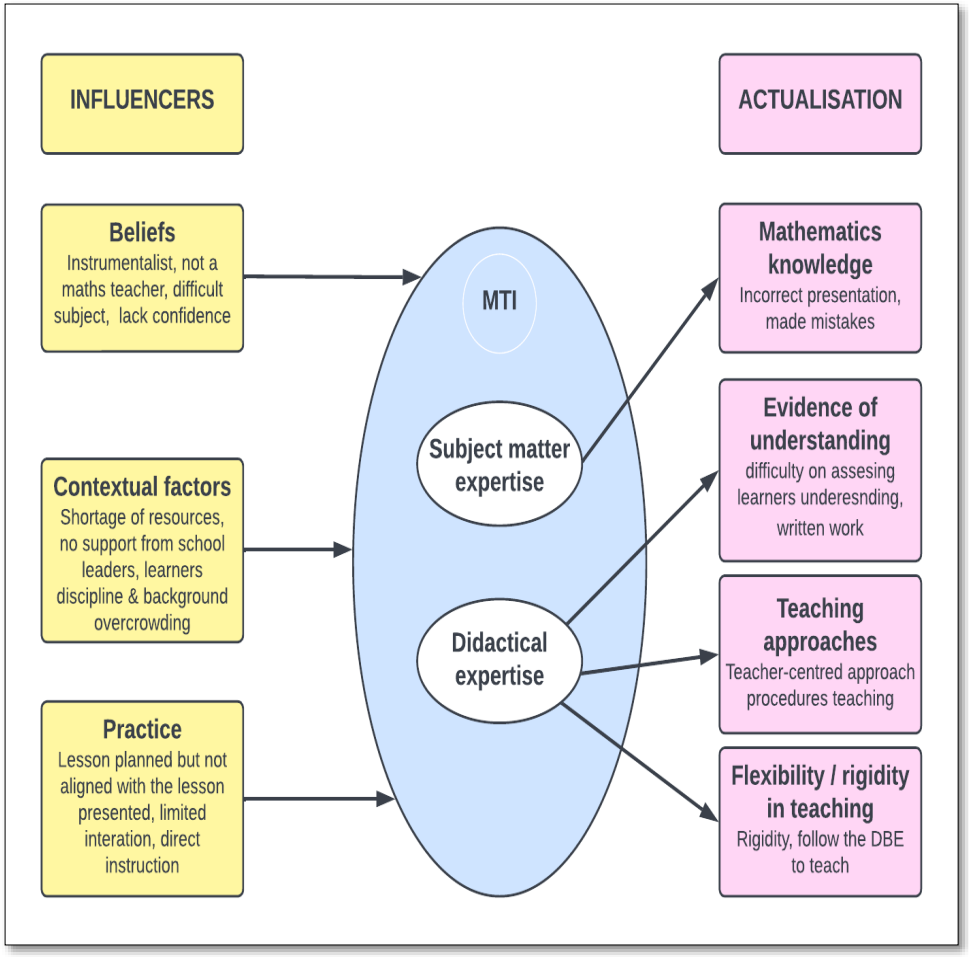
Criteria	**Comments**
Introduction	No introduction.
Teachers' goals what learners should know and be able to do at the end of the lesson.	Not indicated.
Assessing the learner's prior knowledge of the content.	Not indicated.
Explanation of the lesson content (concept development).	The teacher did not describe what is an equivalent fraction. Explained that they will use the fraction wall to determine the equivalent fractions. On the lesson plan the teacher indicated that she would lead the discussion by asking the learners the questions.
Resources the teachers' used in class for teaching and learning.	DBE textbooks and DBE workbooks
What teaching strategies used in the lesson.	The teaching strategy is not mentioned on the lesson plan.

Conclusion of the lesson (question and answer / classwork/ homework or group work)	Classwork and homework.

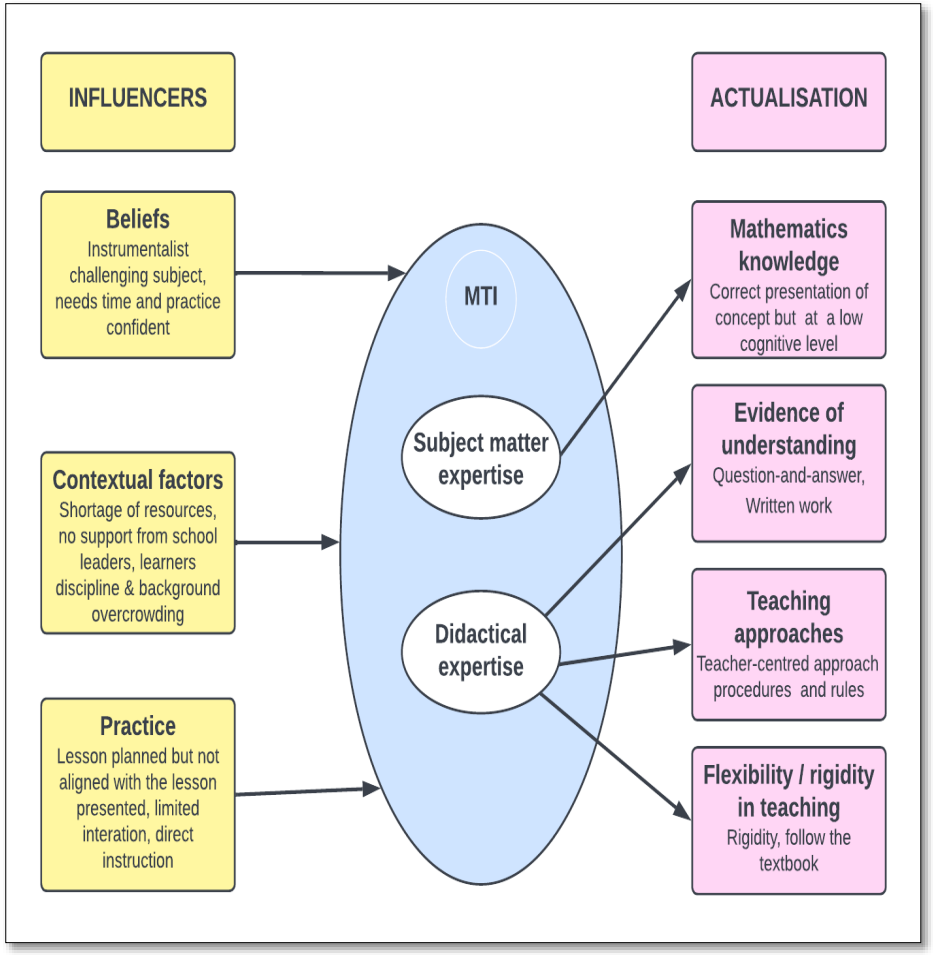
APPENDIX H

The visual representations of ten participants' MTI development summary



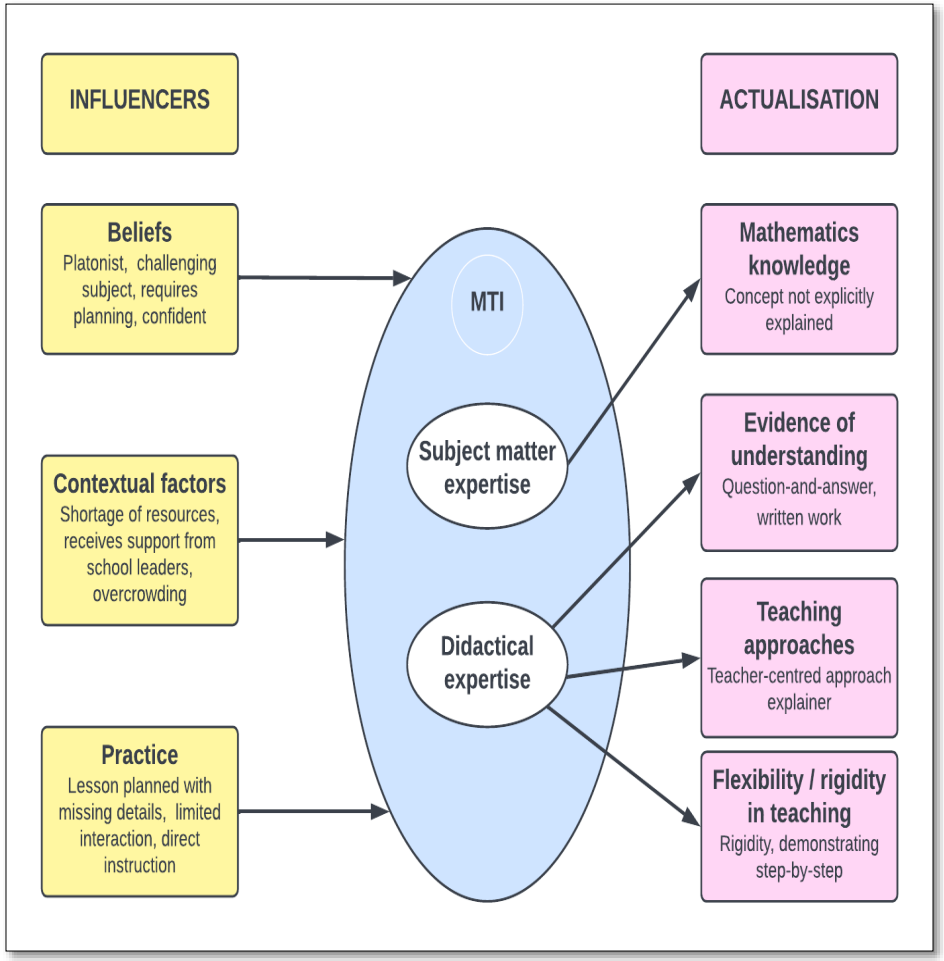


Summary of Plato's MTI development.

