TEACHERS IMPROVEMENT OF MATHEMATICS ACHIEVEMENTS IN RURAL SCHOOLS OF MOPANI DISTRICT-IMPLICATIONS FOR PROFESSIONAL DEVELOPMENT

By

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DECLARATION

I, **Sambo Sosa Isaac,** hereby affirm that the thesis entitled:

TEACHERS IMPROVEMENT OF MATHEMATICS ACHIEVEMENTS IN RURAL SCHOOLS OF MOPANI DISTRICT-IMPLICATIONS FOR PROFESSIONAL DEVELOPMENT

is my original work. All sources have been used and quoted have been acknowledged in the reference list.

01 January 2023

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Sambo Sosa Isaac Date

DEDICATION

This thesis is dedicated to my late parents, Mijaji Nwa-Misengi and Daniel Shilavi Sambo who had a desire to see me educated from my infancy. Their constant love, care and support that have shown to me are highly appreciated. I wish they were still alive so that we could celebrate this achievement together. Secondly, I also want to appreciate my beloved wife Sambo Basani Sylvia and my four children Nsuku Faith; Nhlayisko Blessing; Nhlavutelo Ebenezer and Nkateko Hope Sambo for their prayer support, patience and understanding during my study time. Let glory be given to God.

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ABSTRACT

Throughout the globe, there is an outcry that learners' performance in mathematics is below the expected standard. Hence, teachers need teacher development to improve their skills and knowledge in the subject. The purpose of this study was to explore the role of Professional Development (PD) in assisting teachers to improve learners' achievements in mathematics in rural schools in the Mopani District of the Limpopo Province of South Africa.

The literature review explored how developed and undeveloped countries develop teachers. The literature view also discussed the benefits that teachers gained as well as the challenges encountered when they participate in PD programmes and this helped the researcher to understand the phenomenon better. This study addressed the theories and models that support PD of teachers in schools. The theories included Vygotsky's social cultural theory and Guskey's theory of teacher change which was the main theory in the study. This theory provided details on how teachers should be developed in schools which include training, mentoring, support, involvement in individual guided activities and teacher change.

The study used the qualitative approach to find out how mathematics teachers are professionally developed. It used a case study research design, which followed the interpretive research paradigm. It used purposive and snowball sampling to select the suitable candidates from the Mopani District who included mathematics teachers; mathematics curriculum advisors and school principals.

Data collection was conducted in the participants' natural settings through semi-structured interviews. The participants were probed in order to acquire as much information as possible from them. The study used thematic analysis and focused on seven themes. Among other findings, the study found that teachers should improve their qualifications by furthering their studies with registered accredited higher education institutions and attending workshops. When it comes to challenges, it was found that teachers were invited to the workshops in the afternoon when they were already tired. As a result, the workshops were fruitless.

The study also generated new knowledge on the PD of teachers that can assist in improving the mathematics achievement of learners in schools. It was found that engagement of teachers in PD, led to improved learner performance in mathematics. In contributing to

knowledge, the researcher proposed and developed a PD model for school-based teachers. The proposed model can be used to prepare teachers through various preparation strategies to improve their performance in mathematics teaching in schools.

Key words: professional development; teacher improvement; mathematics achievements; workshops; developed countries; developing countries

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ACE	Advanced Certificate Education
4IR	4th Industrial Revolution
ECD	Early Childhood Education
ANA	Annual National Assessment
ATP	Annual Teaching Plan
B.Ed	Bachelor of Education
CA	Curriculum Advisor
CAPS	Curriculum and Assessment Policy Statement
CPD	Continuing Professional Development
CPTD	Continuing Professional Teachers Development
DBE	Department of Basic Education
DFE	Department For Education
DH	Departmental Head
DoE	Department of Education
DSG	Development Support Group
ELRC	Education Labour Relation Act
GET	General Education and Training
ICT	Information Communication and Technology
IPFTEDSA	Integrated Strategic Planning Framework for Teacher Education and Development in South Africa
IQMS	Integrated Quality Management System
TALP	Taiwan Adaptive Learning Platform
ITT	Initial Teacher Training
LDBE	Limpopo Department of Basic Education
LTSM	Learner Teacher Support Material
MoHE	Minister of Higher Education
MoPSE	Minister of Primary and Secondary Education
MST	Mathematics, Sciences and Technology
NECT	National Education Collaboration Trust
NQT	Newly Qualified Teacher
OECD	Organisation for Economic Cooperation and Development
PD	Professional Development

PGCE	Postgraduate Certificate in Education
PL	Professional Learning
QMS	Quality Management System
RSA	Republic of South Africa
SACE	South African Council for Educators
SA-SAMS	South African School Administration and Management System
SMT	School Management Team
STEM	Science, Technology, Engineering and Mathematics
TEC	Teacher Education College
TEI	Teacher Education Institution
TESSA	Teacher Education in Sub-Saharan Africa
TIMSS	Trends in International Mathematics and Science Study
UK	United Kingdom
UNESCO	United Nations Educational Scientific and Cultural Organisation
UNISA	University of South Africa
US	United States
USA	United States of America
ZPD	Zone of Proximal Development

CHAPTER 1
OVERVIEW OF THE STUDY

1.1 INTRODUCTION AND BACKGROUND

A preliminary review of the literature related to the importance of PD of teachers in mathematics in South African schools suggests that value may be added to the knowledge base of the topic by further in-depth research. According to Department of Basic Education (DBE) (2016a:1), professional development should be given greater attention in order to help solve the problem of a lack of qualified and under-qualified mathematics teachers in public schools. This source (DBE, 2016a:1) indicates that there is a lack of mathematics teachers in provinces like KwaZulu-Natal, Limpopo and the Eastern Cape. Furthermore, DBE (2016a:1) also maintains that amongst mathematics teachers in Limpopo there are high levels of incompetence which is attributed to teachers' reluctance to develop their qualifications. According to Abdella (2015:224), reasons that hinder teacher engagement regarding PD include excessively large classes of learners as well as poverty. The current researcher agrees that overcrowding and low salaries earned by teachers may contribute to the low level of teacher development in schools. The researcher believes that when classes are overcrowded teachers may experience problems in teaching learners effectively as the classes are poorly ventilated and there tends to be a lack of discipline. Furthermore, United Nations Educational Scientific and Cultural Organisations (UNESCO) (2015:8) indicates that poor remuneration may encourage teachers to seek supplementary sources of income after school hours rather than engage in the improvement of their mathematical teaching skills. This suggests that the DBE needs to improve the working conditions of teachers and their salaries for them to pay more attention to teacher development programmes and their implementation.

In order to improve teacher performance in teaching mathematics, Gomez, Gomez, Rodela, Horton, Cunningham and Ambracio (2015:461) suggest that teachers should be fully engaged in PD programmes. They are also of the opinion that PD equips teachers with new skills and extends their roles and knowledge by means of Continuous Professional Development (CPD) Programmes. Researchers believe that the skills and the knowledge that teachers acquire through PD help them teach key subjects, such as mathematics and science effectively. Authors like Gomez et al. (2015:461) and Danaher, Redmond and Lock (2015:4) also maintain that quality PD empowers teachers to teach learners with enthusiasm and that it increases teachers'

confidence and encourages them to try new things gradually; it enables them to involve learners in practice; and it further equips them with a variety of teaching methods which leads to quality teaching as well as quality learning. The programmes also enrich teachers with positive attitudes towards lessons; they allow them to teach comfortably, to provide learners with feedback and to implement the skills and knowledge gained in workshops (Abdella, 2015:223). This indicates that when teachers are developed in various areas, they are able to improve their teaching and learning activities in schools. The fact that PD provides teachers with suitable teaching skills and further knowledge implies that if the DBE could more stringently implement PD, the shortage of qualified mathematics teachers can be overcome.

Internationally, various programmes are designed to enhance standards of teaching in schools. For example, in Nigeria, the Federal Government has engaged the National Teachers Institute to re-train teachers so that they may operate effectively in terms of global challenges (Fareo, 2013:65). According to the literature, various ways used to develop teachers include workshops, conferences, and seminars. Koellner and Jacobs (2014:13) show that there are highly specific PD programmes in the United States (US) where goals, content materials and training manuals are issued to teachers to ensure predetermined outcomes. In addition, the US has also invented an improved science device for designing, developing and refining the contextualised development of mathematics lessons (Gomez et al., 2015:450). Furthermore, Kline and Walker-Gibbs (2015: 81) indicate that in Australia graduate teachers are well-prepared before they teach in rural schools. The authors show that graduate teachers are developed in their educational expertise on professional involvement with parents and in terms of teaching methodologies. The various strategies used by international countries to develop teachers imply that they are highly committed to improving teacher skills, content knowledge, and the academic performance of learners.

Locally, South Africa has adopted PD to develop teachers in mathematics and other subjects. Various policies have been implemented to support teacher development even though some teachers are reluctant to engage in PD. The National Policy Framework for teachers is one policy that is intended to equip teachers with the necessary skills and knowledge that allows them to meet the educational changes taking place in the country (Steyn, 2013:277). Other policies intended to develop teachers include the Integrated Strategic Planning Framework for Teacher Education and Development in South Africa (IPFTEDSA) and the Integrated Quality Management System (IQMS). These policies are intended to develop teachers in the form of

in-service training and to encourage them to stay in the system. Prospective teachers are recruited to receive pre-service training at teachers' colleges and universities on scarce subjects, such as Mathematics, Sciences and Technology (MST) (DBE, 2015b:24). The fact that South Africa uses various programmes to develop teachers suggests that it aspires to offer quality education in schools. In view of the abundant literature on low performance in mathematics despite the implementation of PD programmes nationally, the question is: Does PD effectively serve the purpose that it is intended for? The aim of the study was to explore the role of PD in assisting teachers to improve mathematics achievements in rural schools in the Mopani District of Limpopo Province in South Africa.

1.2 SIGNIFICANCE OF THE STUDY

Most studies related to PD have been conducted in non-rural and private schools. For example, the study by Mpahla and Okeke (2015a:18) indicates that teachers in rural schools are not involved in drawing up PD programmes and that PD policies do not acknowledge the context of rural schools. This makes it difficult for the rural teachers to implement skills and knowledge required in PD programmes. In view of the literature about teacher PD in schools (Moekwa, 2020:133; Mpahla & Okeke, 2015b:30), teachers need to be involved in the programmes that affect their work so that they can be encouraged to implement their educational programmes effectively. Besides encouraging teachers, the involvement of teachers in the school programmes may reduce misunderstanding between the programme facilitators and trainee. It is believed that this study will create awareness among the educational authorities that they need to consider rural teachers when drawing up PD programmes and ensure that the policies also address the needs of rural schools. The involvement of rural teachers in PD plenary sessions may allow them to share ideas that may help to improve PD in rural schools.