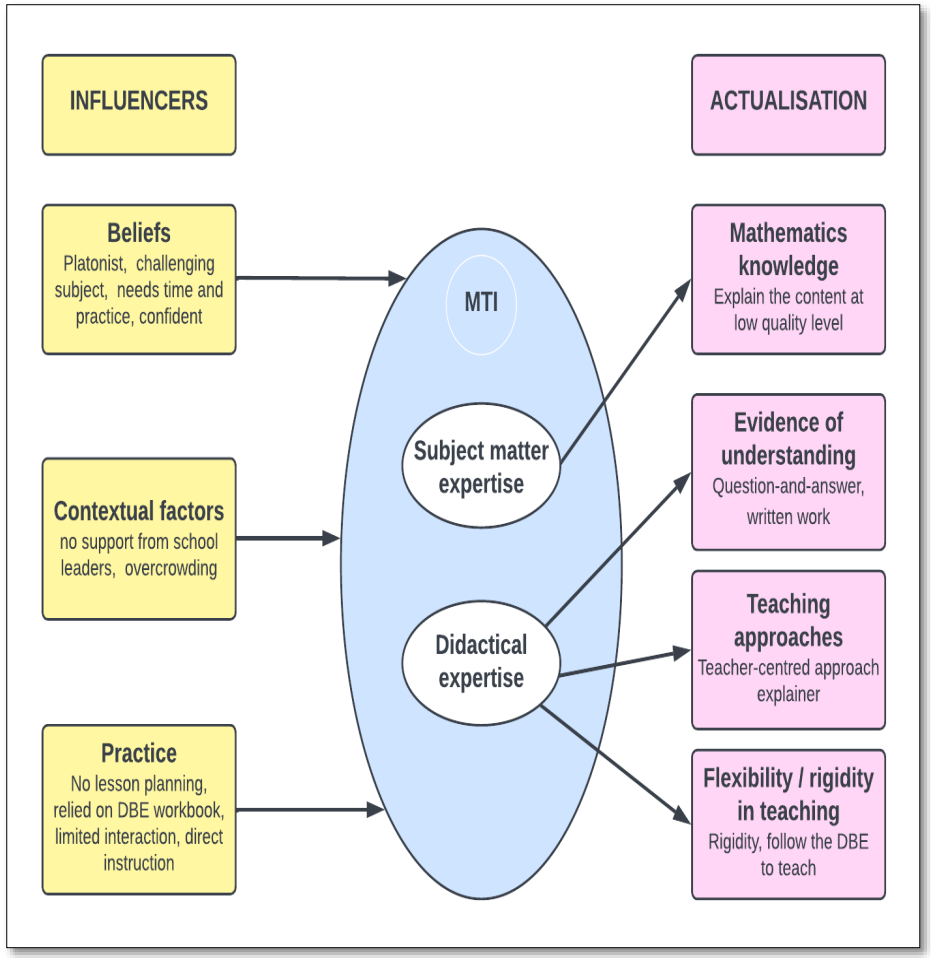


Summary of Thando's MTI development

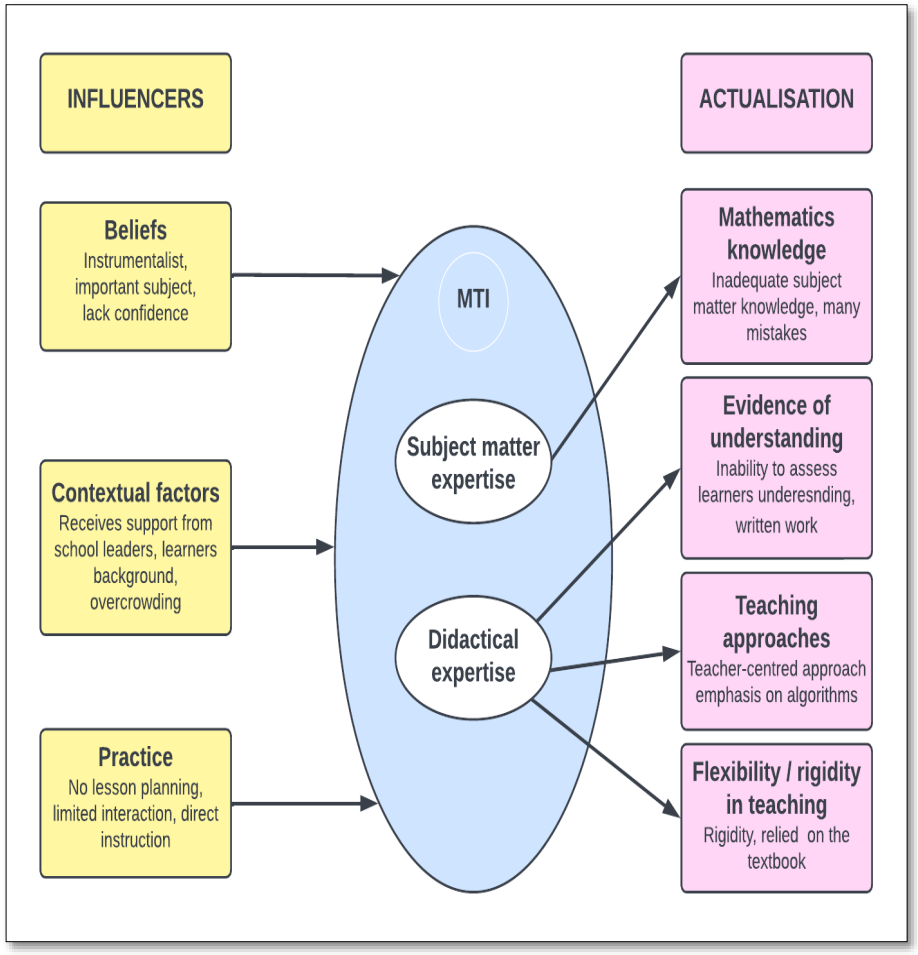
Summary of Zano's MTI development.