The study by Shaturaev (2021 : n.p) attributes the causes of poor performance in mathematics among public senior secondary school learners to inadequately qualified teachers of mathematics. This study aims to provide the DBE with information regarding the use of various strategies to develop teachers' skills and knowledge. For example, Hoppey (2016:21) posits that teachers can be developed through pre-service and in-service training. The author also suggests that teachers in rural schools can be enrolled at universities where they can acquire the knowledge, skills and abilities of inclusive teachers. It is assumed that, if teachers were adequately developed, the academic performances of learners in mathematics would increase.

Again, the development of teachers in mathematics will also minimise incidences where teachers are allocated to teach mathematics without the proper qualifications or ability.

1.3 STATEMENT OF THE PROBLEM

Research reveals that learners across the globe and in South Africa perform poorly in mathematics (Reddy, Isdale, Juan, Visser, Winnaar & Arends, 2016a:3; Spaull & Kotze, 2015:13). These scholars found that most learners lack basic knowledge and skills in mathematics, which results in poor performance when they undergo assessment in schools and in tertiary institutions. The allegation is supported by Reddy et al. (2016a:2) who explain that out of 48 countries that participated in Trends in International Mathematics and Science Study (TIMSS) 2015 mathematics in Grade 4, only 31 countries managed to obtain more than 500 points or average scale score which is the set benchmark of study while 17 countries scored below 500 points. The top-achieving countries had average scale score from 502 to 618 while the 17 underperforming countries obtained an average scale score from 353 to 498 (Reddy et al., 2016a:2). Reddy et al. (2016a: 1) show that learners who scored less than 325 points lack knowledge of the most basic skills in mathematics while those who scored from 400 to 475 have some basic knowledge in mathematics but they have not yet reached the required benchmark.

South Africa is also not faring any better in the performance of learners in mathematics. The results released by Reddy et al. (2016a:3) for TIMSS 2015 which assessed Grade 4 learners indicates that South Africa obtained position number 47 with 376 points out of 48 countries, which is below the international standard. According to the report, South Africa had only out scored one country (Kuwait) which had 354 points while Singapore scored pole position with 618 points which is a good achievement. Again, a similar performance in mathematics was recorded in TIMSS 2015 Grade 9 where South Africa participated with 39 countries and obtained position 38 with 372 points (Reddy et al., 2016b:3). According to the authors, South Africa only managed to outscore only one country (Saudi Arabia) which had a minimal average score of 368. Poor results were also recorded by Mullis, Martin, Foy and Fishbein (2020:9) for TIMSS and PIRLS which assessed Grade4 learners show that South Africa obtained position 56 out of 58 countries with 374 scores. The report showed that South Africa only managed to out scored only two countries (Pakistan) which had 328 scores and Philipine with 297 scores.

A closer look at the report indicates that South Africa is facing challenges in mathematics as it is performing below the expected standard.

My observation as a mathematics teacher is that most rural schools in the Mopani District perform below the expected standard. This is evidenced by the Annual National Assessment (ANA) results depicted below where Mopani District is compared with other districts in Limpopo Province.

Table 1.1: The average percent marks for mathematics Grade 9 for districts in Limpopo

POSITION	NAME OF DISTRICT	2013	2014	AVERAGE %
1	Vhembe	9.5	6.5	16
2	Capricorn	9.8	6.1	15.9
3	Waterberg	9.4	6.5	15.8
4	Greater Sekhukhune	7.8	5.9	13.7
5	Mopani	8.5	3.5	12

Based on the above average percent marks, Mopani District obtained last position with an average of 12% while Vhembe district attained position one with an average of 16 %. According to the Minister of DBE, Mrs Angie Motshekga, poor performance in mathematics may be attributed to the shortage of mathematics teachers, and the presence of under-qualified mathematics teachers in the system (DBE, 2016b:1). This indicates that the study on PD of teachers in the Mopani District is needed in order to address the catastrophe of low performance of learners in mathematics. Given the evidence of poor performance in South Africa, especially Mopani District (Reddy et al, 2016a:3) mathematics teachers, especially in rural schools need to engage in PD in order to improve the performance of learners in mathematics. Mopani District was selected as the choice of the study due to its poor performance when compared with the other nine districts in Limpopo in mathematics. The prevalence of the district's poor performance could be the result of ineffective teacher PD (Kukano, 2020:139). The majority of the studies on PD (Arikan, Fernie & Kantor, 2017:1832; Armah, 2017:6; Bantwini, 2019:228) focused on the implementation of PD programmes. Very few studies such as that of Weli and Ollor (2021:6) and Kohli (2019:7) pay attention to how PD assists in improving

performance. The current study aims at exploring the role of PD in assisting teachers to improve mathematics achievement in rural schools of the Mopani District.

1.3.1 Research Questions

The main research question was formulated as follows*:* **What is the role of teacher professional development in the improvement of mathematics achievement in rural schools?**

The following sub-questions were asked to support the main research question:

- How can teachers' professional development enhance knowledge about teaching of mathematics?
- What are the challenges hindering the professional development of teachers in rural public schools?
- How can mathematics teachers be inspired to engage in professional development?
- How does the professional development of teachers contribute to the improvement of learners' achievement in mathematics?
- What capabilities do teachers acquire during their participation in professional development?

1.3.2 Aim and Objectives

Based on the above main research question, the study is aimed at exploring **the role of teachers professional development in the improvement of mathematics achievement in rural schools of the Mopani District.**

To reinforce the aim of the study, the objectives formulated are:

- To explore how teachers' professional development can enhance knowledge about teaching of mathematics.
- To understand the challenges that hinder the professional development of teachers in rural public schools.

- To explore how mathematics teachers can be inspired to engage in professional development.
- To explore how professional development of teachers contributes to the improvement of learners achievement in mathematics.
- To understand the capabilities that teachers acquire during their participation in professional development.

1.4 LITERATURE REVIEW

The literature review of this study focuses on the improvement of teaching and the implications of PD. It explores the concept of professional development; the value of PD on teachers and strategies used for PD. The concept 'professional development' refers to the development of people in their professional roles (Serin, 2017:13). Ozdemir (2019:48) maintains that PD connects teachers with other teaching professionals and enhances their own practice. This implies that PD equips teachers with a wide range of professional skills that enhance their teaching careers and learner performance. Instead of PD, Prestridge (2019::22) uses the concept professional learning (PL) in referring to the development of teachers in schools. These concepts are used interchangeably to explain the improvement of teachers in schools, which suggests that there is no clear demarcation between PL and PD as both concern the improvement of teachers in schools.

The available literature by Koellner and Jacobs (2014:1), Edwards, Sandoval and McNamara (2015:466) and UNESCO (2015:2) indicates that PD exists in countries, such as the United states (US), the United Kingdom (UK), Afghanistan and Bangladesh. Koellner and Jacobs (2014:1) and Edwards et al. (2015:468) are of the opinion that PD plays a pivotal role in improving the quality of education in American schools where school systems and state organisations of education are involved in developing teachers in schools. They found that schools are supported by state and federal policies that encourage regular collaboration and PL; those schools are provided with resources and time to ensure that teaching; and learning is carried out effectively. The support of teachers by school systems and state organisations – through various resources – signifies that developed countries are devoted to quality education.

South Africa, like most developing countries, has developed policies and programmes that support the implementation of PD in schools. PD policies and programmes have been formulated and developed to enhance the quality of teacher education and to promote a system that improves the standard of teaching and learning in the country (DBE, 2011:1). One policy that plays a pivotal role in terms of PD is Integrated Strategic Planning Framework for Teacher Education and Development in South Africa as its primary aim is to improve the quality of teacher education and development (DBE, 2011:1). This programme addresses the development of teachers from Grade R to Grade 12 as well as in phases, including the recruitment of potential teachers; the preparation of new teachers; their induction into the world of work; and CPD programmes. The belief is that when teachers are developed, they acquire suitable skills to interact at various levels regardless of any academic challenges learners encounter.

1.4.1 Strategies that can Drive Professional Development

Various strategies can drive the PD of teachers in South African schools.

1.4.1.1 Lesson study

Lesson study is a model of teacher learning that was initiated in Japan. “It involves small groups of teachers meeting regularly to engage in a collaborative process of lesson planning, implementation, evaluation and refinement” (Ozdemir, 2019:48).

Ustuk and Comoglu (2019:48) maintain that lesson study plays an important role in the PD of teachers. According to Ogegbo,Gaigher and Salagaram (2019:5), lesson study improves teachers’ subject content knowledge, develops their skills and contributes to a change in teachers’ beliefs and attitudes. The authors suggest that lesson study can be prolonged for up to one year in order to encourage active participation, close relationships and build trust among participants as well as enhance interpersonal relationships. The fact that teachers acquire various skills and knowledge while using lesson study implies that school principals and the school district should encourage teachers to implement it.

1.4.1.2 Cluster meetings

Schools can also engage teachers in cluster meetings to discuss their experiences of their subject teaching (Jita & Mokhele, 2014:11), including issues, such as lesson planning, lesson presentation, assessment, lesson studies, and sharing ideas in terms of content analysis and knowledge. The authors also mention that teachers get time to observe one another and to assist each other when they encounter problems. Teachers, whose schools are involved in cluster meetings, are better equipped to set balanced question papers and write meaningful lesson plans than those at schools that do not have cluster meetings.

1.4.1.3 Recruitment

Another strategy that can be used to drive the PD of teachers is recruitment. UNESCO (2015:8) recommends that polices and strategies should be used to attract qualified teachers who are prepared to work in rural schools. According to DBE (2015b:44), the DBE recruits young people to undergo pre-service training in scarce subjects, such as mathematics, physical science and accounting, as well as in the foundation phase. The policy also encourages under-qualified teachers to undertake in-service training in order to improve their qualifications. Mukeredzi (2016a:1) and UNESCO (2015:8) argue that even though teacher recruitment may take place in different ways, there is a lack of appropriately qualified teachers globally. Consequently, unqualified teachers are employed to keep the schools going. The assumption is that when unqualified teachers are employed in schools, teaching and learning is negatively affected as learners tend to receive inferior education.