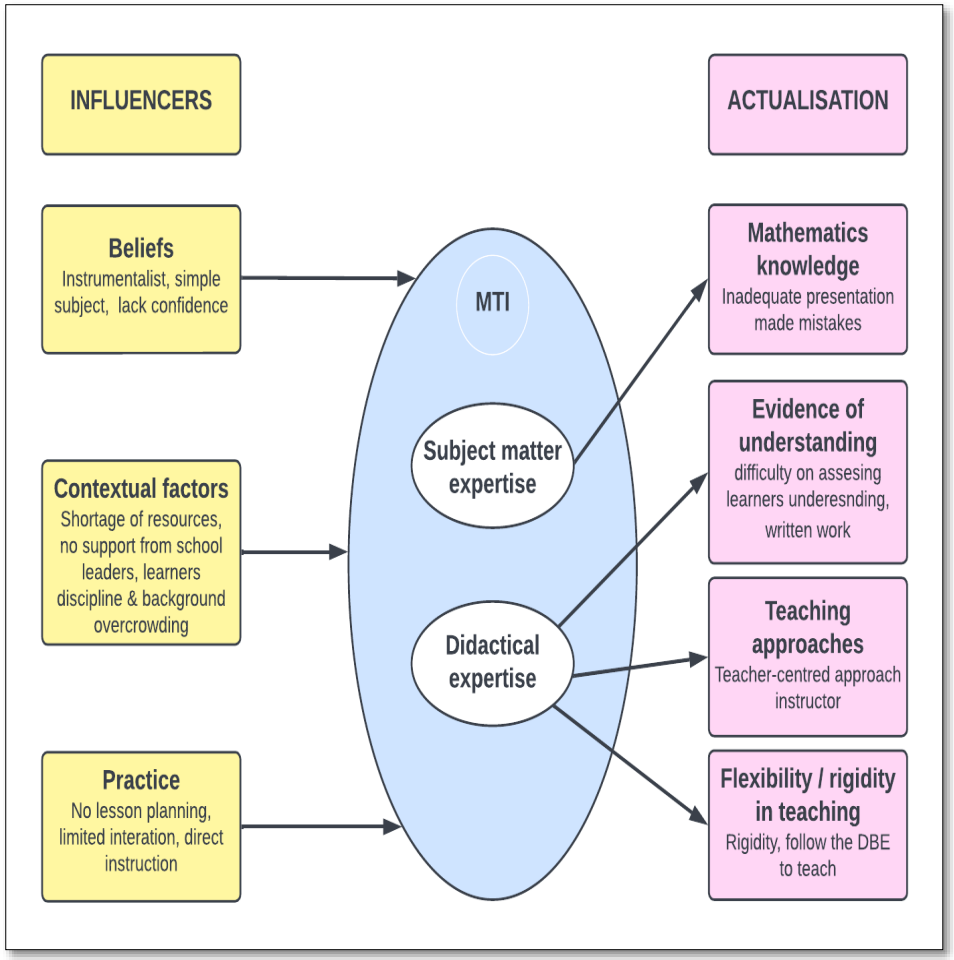
Summary of Thato's MTI development.



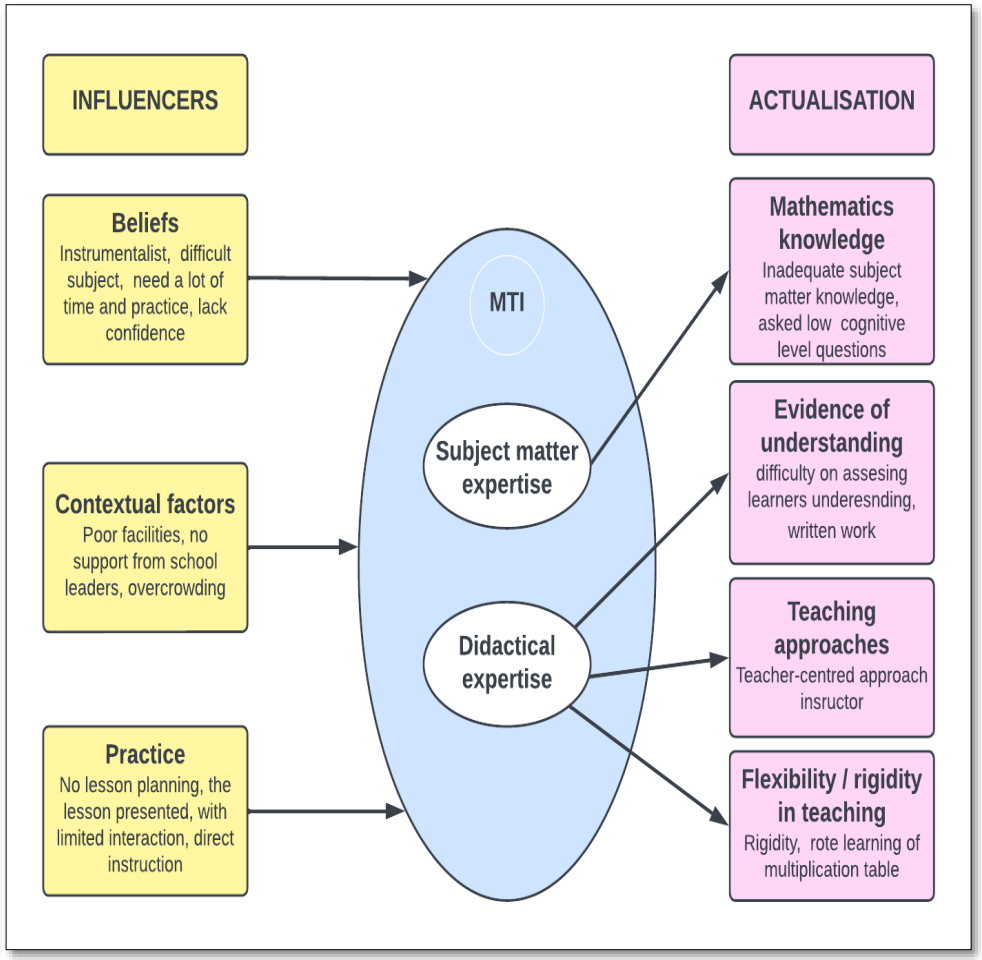
Summary of Bonga's MTI development.



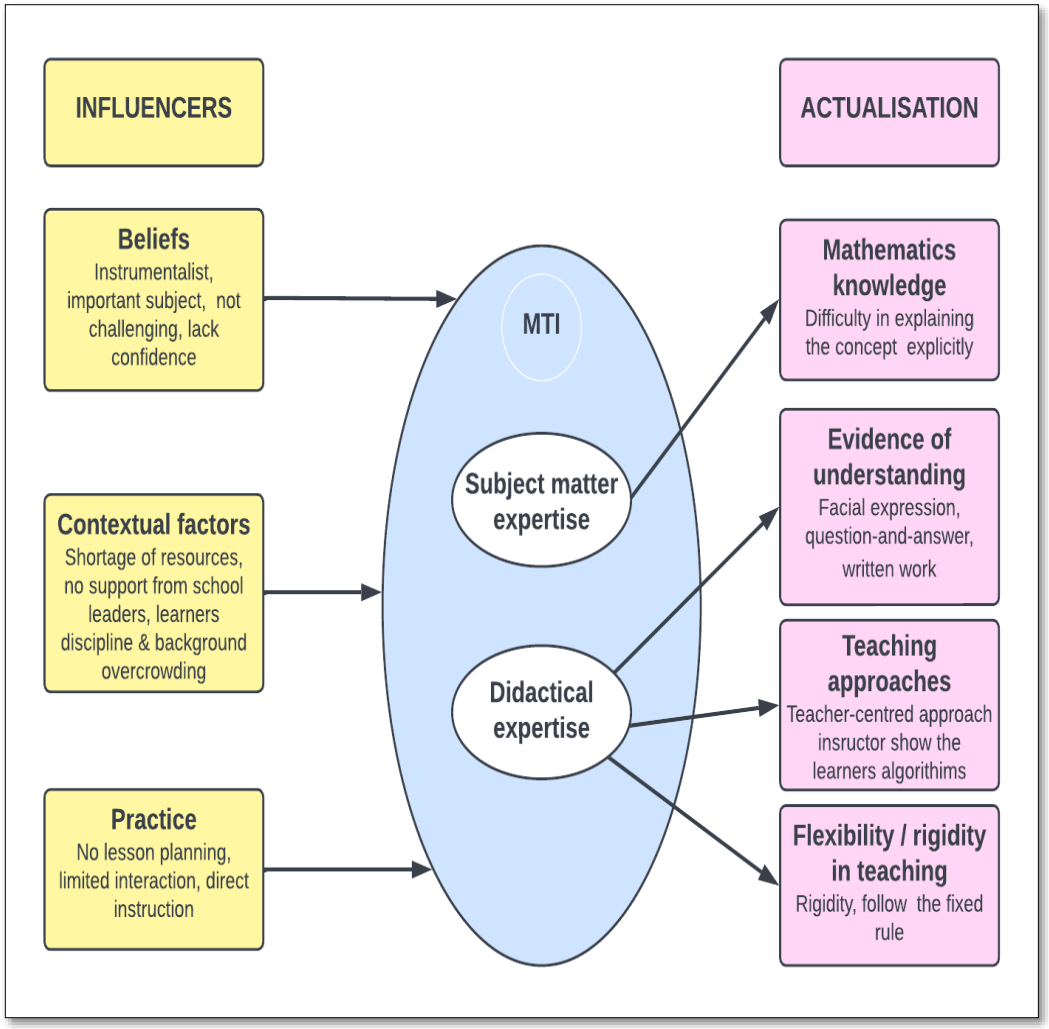
Summary of Xoli's MTI development.



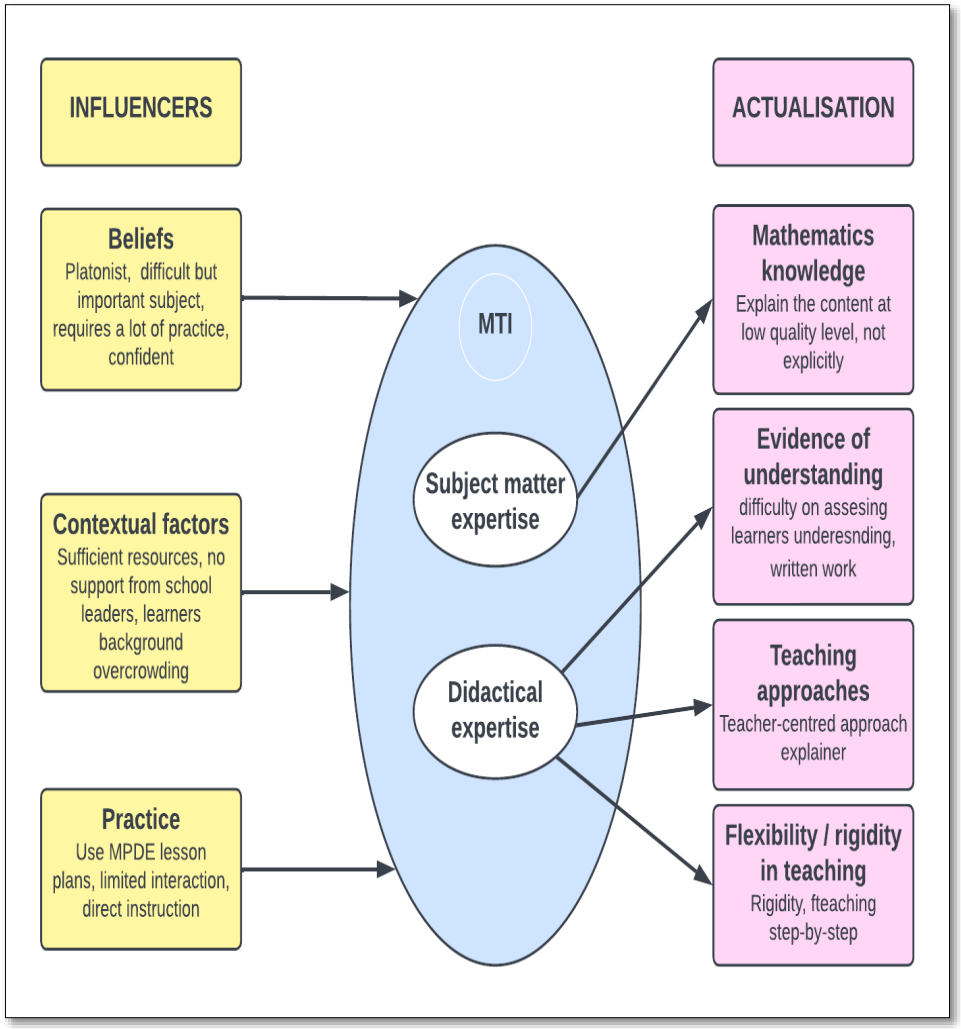
Summary of Lihle's MTI development.



Summary of Thoko's MTI development.



Summary of Buhle's MTI development.



Summary of Mpho's MTI development.

APPENDIX I: CODES FOR EACH PARTICIPANT

All identified codes from interview transcripts based on anchor codes.

Plato	Zano
Beliefs: mathematics its difficult	**Beliefs:** mathematics its difficult
Beliefs: challenging subject	**Beliefs:** I don't see myself as a mathematics teacher
Beliefs: I see myself as language teacher	**Beliefs:** mathematics its difficult
Beliefs: I am not a maths teacher	**Subject matter knowledge:** insufficient subject matter knowledge
Beliefs: I am not a maths teacher	**Didactical expertise:** other topics difficult
Subject matter knowledge: insufficient subject matter knowledge	**Didactical expertise:** difficult teaching
Subject matter knowledge: insufficient subject matter knowledge	**Beliefs:** lack confidence
Didactical expertise: other topics difficult	**Didactical expertise:** other topics difficult
Didactical expertise: difficult teaching	Didactical expertise: learner and teacher-centred approach
Subject matter knowledge: insufficient subject matter knowledge	**Contextual factors:** challenges from learners
Beliefs: lack confidence	**Didactical expertise:** assess by asking questions
Beliefs: lack confidence	**Didactical expertise:** group work
Didactical expertise: teacher-centred	**Didactical expertise:** peer learning
Didactical expertise: old method chalk and talk	**Subject matter knowledge:** developed a little
Didactical expertise: assess by asking questions	**Didactical expertise:** other topics difficult
Didactical expertise: assess using informal assessment	**Contextual factors:** textbook and chalkboard
Didactical expertise: peer learning	**Subject matter knowledge:** lesson plans provided by MPDE
Didactical expertise: individual assist the learners struggling	**Contextual factors:** learners performance
Subject matter knowledge: developed a little	**Contextual factors:** challenges from learners
Subject matter knowledge: knowledge gap	**Contextual factors:** no support from the school leaders
Contextual factors: textbook	**Contextual factors:** no support from the school leaders
Contextual factors: previous question papers	
Subject matter knowledge: lesson plans provided by MPDE	
Subject matter knowledge: lesson plan using textbook	
Contextual factors: monitoring teachers' work	
Contextual factors: Insufficient support from the school leaders	
Contextual factors: HOD is not maths specialist	

Thando	Thato
Beliefs: challenging subject	**Beliefs:** challenging subject
Beliefs: always practice	**Beliefs:** challenging subject
Beliefs: important subject	**Beliefs:** challenging subject
Beliefs: I see myself as a mathematics teacher	**Beliefs:** practical subject
Beliefs: important subject	**Beliefs:** practical subject
Didactical expertise: other topics difficult	**Beliefs:** lifelong learner
Didactical expertise: other topics difficult	**Beliefs:** lifelong learner
Beliefs: confident	**Subject matter knowledge:** insufficient subject matter knowledge
Didactical expertise: learner and teacher-centred approach	**Subject matter knowledge:** insufficient subject matter knowledge
Didactical expertise: assess with classwork	**Beliefs:** lack confidence
Didactical expertise: correctios done with learners	**Subject matter knowledge:** still developing
Didactical expertise: peer learning	**Didactical expertise:** other topics difficult
Subject matter knowledge: developed a lot	**Subject matter knowledge:** a knowledge gap
Subject matter knowledge: developed a lot	**Beliefs:** lifelong learner
Didactical expertise: other topics difficult	**Beliefs:** lack confidence
Contextual factors: textbook, chalkboard and DBE workbook	**Didactical expertise:** teacher-centred
Contextual factors: teaching aids	**Didactical expertise:** assess by asking questions
Subject matter knowledge: lesson plan using ATP	**Didactical expertise**: assess with classwork
Subject matter knowledge: lesson plans provided by MPDE	**Didactical expertise**: corrections done with learners
Contextual factors: learners' discipline	**Didactical expertise:** assess by asking questions
Contextual factors: learners not doing their work	**Didactical expertise**: assess with homework
Contextual factors: HOD assist with learners' discipline	**Didactical expertise:** group work
	Subject matter knowledge: developed a little
	Contextual factors: teaching aids
	Contextual factors: real life things
	Subject matter knowledge: CAPS document
	Contextual factors: textbook and DBE workbook
	Contextual factors: learners
	Contextual factors: support from the school leaders

Bonga	Xoli
Beliefs: needs time	**Beliefs:** important subject
Beliefs: challenging subject	**Didactical expertise:** difficult teaching
Subject matter knowledge: still developing	**Beliefs:** confident
Didactical expertise: difficult teaching	Didactical expertise: using presentations
Subject matter knowledge: a knowledge gap	Didactical expertise: teacher-centred
Didactical expertise: other topics difficult	**Didactical expertise:** assess by asking questions
Beliefs: lack confidence	**Didactical expertise:** individual assist the learners struggling
Didactical expertise :learner-centred	**Subject matter knowledge:** developed a lot
Didactical expertise: assess by asking questions	**Contextual factors:** textbook, workbook, ATP and CAPS document
Didactical expertise: assess with classwork	**Contextual factors:** learners not doing their work
Contextual factors: overcrowding	**Contextual factors:** support from the principal and HOD
Didactical expertise: difficult to accommodate all learners	**Contextual factors:** HOD assist with learners' discipline
Didactical expertise: individual assist the learners struggling	**Didactical expertise:** other topics difficult
Subject matter knowledge: subject knowledge developed	
Subject matter knowledge: a knowledge gap	
Contextual factors: textbook, chalkboard and DBE workbook	
Subject matter knowledge: lesson plan using ATP	
Subject matter knowledge: lesson plan using textbook and workbook	
Contextual factors: learners' performance	
Contextual factors: insufficient support from the school leaders	
Contextual factors: the deputy is not the maths expert	