1.4.2 The Value of Professional Development on Teachers

Teachers' participation in PD can help teachers to improve their qualifications in different ways. Salmeron Aroca, Moreno Abellan and Martinez de Miguel Lopez (2022:13) highlight that the use of Information Communication and Technology (ICT) helps teachers during teaching and learning. According to the scholar, teachers use ICT skills and knowledge to access educational information from the internet and WhatsApp to communicate with their colleagues and learners on the issues of education. For example, teachers can use computers in teaching to perform numerous activities such as motivating and assisting learners and make topics interesting (Khobo, 2015:65). The fact that teachers can use ICT to interact with their

colleagues and learners to advance teaching and learning indicates that DBE should ensure that all teachers are ICT literate to improve the performance of learners in schools. This can also assist teachers to administer school work well. For example, they can use computers to set question papers, record learners' marks and save school information.

Teachers' support via PD can add value to the performance of teachers. According to Moekwa (2020:133), if teachers' qualifications are upgraded, re-skilled and up-skilled, they become an asset to the school because they acquire more knowledge and abilities in their profession. As a result, learners' performance increases. Thus, Kukano (2020:140) emphasises that teachers should be given full support by their principals by ensuring that they provide them with teaching materials, care and regular PD to encourage them working with enthusiasm. The researcher's view is that before teachers get upgraded and re-skilled, a needs analysis should be performed to help them identify their weaknesses and strengths. This will help the people in charge to develop or support them correctly since needs differ from teacher to teacher. In addition, when teachers are given care and supported with resources, they become committed to their work; in fact, a lack of resources discourages teachers from working effectively. Regular PD might help teachers to keep abreast of their profession and would help them to apply what they have already learnt.

1.4.3 Theoretical Framework

This study uses Guskey's (2002) theory of Professional Development. Guskey's theory of PD focuses on teacher change. The theory is closely related to this study which encourages the PD of teachers in schools. According to Guskey (2002:381), PD and teacher change involve an improvement of teachers' educational practice, including teaching methods, content knowledge, beliefs, attitudes and the learning outcomes for learners. It is maintained that there are various PD programmes that teachers can attend to enhance their educational needs. The researcher is of the opinion that PD programmes that can be used for teacher development include teacher workshops, conferences and meetings in order to expand teachers' skills and knowledge related to matters that affect teaching and learning in schools.

Guskey's theory (2002:384) indicates that PD programmes are intended to bring about change in the classroom practice of teachers in terms of their attitudes and beliefs and in learner improvement. This suggests that the way in which teachers teach learners in the classroom

affects their emotions. According to Zambak, Alston, Marshall and Tyminski (2017:113) in their discussion of PD and teacher change, change in practice comes before change in belief. This indicates that change does not necessarily follow a pattern but that it can come before practice or before belief depending on circumstances. Therefore, it is possible for teachers to implement programmes before believing that they will work.

According to Guskey's theory (2002:382), teachers like PD programmes which they believe will improve their knowledge and skills; contribute to their growth; and improve their effectiveness with their learners. The theory suggests that teachers should be involved in the planning of PD programmes, as their involvement will ensure that practice or strategies is aligned to their needs.

1.5 RESEARCH DESIGN AND METHODS

This study was located within qualitative research. The reason for using qualitative research was to obtain detailed human experiences and the meanings they give to the problem (du Plooy-Celliers, Davies & Bezuidenhout, 2014:17). The participants were interviewed in their natural setting where they shared their experiences concerning the topic. For the participants to share their experiences about the phenomenon and the meanings attached to their responses more fully, the researcher probed responses to obtain further details.

This study used a qualitative case study. Lune and Berg (2017:170) describe a case study as a programme that can be used to understand information from a single case or a collection of cases. The case study was suitable in this study as it was used to explore the role of PD in assisting teachers to improve mathematics achievement in rural schools in the Mopani District. In addition, a case study was suitable for this study because it studies real life and current information that affects the society in a particular area (Creswell, 2013:97). It also asked "how" and "what" questions to collect data (Creswell, 2013:101). The researcher used the case study to understand how mathematics teachers improved their teaching of the subject in rural schools; to explore the challenges that hinder mathematics teachers from engaging in PD; and to determine how they might be encouraged to engage in PD programmes.

1.5.1 Research Paradigm

The study employed an interpretative paradigm using a qualitative approach. According to Creswell (2013:45), qualitative research acquires in-depth data by interacting with participants in their natural settings. The researcher used open-ended questions to collect information from the participants and avoided influencing them while they were responding to questions. The use of open-ended questions assisted the researcher to understand the attitudes, explanations and experiences of the principals, mathematics teachers and curriculum advisors (CA) for mathematics concerning how they perceive the PD of mathematics teachers in rural schools. Creswell (2013:44) mentions that the voices of the participants are important when writing the report of the study.

1.5.2 Population and Sampling

In terms of sampling, the study employed two sampling strategies. The first sampling strategy used was purposive sampling. According to Cohen, Manion and Morrison (2018:218), purposive sampling focuses on selecting suitable participants who are able to provide rich information based on their characteristics, such as qualifications and experience. Merriam and Tisdell (2016:100) also stipulates that purposive sampling is often used in qualitative research with the participants being selected before the process of data collection takes place. In this study, purposive sampling was used to select principals, and CAs for mathematics in the public rural schools of the Mopani District. The circuit office provided the researcher with a list of rural schools in the Mopani District for sampling and six primary schools having higher enrolments were sampled. The researcher purposively selected the principals who had five years of experience or more working in rural primary schools from each school who later helped to find additional participants. The researcher also purposively selected two CAs for Mathematics in the Mopani District. The CAs were selected as follows: one CA was supposed to be supervising mathematics in foundation phase while the other one supervising Grades 4–9. Both CAs were selected from the General Education and Training (GET) band. According to DBE (2016b:3), GET is the phase that covers education starting from foundation through Intermediate to Senior phases. It focuses on grade R to 9. The CAs were selected because they were directly involved with curriculum support of teachers in schools and facilitated PD programmes in the circuit and at regional level. The sampling strategy also provided the

researcher the opportunity to select participants who were readily available and who were responsible for the implementation of PD.

The study also used snowball sampling. Merriam and Tisdsell (2016: 98) reveal that snowball sampling is used as a chain or network to find the participants. According to Cohen et al. (2018:220), researchers who embark on snowball sampling first choose participants who have the characteristics required to participate in the study; thereafter, they use them as informants to identify other people who may be suitable to the study. In this study, each principal from each school helped the researcher to identify a teacher who taught Grade 6 mathematics.

In terms of population, the total number of the principals selected was six, three women and three men. The CAs were two in number, one man and one woman. Both the principals and CAs were selected through purposive sampling as described above. Mathematics teachers were also six in number, three men and three women, who were selected through snowball sampling. The total number of the participants selected in this study was 14. Their selection considered gender and experience. The researcher made sure that participants who had more experience were selected and gender was balanced. Grade 6 mathematics teachers were chosen on the basis that the DBE officials frequently monitored their work.

1.5.3 Data Collection

Qualitative researchers are encouraged to use data collection methods that will inspire readers and editors to read their studies (Creswell, 2013:161). This study used semi-structured interviews to accumulate in-depth information.

In planning the study, given the research purpose and main question, interviews were deemed appropriate as the main data collection instrument. Creswell (2015b:216) describes an interview as a two-way communication between the researcher and the interviewee in which the researcher asks the interviewee questions to find out about the phenomenon in the study and to observe behaviour, emotions and actions as well. According to Bertram and Christiansen (2014:83), in-depth semi-structured interviews allow the researcher to probe the participants to provide rich information about the problem under investigation. In-depth qualitative interviews provide the researcher with time to probe the participants with the purpose of acquiring more views, opinions and beliefs about the topic under study (Du Plooy-Cilliers et al., 2014:188).

Before the administering of the interviews, the researcher initially sent consent letters to the participants. The consent letters contained information such as information about the content of the research and participants' rights of withdrawal, confidentiality and anonymity. According to Cohen et al. (2018:313), both the researcher and the participants should be fully aware about the purpose, the information required and the procedure of conducting the project and participants should not be forced to participate in the project.

1.6 DATA ANALYSIS

Data analysis in this study followed the steps developed by Creswell (2013:199). After the researcher collected data through semi-structured interviews, the researcher organised the information. The information was coded and categorised into themes and sub-themes to observe the emerging patterns. The information and its interpretation were then inspected to identify the similarities and the differences between the cases. This helped the researcher to determine the overall results and to write the research report.

1.7 TRUSTWORTHINESS

Creswell (2013:244) uses the concept validity to refer to trustworthiness. To ensure that the study was trustworthy, the researcher used field notes and an audio recorder to record interviews. According to McMillan and Schumacher (2014:386), audio recorders are instruments that can be used by researchers to capture verbal interactions and information and they are a reliable source for checking accuracy of the data, and field notes are more important because they also record nonverbal information. The audio recorder was able to record all the information that could be missed when only taking field notes. "Qualitative researchers speak of trustworthiness, which simply poses the question 'Can the findings be trusted?'" (Korstjens & Moser, 2018:121). The elements of trustworthiness are credibility, transferability, dependability, and confirmability.

1.7.1 Credibility

According to du Plooy-Celliers et al. (2014: 258), credibility refers to the uniformity with which the measuring instrument yields a certain result when the entity being measured has not changed. To ensure that the study was credible, the researcher used member checking. Member

checking is the process in which the researcher double-checks the accuracy of the information provided by the participants during data collection (McMillan and Schumacher, 2014:355) by confirming this with the participants before the report is written up. The participants were given time to correct mistakes and give clarification where necessary before the data were analysed.

1.7.2 Prolonged engagement

The researcher used prolonged engagement to make sure the data collected were credible. This was achieved by interviewing the participants for between 30 and 60 minutes. Again, the researcher also arranged to interview the participants for a second time for those the information already collected was not adequate.

1.7.3 Tranferability

The researcher also made sure that the study had transferability. According Yin (2016:106), transferability refers to the extent to which the outcomes of a qualitative study can be applied to other locations. The researcher improved the transferability of the study through defining the research context and clarifying the assumptions that form the basis of the study.

1.7.4 Dependability

The researcher also ensured that the study had dependability. Howitt and Crammer (2017:310) define dependability as the consistency and persistence of the research findings and the point to which research procedures are documented, allowing someone outside the research to follow, examine and analyse the research process. The researcher ensured the dependability of the study via an observant conceptualisation of the study, reporting the findings and using descriptive data.

1.7.5 Confirmability

The researcher also ensured that the study had confirmability. According to Merriam and Tidsell (2016:239), confirmability is the degree to which results can be supported by others. In this study, the researcher ensured the confirmability of the study through precise referencing, a clear audit trail of methods and strategies used in the collecting of data and through the

researchers' own reflexivity when networking with the research participants and analysis and interpretation of data.

1.8 ETHICAL CONSIDERATIONS

The researcher applied for ethical clearance from the University of South Africa (UNISA) (Appendix B). The researcher also sought permission from the Limpopo Department of Basic Education (LDBE) (Appendix C & D) and the district senior Manager of Mopani District in Limpopo Province (Appendix E &F). According to du Plooy-Celliers et al. (2014:264), the participants should be made aware of what is involved in taking part in the study. The researcher ensured that the participants were provided with detailed information about the nature of the study so that they could decide whether to participate or not.

The participants were also informed about the risks, the benefits, and the purpose of the study. They were informed that they could terminate their participation at any time should they wish to do so. The anonymity of the participants was guaranteed. The researcher ensured that the names of the participants were concealed so that readers could not identify their names from their responses. The participants were asked to sign a consent form which contained the details of the study and the researcher.

1.9 LIMITATIONS AND DELIMITATIONS OF THE STUDY

1.9.1 Limitations

This study was limited by financial constraints during data collection since the researcher had to travel long distances to collect data from the participants. The financial challenges were caused by the fact that the participants were located at considerable distances from the researcher's home. The researcher also encountered a problem of being denied access to conduct research in the sampled schools by the school principals who believed the process would disturb them. The researcher had to request permission to collect data from participants in other schools. The study was also limited by the time factor during data collection since more time was needed to interact with the participants. The few sampled schools may not be

the representative of all rural schools in the Mopani District. As a result, the outcomes of the study may not be able to be generalised.

1.9.2 Delimitations

This study was confined to rural public primary schools of the Mopani District in Limpopo Province. It focused on school principals, mathematics teachers and mathematics CAs responsible for GET mathematics teachers. Mathematics teachers who participated in the study were expected to have had at least three years or more teaching experience in mathematics. The study only used rural public primary schools. Private schools and schools located in townships were excluded because they fell outside the scope of this study. This study used a case study design in order to enable the researcher to sample schools and participants that would provide in-depth information.

1.10 CLARIFICATION OF PERTINENT CONCEPTS

The following concepts, frequently used in the study, are clarified and simplified.

1.10.1 Cluster

According to Mukhamedov, Khodjamkulov, Shofkorov and Makhmudov (2020:256), a cluster refers to the collection of teachers that have a common goal from the various schools in a particular geographical area or circuit in order to discuss matters that affect their educational needs. Akhmedv and Majidov (2021:472) view a cluster as the schools that are located close to one another with the purpose of sharing knowledge and skills, solve problems in the implementation of educational process as a whole, and increasing the interest of students on the part of the teacher. In addition, Khodjamkulov (2020:136) indicates that the role of a cluster is to equip teachers with subject content knowledge, pedagogical knowledge and work-related skills that assist them in planning, lesson preparation and sharing skills and resources with others. In this study, the cluster refers to the groups of primary schools located in rural areas of Mopani District with the purpose of sharing their skills, experience and content knowledge in mathematics.

1.10.2 Rural Schools

Rural schools are schools that are situated in geographical areas which have no access to urban support or resources such as good roads and railway lines, school infrastructure or health facilities. Rural schools are found in sparse settlements (Nkambule & Mukeredzi 2017:2). According to the scholars, most of the parents in rural areas are poor, illiterate, and do not participate in the education of their children. In this study, rural schools are schools located in the rural areas of Mopani District excluding the schools located in townships and in other districts.

1.10.3 Lesson Study

Ogegbo and Gaigher (2019:5) describe lesson study as a form of PD strategy that is used to support teachers' learning by ensuring that they improve content knowledge, skills to apply classroom practice, and contribute to teacher change in beliefs and attitudes. Ozdemir (2019:49) explains lesson study as process whereby teachers work together to formulate a research lesson that is presented in class by one teacher while other teachers give feedback to the one who presented the lesson. Additionally, in lesson study, a team member explores the best method that can be used to teach or present a lesson in such a way that it can be well understood by learners. Other teachers reflect on the lesson with a view to improving it (Phiri, 2020:68). In this study, lesson study refers to when teachers at the same school and subject share their teaching skills where one teacher presents a lesson and others give comments in order to assist the teacher to improve their teaching practice.

1.10.4 Curriculum advisors

Some scholars use the concept of curriculum advisors interchangeably with subject advisors. Stephen (2018:221) describes CAs as educational professionals who give support to teachers at schools by making sure that teachers have thorough subject content knowledge, attend workshops and seminars, are assessed, and monitored in order to improve their teaching careers. On the other hand, Mbanjwa (2014:1) alleges that subject advisors are employed by the Department of Basic Education to participate in curriculum planning in the districts and to monitor an implementation of curriculum in schools and to give necessary support to teachers. Rasebotsa (2017:13) states that the role of CAs is to make sure that schools follow and

implement policies and develop and facilitate programmes. In this study, CAs refer to the subject advisors who give support, monitor, and develop mathematics teachers in GET in the Mopani District.

1.10.5 Learner

According to Jonicnada (2012:4), learners are children requiring structure, framework, timelines and organisation to achieve basic learning through the education system. In South Africa, a learner means any person receiving education or one who is obliged to receive education in terms of the South African Schools Act No. 84 of 1996. For the purpose of this study, a learner refers to any child attending school from Grade R to Grade 12 in rural schools in the Mopani District.

1.10.6 Teacher

A teacher is a person who is appointed to teach or train other people, to perform –curricular duties, to give advisory and education psychological services, at school (Education Labour Relations council (ELRC), 2003: C-3). Sukawati, Gunawan, Prayoga and Wardani (2020:250) view a teacher as someone who is appointed to execute learning and teaching and has ability to change the morals and behaviour of learners because teaching profession is noble. In this study, a teacher refers to the mathematics teacher who is employed to teach mathematics by the DBE in rural schools of the Mopani District .

1.10.7 School

According to ELRC (2003:C-26), a school refers to any educational institutions that provides education and training, including pre-primary education and it is managed, controlled and maintained by the provincial Department of Education. The definition excludes universities and technical and vocational training colleges. In terms of this study, the school refers to any institution governed by the DBE policies that provides educational activities offered by professional teachers within the Mopani District.

1.10.8 In-service Training

The concept in-service training is defined in various ways. Junejo,Sarwar and Ahmed (2018:50) describe in-service training as an ongoing PD of teachers executed with a view to keeping employed teachers abreast of current skills and knowledge. Additionally, in-service training is the PD of teachers working in the same environment where teachers collaborate on different teaching activities with a view to enhancing quality teaching and learning (Rodriguez,Condom-Bosch,Ruiz and Oliver, 2020:8). Muslu, Okulu, Senler, Arabacioglu, Yilmaz and Unver (2022:350) describe in-service training as PD used by teachers to support each other in their workplace by sharing valuable information that helps them enhance their teaching careers on matters such as assessment techniques, lesson preparation and problem-solving. In this study, in-service training relates to all programmes intended to improve the quality of education of all the mathematics teachers employed by the DBE in rural schools of the Mopani District. The PD activities may include workshops, support meetings and cluster meetings.

1.10.9 Pre-Service Training

According to Manasia,Lanos and Chicioreanu (2019:18), pre-service training is an initial formal training given to prospective teachers by higher education institutions where they are exposed to the basic skills and knowledge needed in the real working situation, while Ryan, Young and Kraglund-Gauthier (2017:3) describe it as an activity that prepares teachers for the work environment and encourages them to transform their experiences from theory to practice by being exposed to practicum settings. According to Orlad-Barak and Wang (2021:86), the role of pre-service training is to enhance the educational teaching practice of prospective teachers, to expand their intellectual thinking for them to gain problem-solving skills and to orientate them on their future work. In this study, pre-service training refers to professional training of prospective teachers by registered higher educational institutions that prepare them to teach mathematics in the rural schools of the Mopani District.

1.10.10 Professional Development

The term professional development is described in different ways. According to Ndebele, Muhuro and Nkonki (2016:132), PD is measured in terms of academic achievement rather than

acquiring content knowledge, teaching skills and advanced teaching methods, while . Salmeron Aroca et al. (2022:13) mention that PD inculcates a desire to learn, innovation of ideas and the acquisition of new teaching abilities. Gomez et al. (2015:461) describe it as a source of knowledge distributed to teachers that has power to change their abilities, attitude and beliefs. In this study, PD refers to teachers' engagement in various programmes that have ability to improve their careers in terms of teaching skills, practices, and subject content in order to improve the performance of learners in mathematics in the Mopani District.

1.11 CHAPTER OUTLINE

This study comprises of six chapters, namely:-

Chapter 1- This chapter provides the introduction and background, statement of the problem, the significance of the study, research questions, research aims, theoretical framework, literature review, research methodology and design, population and sampling, data collection, data analysis, credibility and trustworthiness, ethical issues, limitations and delimitations and clarification of concepts.

Chapter 2- The chapter discusses the literature of the study.

Chapter 3- The chapter presents the theoretical framework.

Chapter 4- Research methodology and procedures for undertaking the study is explored at a greater length.

Chapter 5- This chapter comprises the research findings, data analysis and interpretations.

Chapter 6- In this chapter, the summary, concluding remarks and recommendations based on the findings are discussed.

1.12 CHAPTER SUMMARY

This chapter provided an overview of the study including the introduction and background, statement of the problem, significance of the study, research questions, aims and the objectives of the study, the theoretical framework and a preliminary literature review. Furthermore, the study discussed the research methodology and design, credibility and trustworthiness, ethical issues, limitations and delimitations of the study, and the outline of the study. The next chapter presents the literature review in detail.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

This chapter discusses various forms of professional development in order to understand how they contribute to the quality teaching in schools. The literature review looks at PD in developed countries, developing countries and in South Africa, including the Mopani District to understand how the countries implement the PD of teachers. According to DBE (2016a:16), South African national education system's teacher development plan includes teacher recruitment, training of initial teachers as well as CPD where teachers would be developed in various skills.

Among other things, the chapter discusses the literature review which involves the recruitment of prospective teachers, development of teachers in teacher education institutions, induction of teachers in workplace and CPD through various strategies. The chapter also reviews literature on mathematics teaching to understand how mathematics teachers around the globe, including in the Mopani District are developed.

2.2 PROFESSIONAL DEVELOPMENT OF TEACHERS IN SELECTED COUNTRIES

The sections below discuss the PD of teachers from selected developed and underdeveloped countries. The developed countries include UK, Australia, Canada, Finland and Singapore, while underdeveloped countries are African countries such as Nigeria, Ghana and Zimbabwe. After these, the chapter discusses the PD of teachers in mathematics from selected developed countries: Israel, United States of America (USA), Turkey and Taiwan.