Lihle	Thoko
Beliefs: easy subject	**Beliefs:** needs time
Beliefs: important to master the four operations	**Beliefs:** mathematics is not a difficult subject.
Beliefs: confident	**Didactical expertise:** teacher-centred approach
Beliefs: mathematics is not a difficult subject.	**Subject matter knowledge:** sufficient subject matter knowledge
Contextual factors: DBE workbooks provided	**Beliefs:** confident
Subject matter knowledge: no knowledge gap	**Didactical expertise:** teacher-centred approach
Contextual factors: no teaching aids	**Didactical expertise:** assess by asking questions
Beliefs: confident	**Didactical expertise:** individual assist the learners struggling
Didactical expertise: group work.	**Didactical expertise:** peer learning
Didactical expertise: assess by asking questions	**Contextual factors:** textbook, DBE workbook and pictures
Didactical expertise: assess with classwork and homework	**Subject matter knowledge:** insufficient subject matter knowledge
Didactical expertise: difficult to accommodate all learners	**Contextual factors:** learners' performance
Didactical expertise: code-switching	**Contextual factors:** support from the principal
Subject matter knowledge: developed a lot	
Contextual factors: workbook, ATP and CAPS document	
Subject matter knowledge: lesson plans provided by MPDE	
Contextual factors: teaching aids not enough	
Subject matter knowledge: lesson planned according to terms	
Contextual factors: overcrowding	
Contextual factors: learners' background	
Contextual factors: receive support from the school leaders	
Contextual factors: support from the principal and HOD	

Buhle	Mpho
Beliefs: challenging subject	**Beliefs:** mathematics is difficult
Beliefs: always practice	**Contextual factors:** learners not doing their work
Beliefs: I see myself as a mathematics teacher	**Contextual factors:** learners' discipline
Didactical expertise: other topics difficult	**Beliefs:** interesting subject
Beliefs: lack confidence	**Beliefs:** challenging subject
Didactical expertise: teacher-centred approach	**Beliefs:** important subject
Didactical expertise: assess by asking questions	**Subject matter knowledge:** insufficient subject matter knowledge
Didactical expertise: individual assist the learners struggling	**Didactical expertise:** different teaching method
Subject matter knowledge: developed a lot	**Didactical expertise:** assess learners by their facial expression
Contextual factors: textbook, DBE workbook teaching aids, chalkboard and	**Didactical expertise:** difficult to accommodate all learners
Subject matter knowledge: lesson plans provided by MPDE	**Didactical expertise:** old methods
Contextual factors: no maths HOD in the school	**Contextual factors:** textbook and DBE workbook
	Contextual factors: teaching aids not enough
	Subject matter knowledge: lesson plans provided by MPDE
	Contextual factors: learners' background

APPENDIX J

CODES BASED ON RESEARCH QUESTIONS.

Table J: Interviews code-to-theme process

How may the beliefs that non-specialist mathematics teachers have about mathematics as a subject and its teaching and learning change through practice?			
Codes and their respective frequencies	**Category**	**Sub-theme**	**Theme**
• I am a mathematics teacher (2) • I don't see myself as a mathematics teacher (2) • I see myself as a mathematics teacher (2) • life-long learner (3) • I see myself as a language teacher (1) • no need for professional development (1)	View of self as a mathematics teacher.	Beliefs	Influencers
• mathematics challenging subject (10) • mathematics is not a difficult (3) • important subject (5) • interesting subject (1) • problem-solving subject (1)	Nature of mathematics		
• always practice (3) • important to master the four operations (1) • needs time (2) • practical subject (2)	Mathematics teaching and learning		
• lack confidence (9) • confident (5)	Confidence		

What contextual factors influence the non-specialist mathematics teacher's MTI development through practice?			
Codes and their respective frequencies	**Category**	**Sub-theme**	**Theme**
• overcrowding (10)	School context	Contextual factors	Influencers
• teaching aids (4) • no teaching aids (5) • textbook (7) • chalkboard (3) • DBE workbook (9) • pictures (1) • previous question papers (1) • real-life things (1) • maths lab (1) • ATP and CAPS document (2) • a shortage of teaching resources (2) • teaching aids not enough (2)	Resources		
• attention-seeking learners (1) • challenges from learners (2) • learners' behaviour challenging (1) • learners' discipline (5) • learners disrespecting teachers (1) • Contextual factors: learners not doing their work (2) • learners' performance (2) • learners' background (4)	Learner's background		
• HOD assist with learners' discipline (2) • HOD is not a mathematics specialist (2) • no maths HOD in the school (2) • no support from the school leaders (2)	Support from school leaders		

• insufficient support from the school leaders (4) • receive support from the school leaders (1) • support from the principal and HOD (1) • the deputy is not the maths expert (1)			
• lesson plan using ATP (2) • lesson plan using the textbook (2) • CAPS document (1) • lesson plan using textbook and workbook (2) • lesson planned according to terms (1) • lesson plans provided by MPDE (7)	Lesson planning	Practice	
• Individually assist learners who are struggling (5) • Corrections done with learners (3)	Interaction with learners		

How do non-specialist mathematics teachers' subject matter knowledge and didactical expertise develop through classroom practice?

Codes and their respective frequencies	**Category**	**Sub-theme**	**Theme**
• knowledge gap (4) • developed a little (3) • developed (6) • insufficient subject matter knowledge (10) • no knowledge gap (1) • still developing (2) • sufficient subject matter knowledge (1)	Subject matter knowledge	Subject matter expertise	MTI and actualisations
• assess by asking questions (9) • assess using informal assessment (8) • assess learners by their facial expression (1)	Evidence of understanding	Didactical expertise	MTI and actualisations

• teacher-centred approach (9) • learner-centred (1) • old method chalk and talk (2) • different teaching methods (1) • peer learning (4) • using presentations (2) • group work (3) • learner and teacher-centred approach (2)	Teaching approaches		
• code-switching (1) • corrections done with learners (2) • difficult teaching (6) • difficult to accommodate all learners (3) • other topics difficult (12) • individual assist the learners struggling (5)	Flexibility or rigidity		

APPENDIX K: WORD CLOUD VISUALISATION OF CODES, CATEGORIES AND THEMES

APPENDIX I: LESSON PLANS

Plato

Activity1

1. How many twentieths are equal to one fifth? Is $\frac{4}{20}$ equal to $\frac{1}{5}$?
   a) Is $\frac{1}{5}=\frac{5}{20}$ or is $\frac{1}{5}=\frac{4}{20}$
   b) Is $\frac{1}{5}+\frac{3}{20}=\frac{4}{20}+\frac{3}{20}$

2. Calculate:
   a) $\frac{3}{10}+\frac{5}{20}$
   b) $\frac{7}{20}+\frac{3}{10}$
   c) $\frac{8}{15}+\frac{11}{20}$
   d) $\frac{5}{12}+\frac{3}{6}$
   e) $\frac{7}{20}+\frac{3}{5}$
   f) $\frac{4}{9}+\frac{7}{12}$

Group work

- discuss in groups and give feedback
- share their solutions with the whole class.

Activity 2

It is easy to add fractions that are expressed with the same denominator, like $\frac{5}{12}$ and $\frac{3}{12}$:

5 twelfths + 3 twelfths = 8 twelfths
To add fractions with different denominators, we have to use **equivalent fractions** .

For example, to calculate $\frac{5}{12}+\frac{1}{3}$ we have to replace $\frac{1}{3}$ with $\frac{4}{12}$:
($\frac{1\times4}{3\times4}=\frac{4}{12}$) 5 twelfths + 4 twelfths = 9 twelfths

- Work in groups and provide feedback on your solutions.