2.2.1 United Kingdom

Teacher development is given a high priority in the UK. Various routes are used to train and re-train teachers in order to maintain a suitable number and quality of teachers. Some of the PD programmes that are carried out include Initial Teacher Training (ITT); induction and continuing teacher development which help teachers to acquire quality teaching skills.

According to the UK Department For Education (DFE) (2019a:10), some of the issues that necessitate ITT in UK include:

- the shortage of teachers in subjects such as mathematics, science and modern foreign languages.
- 20% of the teachers leave their profession within their first two years of start working while 33% quit the system within their first five years. In response to this, the DFE recruits students by giving bursaries to those who passed well in post-secondary education as well as in mathematics. In order to be awarded the bursaries, the students should obtain at least Grade B in mathematics A level or equivalent subject knowledge to be trained as teachers (DFE, 2018c:10). ITT in UK is endorsed by sectors such as unions, teacher training colleges and university researchers and focuses on aspects that teachers would need in the workplace. According to DFE (2019a:20) and DFE (2019b:5), these include:

    - Behaviour management.
    - Teaching methodology.
    - Subject content.
    - Subjects' assessment, and
    - Professional behaviour of teachers.

After Newly Qualified Teachers (NQTs) have completed their initial training by ITTs, they are expected to undergo induction which they have to satisfy without fail to become qualified teachers. Induction is mainly implemented to support NQTs as soon as they start working in order to get full-time employment. They only have one chance for induction. When they lose it, they become unemployable in lawfully registered schools in the UK which include maintained schools (i.e those under the control of a local authority), maintained nursery schools and non-maintained special schools, which are managed by trusts of charities. For the NQTs to do induction, they should occupy a suitable post which is verified by the school principal who ensures that a suitable tutor is assigned. The periods and schoolwork for the NQTs are reduced to reasonable numbers so that they can become productive in induction process. According to the DFE (2018a:16), suitable programmes for monitoring, supporting and

assessing are put in place so that NQTs can become suitably qualified. The programmes include:

- Support and guidance from the assigned tutor who has suitable experience and knowledge.
- Observation of NQTs' lessons and follow-up discussions.
- Regular professional reviews of the progress.
- Observation of experienced teachers within the workplace.

During the induction period, the tutor assigned to induct NQTs should frequently and fairly make judgements about the PD of the NQTs.

There is an outcry that most teachers in UK are burdened by heavy workloads which negatively affect teaching and learning and performance. The CPD programmes exist to address workload-related issues and are facilitated by sectors such as unions and private training providers in the form of workshops, conferences, face-to-face courses and seminars. According to the DFE (2018b: 22), the subjects offered during CPD include:

- Time management.
- Marking and assessment strategies.
- Planning strategies.
- Financial management.
- Training of specific subjects, and
- Behaviour management.

The fact that teachers are given CPD training in behaviour management, time management and financial management to address their workload shows that the UK might be ahead in terms of teacher professional development. If teachers are given necessary support in their work, they can work very hard even when the setup is not favourable to them. Ultimately the performance of their learners would improve greatly because they implement various strategies such as marking and assessment which are core tasks for learning and teaching in schools.

2.2.2 Australia

The Australian government provides various PD programmes to teachers. According to the Organisation for Economic Cooperation and Development (OECD) (2018:7), some of the educational programmes generated in Australia include The Smith's Learning for life Programme from 2016-17 to 2019-20 which funds students to study and improve their careers including student-teachers who come from poverty-stricken families. The OECD (2018:7) further indicates that the Indigenous Student Success Programme (2017) provides money to the universities so that they can give bursaries to student-teachers in order to help them acquire mentorship, tutorial support assistance and personal support.

Teaching institutions are provided autonomy to plan their own programmes when it comes to PD of teachers in Teacher Education Institutions (TEIs) and schools. For example, teachers can use any resources or classroom practice of their choice while implementing PD (Schleicher 2016:60). According to OECD (2015:90), the recruitment of student-teachers by TEIs should be done in such a way that they can get quality teachers and improve the performance of learners. This implies that the selection of student-teachers by TEIs should focus on students who have good matric results so that they can cope with their studies.

Continuing PD is also offered to in-service teachers in order to add to the skills and knowledge acquired from the initial education institutions to be in line with standards around the globe. For example, the Australian Government Quality Teacher Programme funds state and territory education authority projects with a focus on improving middle school teachers's performance by attending conferences with follow-up school visits to support what they have learnt in the conferences and to cope with educational reforms (Australian Government Department of Education and Training, 2016:6). According to Schleicher (2016:41), most PD programmes focus on teacher content, pedagogical training and the practical aspects of the subject taught in schools. There is a shortage of specialist teachers in MST and for that reason the Australian government has started developing primary and secondary teachers on Science, Technology, Engineering and Maths (STEM) subjects in order to strengthen their competencies (Australian Government Department of Education and Training, 2016:6; OECD, 2018:7). Teacher development also focuses on ICT competencies. According to Finger (2019:196), training of teachers on ICT in Australia allows them to engage with their colleagues. The benefits acquired include:

- improvement on professional practice;
- selecting and organising resources for teaching and learning purpose;
- ICT for reporting and recording; and
- professional collaboration on online.

ICT also allow initial teachers in Australia to collaborate with teachers from other schools and they also get the chance to share ideas and skills, that can help them implement new curriculum (Howard, Akiba, Kuleshova, Wilkinso & Farfan, 2016:13). Teachers also attend workshops and seminars which help them to expand their skills and knowledge during interaction (Guskey, 2014:13). The fact that teachers in Australia are engaged in ICT signifies that the country is committed to providing them with skills needed in 4th Industrial Revolution (4IR). This helps them to learn various technological strategies that are needed in their profession and make learning and teaching effective. For example, teachers can use ICT to teach learners from different places without having direct contact with them.

2.2.3 Canada

Canada budgets considerable money to improve teachers' capabilities. The study by OECD (2018: 23) reveals that Canada invests over CAD150 million in a Technology and Learning Fund (2014-17) to improve classrooms and support teachers in matters that affect teaching and learning since education keeps on reforming due to changes in life and resources. According to the OECD (2018:23), there are programmes that mentor and guide young students to become student-teachers and provide them with bursaries that allow them to study in various teachers' universities and colleges freely. Consequently, enough quality teachers are developed in crucial subjects such as mathematics and science which are needed by most countries.

Canada also develops teachers to teach learners in early childhood education centres so that they can acquire basic skills and knowledge before they commence with primary education. The national education system requires teachers to receive adequate PD from teachers' institutions before the programmes can be rolled out. The OECD (2018:23) mentions that in 2017 Canadian government had established programmes in provinces that would ensure there were multilateral early learning and childcare services provided to the families that needed it

most. In order to carry it out, funds are provided to ensure that quality teachers are well developed.

Teachers in Canada are also engaged in PD so that they can be on par with their cohorts around the world. This is supported by Herbert and Bragg (2017: n.p) who indicate that equipping mathematics teachers with mathematical reasoning on their curriculum is emphasised globally but most teachers in Canada seldom struggle in this regard. To improve the level of their mathematical reasoning, Loong, Vale, Herbert, Bragg and Widjaja (2017:23) found that teachers in Canada participated in programmes that involved observing demonstration lessons of experienced teachers and other experts on how to provoke reasoning abilities on mathematics learners and later these teachers are trialled in order to master the skills well. The scholars further explain that after lesson presentation, post-lesson discussion takes place whereby the teachers conduct discussions based on the lessons to understand how mathematical reasoning can be provoked to learners. Herbert and Bragg (2017: n.p) whose study focused on peer observation during PL in the mathematics subject in Canada, mention that peer observation lessons is executed to build the understanding of teachers' reasoning. These scholars also mention that a group of teachers can come together to define the content area, but they ensure that mathematical reasoning is kept uppermost. The researcher believes that the observation of mathematics lessons by teachers under PD can help them understand techniques and questions that can be used to provoke the reasoning capacity of learners.

Initial teachers are engaged in induction programmes in order to be acquainted with workplace activities. Teachers who are employed in full-time positions are engaged in new teacher induction programmes and those who successfully complete them are awarded a Certificate of Qualification and Registration (Schleicher, 2016:52). The researcher believes that when initial teachers are subjected to strict assessment, this serves as a tool to test quality teachers who are prepared to work diligently.

It is important that teachers should get PD so that they can increase knowledge and skills on educational matters. According to the OECD (2015:158), teachers should participate in PD because curriculum keeps on changing and new improvements that suggest better ways of doing things emerge and this requires teachers to undergo briefing and attend training. The study also indicates that teachers should believe in the programme in order to realise its effectiveness. The fact that teachers in Canada are engaged in various PD programmes puts

them in a good position because these programmes equip them with necessary competencies for their careers.

2.2.4 Finland

Like other developed countries, Finland provides pre-service and in-service training of teachers. The pre-service training is conducted by the universities which are autonomous, and selection of student-teachers is based on matriculation examination results. As from 2020, they planned to administer aptitude tests (Pollari, Salo & Koski, 2018:7). Pollari et al. (2018: 10) mention that Finland's PD programmes are of a high quality in a sense that prospective teachers have to get master's degree to become teachers, and this makes them able to work in dicerse positions in society. It is no wonder that teachers from other countries, for example, the USA, took a trip to Finland to learn about Finnish developments such as professional growth, personal and cultural gains as part of PD (Szente & Levi, 2019:1). The other courses that are provided in their programmes include studies in education and teachers' pedagogical studies which also involve supervised teaching practice. The researcher understands from this that future teachers participate in practice teaching so that they can develop skills before they take up positions in the workplace.

Hal and Mikulec (2018:55) explain that prospective teachers in Finland are required to undergo reflections and teaching practicum supported by feedback and dialogue from mentor teachers, peers as well as school-based teachers in order to prepare them. Pre-service training which became compulsory in 2015 is also offered to Early Childhood Education (ECD) teachers. The core curriculum was implemented in 2017. According to OECD (2018:40), teachers should first undergo pre-service training in order to work in ECD which is funded by the state before they can start with the programmes. The emergence of ECD programmes forced half of the countries in OECD to introduce policies that required teachers to engage on pre-service training so that they can acquire the necessary skills and knowledge needed in teaching ECD (OECD; 2015:90). Most of these policies focus on nurturing quality; as a result, they are adopted by many countries. This indicates that Finland has huge influence in OECD countries on the matters that affect ECD policies.

Teachers also participate in in-service training in order to enhance their competencies. Part of the courses offered to prospective teachers in teacher education includes research where

teachers must obtain a master's degree in order to become teachers. Thus, Eklund (2019:17) mentions that although future teachers in Finland complete their master's degree, they are still expected to enrol and study for a doctoral degree to acquire all the necessary research competencies. This is because teachers are required to conduct research on the subjects they teach to achieve improvement in their profession.

2.2.5 Singapore

In Singapore, PD of teachers is carried out by the National Institute of Education established in 1950 as a Teacher Training College and it facilitates both pre-service and in-service training (Kandermir, 2017:9). The prospective teachers are chosen according to their talents and qualifications. The researcher believes this could be done to train quality teachers who can improve the level of education in the country. Kandemir (2017:10) highlights that the programmes, levels of teaching and periods of study offered to prospective teachers vary. They include:

- Diploma in Education that takes two years and teachers can teach both in primary and secondary schools.
- Bachelor of Arts in Education which lasts for four years and teachers can teach both primary and secondary schools, and
- Diploma in Special Education that lasts for one year and the teachers are trained to teach in special education.

Besides developing prospective teachers, Singapore also provides a wide scope of in-service training to teachers in government schools such as education research, research-based pedagogical curriculum, lifelong learners and programmes for principals, Heads of Department (HoDs) and other school leaders. Alviz (2019:20453) describes an HOD as a middle manager of the school who helps teachers to deliver quality education by developing them, providing the materials and technology they require to deliver curriculum effectively.

The other forms of PD in Singapore are informed by the immediate challenges of teachers. For example, Wen and Wu (2017:82) showed that teachers in Singapore require continued and persistent training on curriculum knowledge, pedagogical design and the use of ICT for

Singapore Chinese language teaching and learning. Thus, Singapore provides ICT programmes and support to the teachers so that they use it for teaching and learning and most teachers teaching mathematics use computers to teach various mathematics activities (Ayieko, Gokbel & Nelson, 2017:83).

Most teachers in Singapore had a problem of using traditional method for teaching such as "chalk-and- talk" and they were not comfortable being observed by other teachers (Loh, Hong & Koh, 2017:9). To solve such problems, Loh et al. (2017:9) indicate that a team of teachers from various school workplaces use collaborative reflection and support to assist such teachers to reform their classroom practices, beliefs and confidence which help them better teachers.

Wen and Wu (2017:82) found that beginning teachers in Singapore require intensive support from experienced teachers in areas such as classroom management and learning assessment. Thus, induction programmes are conducted both at the national and school level. The programme offered at national level is called the Beginning Teacher Orientation and is conducted for three days by the Singapore Ministry of Education (Schleicher, 2016:50). The programme inducts the initial teachers about their roles in interacting with learners and how they can consolidate learning in the classroom. Schleicher further mentions that, at school level, induction is done in the first two years via a structured mentoring programme where beginning teachers are inducted about practical and skills by mentors who are experienced in school issues. The fact that the Ministry of Education is involved in the induction of novice teachers signifies that it is valuable, and schools should be encouraged to carry it out diligently.

2.2.6 Nigeria

Professional development of teachers in Nigeria is carried out through pre-service and in-service training. The pre-service training takes place in TEIs such as the faculties of education of universities, institutes of education of universities, technical education programmes of polytechnics, colleges of education and the national teacher institutes (Ofoego & Ebebe, 2016:197; Nwokeocha, 2017:129). The institutions develop teachers in different teachers' programmes, but they lack some basic teacher development aspects. For example, Nwokeocha (2017:130) indicates that most pre-service teacher education in Nigeria is criticised for emphasising theory rather than classroom practice and this leads to the poor performance by teachers. Thom-otuya and Inko-tariah (2016:101) also mention that the Nigerian education

system focuses on quantitative matters rather than qualitative as no university in Nigeria falls within the top 50 universities in Africa or the top 3 000 universities in the world. This shows that there is still a lot that Nigeria needs to do to enhance initial teacher education in terms of PD of teachers.

In line with teacher development, Ofoego and Ebebe (2016:197) mention that the minimum qualification for primary school teachers is the National Certificate of Education which replaces the previous Grade II Teacher's Certificate. They also indicate that most teachers lack interest in teaching and select teaching as a last resort. In other words, they prefer jobs other than teaching on the completion of their studies. The reason for this behaviour in Nigeria is due to poor salaries that teachers receive. This suggests that teachers' needs are not met to their satisfaction.

Teachers in Nigeria are also engaged in various in-service programmes with a view to improving the level of their qualifications. According to Nwokeocha (2017:130, various stakeholders that provide CPD for teachers include:

- The Teachers Registration Council of Nigeria deals with the registration of teachers, awareness and recruiting teachers to participate in PD programmes.
- The National Teachers Institute assists unqualified teachers to improve their qualifications using workshops, and open distance learning.
- The National Institute for Educational Administration and Planning develops educational administrators around Nigeria in terms of their duties.
- The Universal Basic Education Commission provides funds to the state with guidelines and supervisory roles to ensure that all teachers in Nigeria are engaged in CPD.
- Other stakeholders include teachers' unions, international development partners and employers of teachers.

Additionally, other PD strategies that develop teachers involve workshops that are conducted in central venues that are convenient to most teachers, and experts provide professional information and PD skills. Teachers also attend annual conferences and seminars. The core focus of CPD involves educational, information and communication technology, measurement

and evaluation, management of large classes and teaching in mother tongue (Nwokeocha, 2017:132). The use of various strategies to develop teachers signifies that Nigeria aspires to equip its teachers with necessary information and skills.

Teachers in Nigeria are also engaged in ICT programmes to enhance their teaching skills in order to cope with 4IR programmes. McAleavy, Hall-Chen, Horrocks and Riggall (2018:28) explain that teachers in Nigeria are engaged in ICT programmes that develop them on pedagogical practice of teaching English content and literacy in primary schools. According to these scholars, teachers are given Nokia cell phones loaded with six months' airtime and internet connectivity. Teachers are grouped in five and given necessary support by their mentors. Consequently, teachers learn how to teach learners using cell phones and to interact with teachers from other schools on issues that affect teaching and learning. Adedeji (2018:317) agrees that the training and retraining programmes of teachers in Nigeria help them to master teaching activities and learning of mathematics curriculum in schools.

2.2.7 Ghana

Like other countries, Ghana executes PD of teachers at various levels. According to Akyeampong (2017:4), Ghana has 38 Teacher Education Colleges (TECs) that provide pre-service training of teachers in primary schools and junior secondary schools and two universities that focus in high school teachers. Amongst these TECs seven develop women and one develops men and the remaining are co-educational. The minimum qualification offered to prospective teachers is the Basic Education Diploma which is a three-year programme. Unlike other countries which offer bursaries to their student-teachers, the student-teachers in Ghana use their own money to attain their qualifications. This is supported by Acheampong and Gyasi (2019:91) who lament that scrapped allowances of trainees should be replaced in order to encourage prospective teachers to attend TECs as most of them cannot afford to pay for themselves. This shows that initially the Ghanaians teachers were getting support from the state and the researcher believes it encouraged them to improve their qualifications.

Teacher education in Ghana went through various reforms to suit the needs of the country. Armah (2017:4) mentions that Education Act No 788 which addresses the concerns of untrained teachers and enforces professionalism in teacher education, Thus, teacher development is highly esteemed in Ghana to reduce the number of unqualified teachers.

According to Akyeampong (2017:5), in 1990, teacher education was reformed based on the criticism that it emphasised content knowledge in the place of pedagogical content knowledge. In 1995, UK's Department for International Development funded Ghana and the Junior Secondary Teacher Education Project was instituted and helped to transform teachers from using a teacher-centred to a learner-centred approach. Teacher educators were professionally developed to develop them on the use of a learner-centred approach with small group work, problem-solving activities and investigations. In 2004, the duration of pre-service teachers spent in residential teacher education was reduced from three to two years in order to give them ample time to do practice teaching in schools. From 2007 to 2014, school teachers became mentors of the NQTs in order to help them with classroom practices and the areas where they needed assistance. The last teacher education reform began in 2015 and its main purpose was to transform teacher education and learning (Akyeampong, 2017:7). This programme focuses on the improvement of teacher educators' classroom practice. It uses aspects such as activity-based learning, the provision of standardised teaching and learning materials and group work.

The lack of competencies and interest necessitates PD of teachers in Ghana. Gyamfi (2017:24) mentions that even when the benefits of Web.2.0 technologies are known to teachers, Ghanaian teachers rarely use it for teaching and learning due to the lack of skills. To curb this problem, Ghanaian Geography student-teachers were trained on the Technology Acceptance Model that was intended to equip them with Web 2.0 technologies for pedagogical purposes. At the end of the programme, teachers who participated in it developed direct and indirect positive inspiration on the use of Web.2.0 technologies (Gyamfi, 2017:35). The researcher's view is that if teachers struggle to implement educational activities, they should be engaged on programmes that can help them to master the activities.

Ghanaian teachers are also engaged on PD programmes that can develop them to teach inclusive education effectively. According to Chitiyo, Kumedzro, Hughes and Ahmed (2019: 73), most teachers in Ghana had a problem of teaching inclusive education but after having attended a PD programme they were able to teach it effectively.

Chitiyo et al. (2019:73) mention that teachers were allowed to identify their own PD needs by ranking them in order of importance; consequently, they tended to own the programme and mastered the skills of teaching in inclusive classrooms. This indicates that teachers need

ownership of the PD programmes in order to implement the activities or programmes effectively.

Teacher Education in Sub-Saharan Africa (TESSA) materials were used to provide pre-service and in-service training in Ghana. According to McAleavy et al. (2018:35), TESSA materials were provided by the Open University in the UK to train school inspectors, head teachers, professional and unqualified teachers as well as volunteers in Ghana through both contact and distance education. The implementation of TESSA had a positive effect on teachers as they were able to develop teacher education practices.

2.2.8 Zimbabwe

In Zimbabwe, the pre-service training of teachers resides with the Minister of Higher Education (MoHE), and prospective teachers should obtain a certificate or diploma of three to four years in order to teach Grade 8-11 (form 1-4) and for Grade 12-13 (form 5 -6) should have "A level" in order to qualify to register for a two-year programme (Mukeredzi, 2016a:4). The prospective teachers should have obtained at least five ordinary level passes including English language and Mathematics as admission requirement (Chirume, 2020:152).The pedagogy courses and delivery strategies that they learn involve revising primary school maths topics and how to teach them, syllabus interpretation and lesson delivery. In terms of assessment strategies, they use both formative and summative in forms of practical and theoretical exercises, tests and assignments.