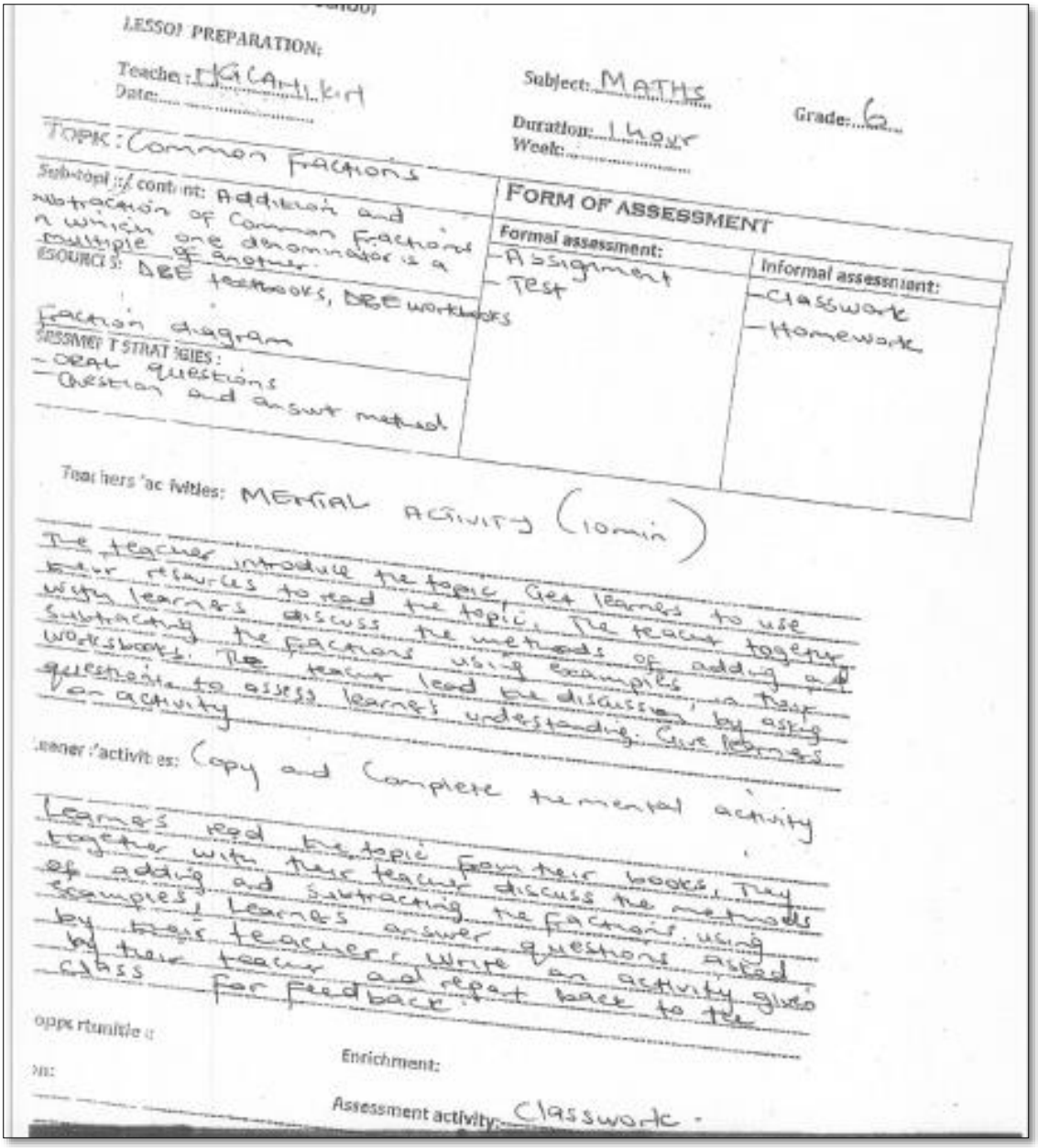
Is it true that $\frac{5}{12}+\frac{1}{3}=\frac{3}{4}$

- Selected learners work on the writing / whiteboards to show how they will reach their conclusion.

Zano

She did not have a lesson plan

Thando



LESSON PREPARATION:

Teacher: [illegible] Subject: MATHS Grade: 6

Date: Duration: 1 hour Week:

TOPIC: Common Fractions

Sub-topic / content: Addition and subtraction of Common Fractions in which one denominator is a multiple of another.

RESOURCES: DBE textbooks, DBE workbooks, fraction diagram

ASSESSMENT STRATEGIES:
- ORAL questions
- Question and answer method

FORM OF ASSESSMENT	
Formal assessment:	Informal assessment:
- Assignment - Test	- Classwork - Homework

Teachers activities: MENTAL ACTIVITY (10min)

The teacher introduce the topic. Get learners to use their textbooks to read the topic. The teacher together with learners discuss the methods of adding and subtracting the fractions using examples in the textbooks. The teacher lead the discussion by asking questions to assess learner's understanding. Give learners an activity

Learner activities: (copy and complete the mental activity

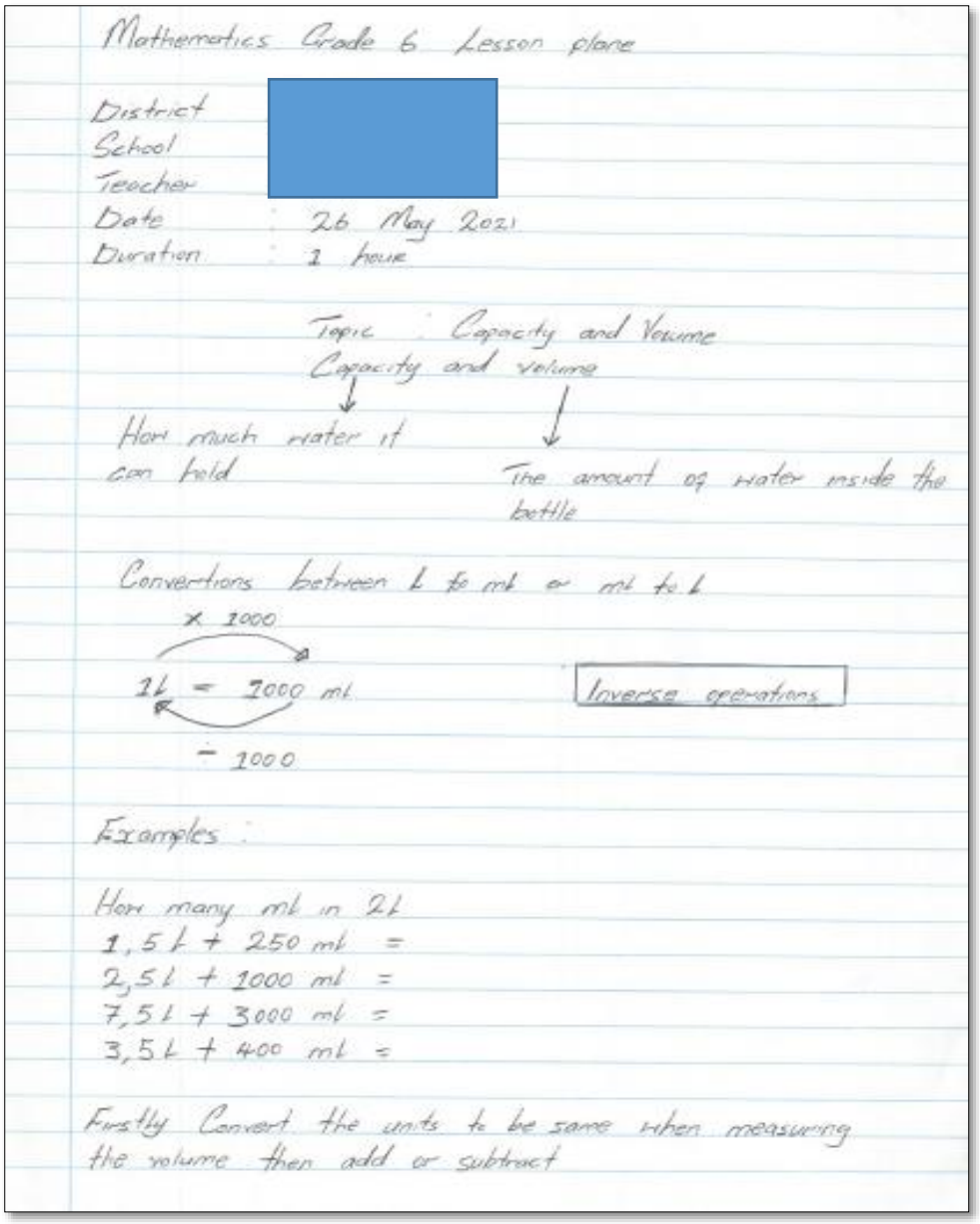
Learners read the topic from their books. They together with their teacher discuss the methods of adding and subtracting the fractions using examples. Learners answer questions asked by their teacher. Write an activity given by their teacher and feed back to the class for feedback.