Continuous professional development of teachers caters for a wide range of programmes such as hands-on capacity development, induction, part-time and continuing education, study tours, and full-time study (Ministry of Primary and Secondary Education (MoPSE) 2016a:26). School based supervisors are responsible for the professional development of novice and experienced teachers and this helps to minimise external supervion ((Ngwenya, 2020:9). Mukeredzi (2016b:102) found that PD in Zimbabwe takes place through school structures and is usually conducted on the school premises through planned and unplanned gatherings, and in classrooms where school structures involve mentoring and supervision. In addition, it involves whole school subject specialisation meetings, while wider professional platforms offer PD through cluster and association meetings. In addition, MoPSE (2016b:27) mentions that in-service training of teachers takes place in primary and secondary schools and focuses on the

interpretation of the syllabus which includes lesson preparation, new pedagogic classroom practices and schema, and a focus on reading skills for primary school learners. Furthermore, WhattsApp group as a social media was used as medium to facilitate PD of teachers. According to Tarisayi & Manhibi (2017:37), WhatsApp group for Hertitage studies teachers was introduced in Zimbabwe in 2017 and it played important role in disseminating Heritage syllabus. This WhatsApp group for Heritage Studies' teachers was used to distribute copies to teachers, facilitate PD, inteprete new syllabus and teachers shared ideas on the new learning. This shows that PD focuses on the needs of teachers as teachers are developed at their own workplaces. The assumption is that during PD, classrooms are used for demonstration purposes to make PD practical and to help teachers understand the programmes better. Furthernore, the introduction of WhatsApp group by Heritage Studies teachers shows that education in Zimbabwe uses information communication technology to advance learning and teaching , and PD of teachers.

2.3 PROFESSIONAL DEVELOPMENT OF TEACHERS IN MATHEMATICS

The section below focuses on the PD of teachers in mathematics in the developed countries: Israel, USA, Turkey, and Taiwan

2.3.1 Israel

Professional development of mathematics teachers in Israel addresses curriculum changes in schools and this is achieved through collaborative learning groups by involving teachers in reflective discussions to learn aspects such as pedagogical content knowledge (Levi- Kerren & Patkin, 2016:26). It also assists mathematics teachers to develop on areas such as didactic knowledge and subject matter content (Mishal & Patkin, 2016:253). The PD of teachers in Israel also focus on the implementation of ICT issues to help teacher improve their profession. Daher, Baya and Anabousy (2018:534) mention that mathematics teachers in Israel are involved in in-service programs that integrate them with ICT to use them in the practice of their profession. According to the scholars, programmes of PD of mathematics teachers that emphasise the use of ICT tools in mathematics classrooms can benefit when following this model of social learning in community of inquiry in which researchers, in-service teachers and pre-service teachers learn together fo find the best ways for utilizing digital tools in mathematics classroom. In addition, teachers are involved in the use of education dashbords to

grow their profession. According to Michaeli, Kroparo and Hershkovitz (2020:73), education dashboards may support teachers' decision-making as it provides them with learners' information, hence teachers should participaticipate in the program. Furthermore, student teachers are engaged in "Academy Class" teacher training model that equip them with PD. Assadi, Murad and Khalil (2019) found that the implementation of "Academy Class" teacher training model result on trained teachers improving their attitudes at the end of the program in reflective mentoring, approaches in teaching and learning, the intergration of student teachers into school life and co-teaching. The scholars also mentioned that integration of student into school workplace is more active and more relevant than the traditional teacher traing model. The idea is that PD of teachers in mathematics focuses on meeting their needs as it helps them to expand their knowledge of mathematics, exposing student teachers and teachers to various programs that prepare to interact with other colleagues well, and classroom practices which are necessary for teaching the subject. Furthermore, being engaged in collaborative learning helps teachers to learn from one another as those who are knowledgeable can assist those who struggle.

2.3.2 United States of America

Professional development of mathematics teachers in USA uses various strategies to help teachers curb problems encountered in mathematics and to improve the performance of learners. Some of the strategies used to develop mathematics teachers include attendance at PD programmes that focus on beliefs and practices of mathematics teachers which ultimately instil positive attitudes on teaching mathematics (Polly, Wang, lambert, Martin, McGee, Pugalee & Lehew, 2017:121) and programmes that involve mathematics teachers in collaborative activities that allow them to share information with regard to the subject matter. As a result, teachers gain content knowledge and skills to teach mathematics (Jung & Brady, 2016:277). A programme that focuses on the use of language to support mathematics learning of highly contextualised materials contributes to changes in content knowledge and beliefs that motivate teachers to try new things (Gomez et al., 2015:461). The idea is that when teachers are engaged in the programmes that deal with beliefs, most teachers tend to approach things differently. For example, teachers who believe that mathematics is difficult tend to change their viewpoint when they participate in these programmes because they help teachers to see things positively. Again, being involved in the programmes that help them to use the correct language when

teaching mathematics helps them to present the subject content to the learners appropriately and efficiently.

Furthermore, teachers are involved in PD programmes that encourage them to reinforce, embrace and master teaching of mathematics in schools. According to Polly (2015:252), teachers are given ownership of the project by being provided time to discuss issues about the subject in the meetings and workshops and this motivates teachers to air their views in support of the project and there is less resistance from teachers. In addition, Galindo, Lee and Yoder (2014:38) reveal that PD focuses on building and sustaining PL by developing teachers in mathematical aspects such as knowledge of patterns and algebra functions. The fact that teachers are involved in PD programmes may encourage them to implement, support and sustain learning because the programmes would address their needs. They would try their best to understand mathematical aspects that are taught during PD programmes even when they seem to be challenging to them.

The PD also aims at reducing the phobia of teaching mathematics as a subject. According to Stoehr (2017:2), and Looney, Perry and Steck (2017:35), 90% of mathematics teachers in the USA are women and have anxiety about teaching mathematics in elementary schools because they believe that mathematics is difficult to understand. To address this problem, prospective teachers attend initial pre-service training that focuses on changing their attitudes and beliefs in mathematics to become better teachers (Looney et al.:36). The idea is that the USA uses various PD programmess that can resolve challenges that teachers encounter when it comes to teaching mathematics. The belief is that these strategies stimulate them to work harder even when the work environment is hostile due to support they get from the state. They might also help to improve the teaching of the subject and learners' performance.

2.3.3 Turkey

Most prospective teachers in Turkey perform well in communication skills, measurement and evaluation while teaching mathematics but they struggle to blend teaching techniques which is a problem for most elementary mathematics teachers. In response to this challenge, pre-service training in Turkey focuses on classroom teaching competencies that give support to teachers regarding the use of non-verbal communication skills in relation to the blended teaching technique (Gokalp, 2016:509).

Teachers who struggle to teach mathematics content and plan lessons well are engaged in PD. According to Bozkurt and Yetkin-Özdemir (2018:379), mathematics teachers in Usak, Turkey participate in PD programmes where they observe their peers for a period of five months on how to teach mathematics content and to plan lessons effectively. Consequently, this makes them able to master teaching skills, encourages them to conduct detailed and reliable assessments and to construct lesson plans based on mathematics content areas that they are supposed to teach.

The elementary mathematics teachers in Turkey are subjected to participate on the programmes that teach algebra knowledge. Güler and Çelik (2018:162) mention that prospective teachers who study mathematics in pre-service training attend programmes that teach them about the relationship between content knowledge and pedagogical content knowledge. The researcher believes that such programmes should be carried out as they can prepare prospective teachers to teach algebra when they go to their workplaces.

2.3.4 Taiwan

In Taiwan, mathematics teachers struggle to change from a teacher-centred approach to inquiry-based learning approach. To address this problem, PD programmes are conducted to help them become proficient teachers (Chin, Lin & Tuan, 2016: 854; Maass, Swan & Aldorf, 2017:1). Like other countries, Taiwan uses proper and effective teacher PD in STEM education to capacitate teachers with the required knowledge and skills (Morris, Song, Soloway & Norris, 2021:81). The national education system should encourage provincial education systems to monitor and support mathematics teachers to use the inquiry-based learning approach. If this approach could be implemented effectively, it would provoke learners' participation, innovation and their ability to work on their own to improve in mathematics. In addition, Taiwan, primary schools use low integration of children's literature in mathematics teaching and learning when compared with a country like Irish (Yang, Sianturi,Chen,Su &Trakulphadetkrai, 2021:142). According the scholars (p.143), their mathematics classes follow textbooks contents and cover all topics included in the textbooks as they have high pressure to focus on covering the prescribed content of the mathematics curriculum . The fact that Taiwanese make sure that all the contents prescribed in the mathematics curriculum are covered implies that their ministry of education follow their teaching plans hence Taiwan's performance in Mathematics is excellent in international assessments. Furthermore,learning

and teaching in Taiwan is guided by Taiwan Adaptive Learning Platform (TALP) established by the Minister of Education in Taiwan. According to Liu (2022:6312), TALP is used in elementary schools and it ensures the provision of precision education is offered. In addition, the scholar found that the teachers observed and responded that students who used TALP were more motivated and improved the learning outcome. The indication is that TALP programme is effective as it motivates learners to learn and improves their performance and it should be continued to encourage teachers teaching.

2.4 SIMILARITIES AND DIFFERENCES BETWEEN PROFESSIONAL DEVELOPMENT IN SELECTED COUNTRIES

This sub-section discusses the similarities and the differences between PD in selected developed and African countries, namely Australia, UK, Canada, Finland, Singapore, Nigeria, Ghana and Zimbabwe.

Professional development in both developed and African countries shows similarities although they are not done the same way due to their different contexts and resources. All the above-mentioned countries require teachers to undergo ITTs before they can be appointed as full-time teachers in order to be productive in their workplaces; however, the duration of teacher training differs from one country to another. The student-teachers get their ITT from the TEIs which comprise TECs and universities. All developed countries provide bursaries to their student-teachers to study for a teaching career and the recruitment of the student-teachers is based on the results of their secondary education. The common basic courses offered to student-teachers in both developed and African countries include subject content, pedagogical content knowledge, classroom practice and management. These courses prepare teachers to work in schools professionally and with ease. Based on the literature, countries such as Australia, Canada, Singapore, Nigeria, and Ghana facilitate ICT PD programmes that equip their student-teachers and full-time teachers with ICT skills in order to use them in their workplaces. Countries such as UK, Canada, Singapore, Australia, and Finland induct their NQTs when they start working although their levels vary from one country to another. For example, in UK induction is compulsory and it takes a period of one year. The NQT is assigned a tutor who ensures that all programmes are well followed. The teacher is given one chance to complete the induction programme and failure to complete it means that the student will not be allowed to work in any registered schools. In Canada, the NQTs receive a certificate of qualification

and registration after the completion of their induction, while in Singapore it is conducted nationally for three days, and at school level, it is conducted in the first two years (Wen & Wu, 2017:82; Schleicher, 2016:56). Countries like Zimbabwe and Nigeria do not induct their teachers. Canada, Finland, and Singapore provide early childhood education ITT programmes for teachers to work in early childhood centres. This is to prepare learners to acquire basic skills before they can go to school.