Opportunities:

Enrichment:

Assessment activity: Classwork.

Thato



Mathematics Grade 6 Lesson plane

District
School
Teacher
Date : 26 May 2021
Duration : 1 hour

Topic : Capacity and Volume

Capacity and volume

How much water it can hold

The amount of water inside the bottle

Convertions between l to ml or ml to l

× 1000

1l = 1000 ml

÷ 1000

Inverse operations

Examples :

How many ml in 2l

1,5 l + 250 ml =
2,5 l + 1000 ml =
7,5 l + 3000 ml =
3,5 l + 400 ml =

Firstly Convert the units to be same when measuring the volume then add or subtract

Bonga

4. PRIOR KNOWLEDGE:	Learners' own understanding of Percentage Decimals- tenths and hundredths , Common Fractions

5. REVIEW AND CORRECTION OF HOMEWORK (suggested time: 10 minutes)

Homework provides an opportunity for teachers to track learners' progress in the mastery of mathematics concepts and to identify the problematic areas which require immediate attention. Therefore, it is recommended that you place more focus on addressing errors from learner responses that may later become misconceptions.

6. INTRODUCTION (Suggested time: 10 Minutes)

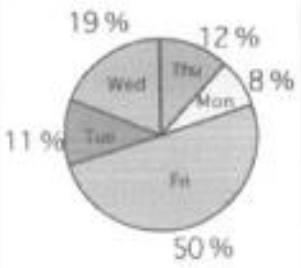
- Discussion on learners' own understanding of Percentage
- Where in everyday life do we see this symbol (%)

Lucky customer
Scratch card 10 % off

Temperature: 20 % chance of rain

All jackets 25 % discount

Favourite day of the week



In newspapers or when surveys are done

- Learners to look up the definition of the word Percentage in a dictionary.
- Discuss the Mathematical definition of Percentage and provide examples of percentage Eg.

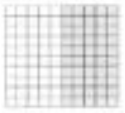
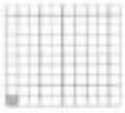
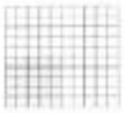
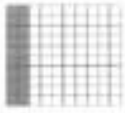
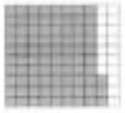
"Percentage" is another word for "hundredths"

23% means $\frac{23}{100}$, which is the same as $\frac{2}{10} + \frac{3}{100}$ or 0,23

Instead of saying 23 hundredths we can say 23%

Give more examples like 25 % means 25 hundredths, which is the same as 0,23
2 % means 2 hundredths, which means 0,02

7. LESSON PRESENTATION/DEVELOPMENT (Suggested time: 20 minutes)

Teaching activities	Learning activities (Learners are expected to:)
Activity 1: Group activity LB pg. 262 What fraction part of each square below is shaded? Give your answers in percentage notation, fraction notation and decimal notation (a)  (b)  (c)  (d)  (e)  What part of each of the above figures is not shaded? Give your answers in percentage notation, fraction notation and decimal notation. **Activity 2: Group activity** Provide learners with cut-out 5 at the back of the DBE Workbook 1. Within their groups they need to match the fraction, decimal fractions, and percentages. **NOTE: Enough activities should be given in order to consolidate conversions from decimals and fractions to percentages**	Learners complete activity and give feedback. Learners match cut-outs in groups

8. CLASSWORK (Suggested time: 15 minutes)

DBE Workbook 2 Pg 70 no. 1-2

9. CONSOLIDATION/CONCLUSION & HOMEWORK (Suggested time: 5 minutes)

a) **Emphasise that:**

- **In the percentage notation only 100 is used as denominator, whereas in fractions any denominator can be used.**
- **Percentage is another word for hundredth**
- **Percentage is another way to represent fractions.**

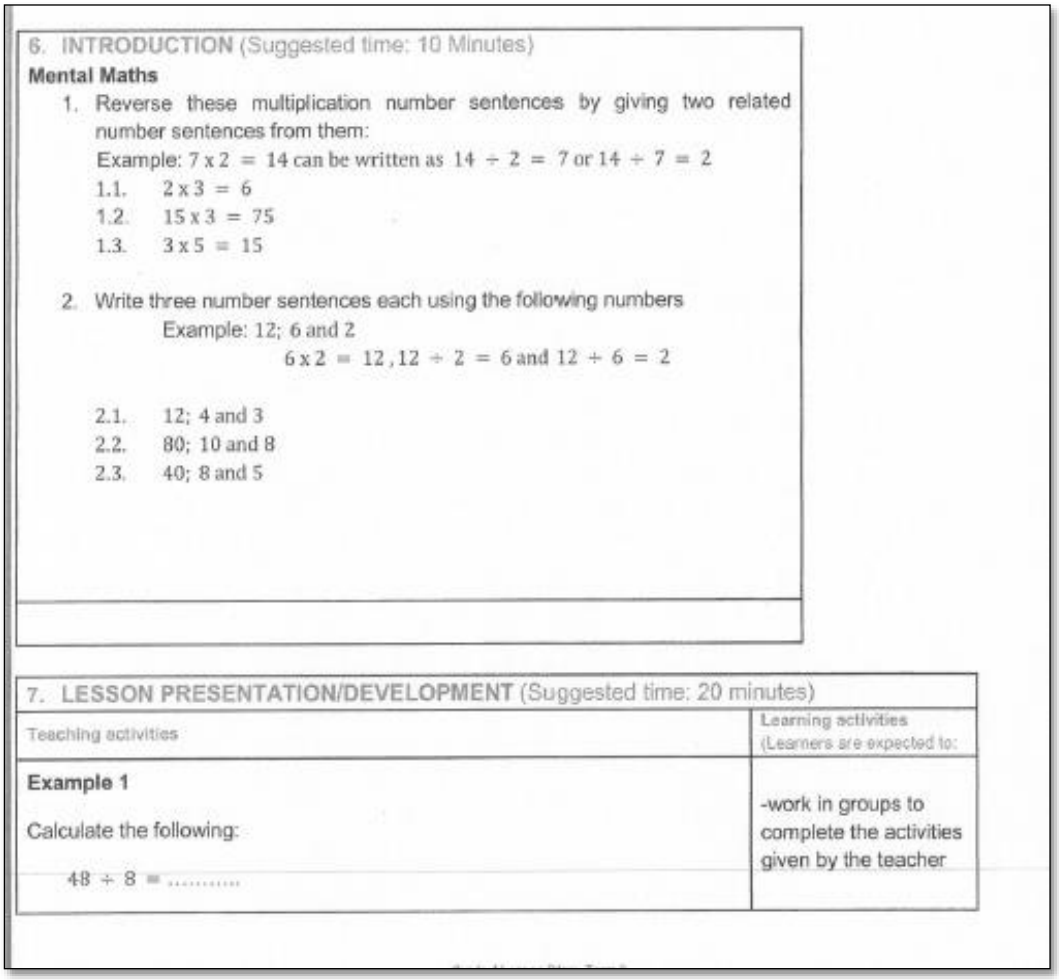
b) The primary purpose of Homework is to give each learner an opportunity to demonstrate mastery of mathematics skills taught in class. Therefore, Homework should be purposeful and the principle of 'Less is more' is recommended, i.e. give learners few high quality activities that address variety of skills than many activities that do not enhance learners' conceptual understanding.

Carefully select appropriate activities from the DBE Textbook TG and LB, DBE workbooks and/or textbooks for learners' homework. The selected activities should address different cognitive levels.

Homework

DBE TEXTBOOK	NATIONAL (DBE) WORKBOOK	TEXTBOOK (OTHER)
	DBE Workbook 2: page 68 No. 1-3	

Xoli



6. INTRODUCTION (Suggested time: 10 Minutes)

Mental Maths

1. Reverse these multiplication number sentences by giving two related number sentences from them:
   Example: 7 x 2 = 14 can be written as 14 ÷ 2 = 7 or 14 ÷ 7 = 2
   1.1. 2 x 3 = 6
   1.2. 15 x 3 = 75
   1.3. 3 x 5 = 15

2. Write three number sentences each using the following numbers
   Example: 12; 6 and 2
   6 x 2 = 12 , 12 ÷ 2 = 6 and 12 ÷ 6 = 2
   2.1. 12; 4 and 3
   2.2. 80; 10 and 8
   2.3. 40; 8 and 5

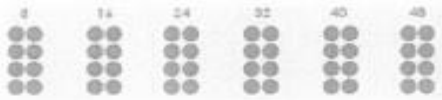
7. LESSON PRESENTATION/DEVELOPMENT (Suggested time: 20 minutes)

Teaching activities	Learning activities (Learners are expected to:
Example 1 Calculate the following: 48 ÷ 8 = ...	-work in groups to complete the activities given by the teacher

Method 1

We can ask ourselves how many groups of 8 will give us 48

Take 48 tokens and put them in groups of 8, then count how many groups we have:

e.g. 

In this example there are 6 groups, which implies that $48 \div 8 = 6$ with no remainder.

Method 2

We can also take division to imply sharing, where we share 48 items between 8 people, and can be done as follows (by breaking it down):

Using the clue board

$8 \times 10 = 80$ and hence $80 \div 8 = 10$ or $80 \div 10 = 8$

$8 \times 5 = 40$ (halving) and $40 \div 8 = 5$ or $40 \div 5 = 8$

$8 \times 20 = 160$(doubling)

$$\begin{aligned} 48 \div 8 &= (40 + 8) \div 8 \\ &= (40 \div 8) + (8 \div 8) \\ &= 5 + 1 \\ &= 6 \end{aligned}$$

Method 3

Use the clue board to complete the table;

Multiply	Subtract
$5 \times 8 = 40$	$48 - 40 = 8$
$1 \times 8 = 8$	$8 - 8 = 0$
$48 \div 8 = 5 + 1$ $= 6$ with no remainder	

Multiply	Subtract
80 x 6 = 480	528 - 480 = 48
8 x 6 = 48	48 - 48 = 0
528 ÷ 6 = 80 + 8 = 88 remainder 0	

Teaching Guidelines :

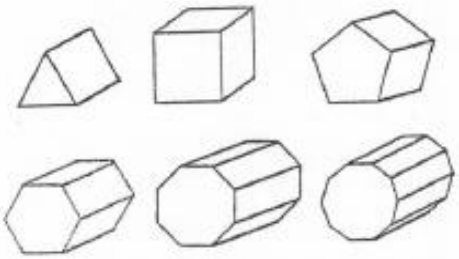
- When breaking down the numbers, use a clue board so that you can divide into numbers that can multiply without a remainder,unless the remainder itself.
- division is the inverse of multiplication, and hence learners must understand basic multiplication facts in order to do well in division.

8. CLASSWORK (Suggested time: 15 minutes)

Calculate the following using any method:

1. 455 ÷ 7
2. 801 ÷ 9
3. 282 ÷ 6
4. 956 ÷ 4
5. 952 ÷ 8

Lihle

Ask learners what 3-D objects are. Ask them the difference between prisms and pyramids. Ask learners to identify a cube and a rectangular prism from the 3-D shapes in the introduction. Ask them to state the difference between the cube and the rectangular prisms. Ask learners how best can they be able to name the prisms. 	Define the 3-D objects, explain how they differ from 2-D shapes and give examples where applicable. State differences between prisms and pyramids Identify a cube and a rectangular prism and state differences between them. Explain how they come up with names for prisms

9. CLASSWORK (Suggested time: 45 minutes)

DBE workbook page 94 Activity 1 & 2

10. CONSOLIDATION/CONCLUSION & HOMEWORK (Suggested time: 5 minutes)

a) **Emphasise that:**

Learners do the following:
1. Use features to distinguish, describe, sort and compare 3-D objects.
2. Understand the importance of 2-D shapes in recognising names of 3-D objects

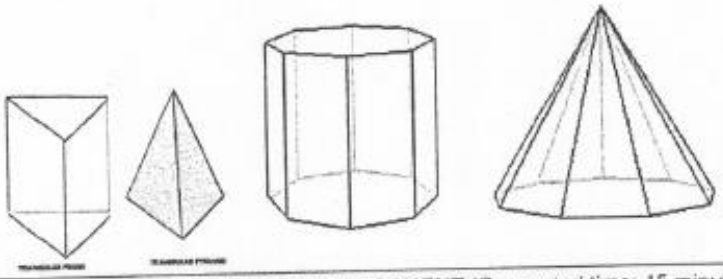
b) The primary purpose of Homework is to give each learner an opportunity to demonstrate mastery of mathematics skills taught in class. Therefore Homework should be purposeful and the principle of 'Less is more' is recommended, i.e. give learners few high quality activities that address variety of skills than many activities that do not enhance learners' conceptual understanding. Carefully select appropriate activities from the workbooks and/or textbooks for learners' homework. The selected activities should address different cognitive levels.

6. REVIEW AND CORRECTION OF HOMEWORK (suggested time: 10 minutes)

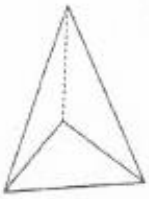
Homework provides an opportunity for teachers to track learners' progress in the mastery of mathematics concepts and to identify the problematic areas which require immediate attention. Therefore it is recommended that you place more focus on addressing errors from learner responses that may later become misconceptions.

7. INTRODUCTION (Suggested time:5 Minutes)

Ask learners the differences between pyramids and prisms



8. LESSON PRESENTATION/DEVELOPMENT (Suggested time: 15 minutes)

Teaching activities	Learning activities (Learners are expected to:)
Ask learners to work in pairs and find similarities and differences between the triangular based pyramids below:   Introduce tetrahedrons to learners	Work in pairs to state similarities and differences between the given triangular-based pyramids. Understand that the triangular-based pyramid made of four identical triangles is called a **tetrahedron**

Thoko

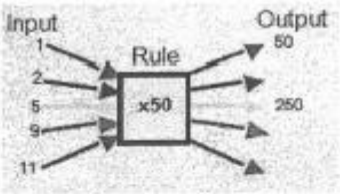
4. PRIOR KNOWLEDGE:	• Counting forward and backward • Addition and subtraction of whole numbers • Multiples • Multiplication of whole numbers • Division of whole numbers • Inverse operations

5. REVIEW AND CORRECTION OF HOMEWORK (suggested time: 10 minutes)

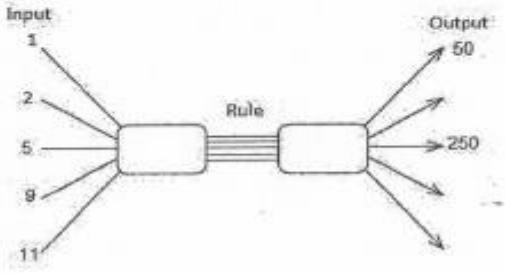
Homework provides an opportunity for teachers to track learners' progress in the mathematics concepts and to identify the problematic areas which require immedia Therefore it is recommended that you place more focus on addressing errors from learn that may later become misconceptions.

6. INTRODUCTION (Suggested time: 10 minutes)
Present the following activity to learners to do in groups and share the responses later.

a) Complete the following flow diagram.



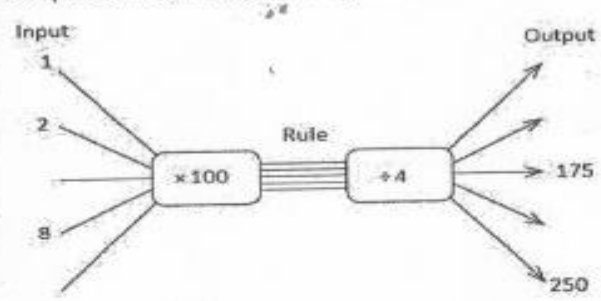
b) Split the rule in the above flow diagram into two smaller factors and complete the n flow diagram.



Divide learners into groups. Present the following activity as an example while asking them probing questions.

Example

Complete the following flow diagrams

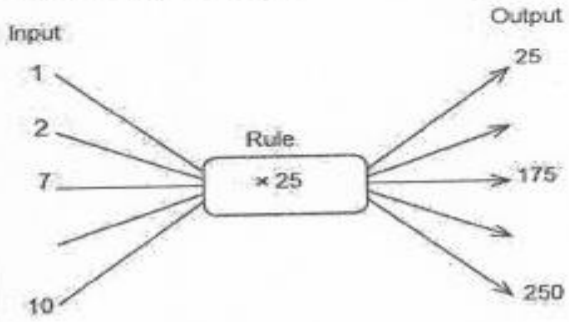


Input	Output
1 × 100 ÷ 4	25
2 × 100 ÷ 4	50
7	175 × 4 ÷ 100
8 × 100 ÷ 4	200
10	250 × 4 ÷ 100

- multiplication can be used to do division calculations
- multiplication can be used to check division calculations

Input × 100 ÷ 4 = Output

Output × 4 ÷ 100 = Output



Buhle

She did not have a lesson plan.

Mpho

She did not have a lesson plan.