There are aspects of PD where countries differ. The demand for in the various countries is informed by the needs of the people. For that reason, each country trains its student-teachers in subjects that are challenging or where teachers are scarce at that given time. For example, Australian student-teachers focus on MST in primary and secondary schools; the UK focuses on mathematics, science and modern foreign languages; Canada's focus is on mathematics and science; Finland requires their student-teachers to pass a master's degree in order to become a teacher; while one of the major courses offered to Ghanaian student-teachers is inclusive education. African countries such as Nigeria, Ghana and Zimbabwe do not offer bursaries to their student-teachers due to their poor economic status, meaning that student-teachers pay for their own education.

2.5 PROFESSIONAL DEVELOPMENT OF TEACHERS IN THE CONTEXT OF SOUTH AFRICA

South Africa like other countries has educational policies that guide all activities around PD of teachers within the country. All the educational programmes operate in line with these policies to ensure that they achieve planned goals. This indicates that all programmes that operate outside the scope of the policies would probably not get financial support or approval from the national education system. Some of the policies that have a bearing on PD of teachers in South African education system include:

- Education Labour Relations Council (2003) which facilitates teacher development at school level; and
- The five-year strategic plan 2015/16-2019/20 (DBE, 2015a), The annual performance plan 2015-2016 (DBE, 2015b); and the revised five-year plan-year strategic plan

2015/16-2019/20 (DBE, 2016b) that contain the plans of how PD should be effectively conducted and implemented within the national education system.

The following sub-sections discuss issues that necessitate the implementation of PD of teachers in South African schools.

2.5.1 Oudated Skills and Knowledge

It is necessary that teachers serving under national education system should be engaged in PD as most of them might have received their pre-service training during the apartheid era meaning that the skills and knowledge that they possess might be outdated due to changes in social life, the curriculum and technology. The reforms to the South African education system started in 1994 after the first democratic elections in order to address challenging issues that were obstacles to the implementation of quality education. The challenges involve the integration of several education systems into a single national system; equipping teachers with new knowledge as well as competencies that are relevant to the current education system (DBE, 2016b:4).

2.5.2 Mismatch between Teacher Supply and Demand

One of the factors that prompted the implementation of teacher development in South Africa was the mismatch of teacher supply and demand. There were too many teachers in certain subjects who were not used while other subjects were overlooked. For example, most rural areas had a shortage of MST teachers. In response to this challenge, policies have been developed to address the shortage of MST teachers by recruiting young teachers to enrol for teaching in tertiary institutions (DBE, 2015b:14; DBE, 2016a:37 & DBE, 2015a:15). According to these policies (DBE 2016a:37; DBE 2015b:14), these young teachers are offered a bursary called the “Funza Lushaka” bursary an isiZulu term meaning “teach the nation” to attract them into the teaching fraternity. These young teachers are enrolled in universities and teacher training colleges to be developed in subjects such as MST and when they have completed their studies are automatically offered teaching posts in public schools by the DBE. The DBE has developed a supply and demand model that gathers information about attrition, recruitment, exit, migration and utilisation to enable it to plan and provide resources to the teacher workforce (DBE, 2015b:14).

2.5.3 Appropriate Qualifications

The responsibility for pre-service training of teachers in South Africa resides with Department of Higher Education and Training where student-teachers are required to pass a four-year B.Ed. degree before they can work as teachers. During these years, there are times when prospective teachers are sent to schools to do observation and practical teaching. The DBE should make sure that teachers in training and those working full-time receive adequate support and monitoring.

Teachers acquire qualifications through contact or distance education with institutions that have registered with South African Council of Educators (SACE). Service providers accredited with SACE provide PD points to SACE after the students have completed their studies (RSA, 2017:22). Distance education is convenient for most teachers because it allows them to study at their own pace although student-teachers should complete the qualifications in four years. Full-time teachers can do the Advanced Certificate in Education (ACE) to develop their teaching subjects; for example, teachers do ACE for Mathematics to improve their competencies and skills in the subject.

2.5.4 The Use of the IQMS

The DBE also uses the IQMS to develop teachers' teaching skills and address other school-related issues. Kimathi and Rusznyak (2018:10) mention that the IQMS is concerned with the developmental appraisal of teachers, performance management for promotion and whole school evaluation with the purpose of improving teacher's competencies. According to them, teachers are evaluated on seven performance competences of which the first four are their classroom practices and the last three are the extra-mural activities that involve outside classroom activities. Mthembu (2017:88) also mentions that teachers can identify their weaknesses and strengths through developmental appraisal and sheds light on how Development Support Groups (DSGs) can support the appraised teacher. Mthembu further mentions that the supported of their DSGs help teachers to improve their teaching skills. This shows that the implementation of the IQMS in schools should be continued as it develops teachers in several areas.

2.5.5 ICT Skills

Prospective teachers are also given training on ICT so that they can use this in teaching and learning, to deliver subject content knowledge and enhance their teaching practice (Alkamel & Chouthaiwale, 2018:32; DBE 2016a:27; DBE 2016b:37). Teachers struggle to use ICT effectively although they are required to use it for teaching and learning (Motene, 2016:60). According to the Motene, the government is in partnership with private sector organisations to develop teachers on the use of ICT. These organisations provide them with ICT equipment for teaching and learning. The DBE (2016b:38) shows that teachers should be trained on the use of ICT throughout the provinces and should be given the necessary support. For that reason, all provinces in South Africa have resource centres that provide ICT programmes to teach teachers to use it in classroom activities (DBE, 2015b:14).

2.5.6 The Curriculum and Assessment Policy Statement

Teachers are developed on the use of Curriculum and Assessment Policy Statement (CAPS) in order to empower them with necessary skills. Since CAPS has been recently implemented in place of National Curriculum statement most teachers struggle to implement it (Mbatha, 2016:74). Regardless of the challenges encountered by teachers, the DBE (2015b:15) states that teachers would be trained on the implementation of CAPS and the use of workbooks so that learners can receive quality education. Thus, teachers for specialised subjects attend one- or two-day workshops at the beginning of each term to be refreshed on how pedagogical content knowledge, content knowledge, workbooks, pace setters or work schedules and assessments are carried out.

2.5.7 The Implementation of Professional Development Programmes

The implementation of PD should not be done to waste time but to develop teachers to become effective in their educational practice. It must develop teachers in school activities such as classroom practice, syllabus interpretation, drafting of schemes of work as well as content knowledge (Luningo, 2015:179; Mumhure, 2017:182). Teachers can master educational activities by being treated as learners performing learner-related activities during their PD. Teachers are able to plan and engage in their own PD through active participation while learning (Paton, Parker & Tannehill, 2015:33).

According to Guskey (2014:12), new practices need to be practised. Teachers should implement change, make sure that after attending PD they reflect on what has been taught and implement before they forget (Martin & González, 2017:38). They should be prepared to work hard and set aside their personal issues in order to have sufficient time to implement PD programmes. They should also be innovative, courageous, smart and ready to try new ways of doing things in order to excel. Richter (2016:1) suggests that the trainee should observe other teachers while doing their practice teaching which would help them to learn and implement new information. Teachers who observe other teachers while presenting lessons learn various techniques of classroom practice and are motivated to do practice teaching.

The PD programmes should last for a long time, for example, two terms to several years and can also allow the repetition of activities in order to allow teachers understand the programme better (Cordingley, Higgins, Greany, Buckler, Coles-Jordan, Crisp, Saunders & Coe, 2015:4). According to Luningo (2015:128), workshops conducted within a short space of time are strenuous and confusing to teachers as they require teachers to learn information that would normally need a month but it is compressed into a short space of time. The indication is that PD should be conducted over an extended period of time in order to provide the participants with sufficient time to grasp the activities better, ask questions on issues not understood and reflect on the workshop.

Teacher development should encourage teamwork, cooperation and good relationships with local schools and networking with other schools as these enhance performance (More, 2016:104). Teachers who connect and cooperate with other teachers get time to share knowledge and skills, and this helps them to develop their careers. Furthermore, teachers can also motivate each other to learn, and this helps them to persevere in their studies. However, most of them are reluctant to study and implement PD if they do not interact with their colleagues.

The complexity of society can influence curriculum changes in schools. Ogbonnaya, Mji and Mohapi (2016:711) posit that frequent curriculum changes should be accompanied by frequent training and retraining of teachers. Teachers should participate in PD so that they can acquire knowledge and abilities that are needed to deal with curriculum changes. If teachers receive proper training before the implementation of curriculum change would not show anxiety and confusion during presentations since they would have received PD. Curriculum change should

respond to the demands of the society. Kempen and Steyn (2016:43) state that the implementation of PD brings changes to the professional capacity of teachers, learners, students' outcome and organisation. Curriculum changes that are preceded by training and retraining of teachers are likely to succeed if teachers receive training before implementation.

2.6 PROFESSIONAL DEVELOPMENT OF MATHEMATICS TEACHERS IN THE CONTEXT OF SOUTH AFRICA

Professional development of teachers in mathematics can yield good results in teaching and learning of mathematics and in the performance of learners if it is carried out well. The DBE (2016a:16) mandates provincial education departments to develop teachers especially in mathematics in order to improve teachers' abilities and to ensure that more than 90% of the learners score above 50% in the ANA. The following paragraphs discuss the PD of teachers in mathematics in the South African context.

Teachers should be able to use various approaches to teach aspects of mathematics that accommodate slow learners. The study by Umugiraneza, Bansilal and North (2017:10) about exploring teachers'practices in teaching mathematics and statistics in KwaZulu-Natal schools found that teachers use only one approach to teach mahematics but use multiple methods in teaching other subjects. In terms of the study, the majority of mathematics teachers use teacher-centered approach where teachers usually do the most talking, and learners are only regarded as vessels that should be filled with knowledge without their active participation. The author laments that using this approach often leads to learners poor performance caused by their inactivity during the learning of mathematic concepts. However, they should also use various approaches in teaching mathematics since learners need to be taught using multiple methods to understand better. To improve on the teaching of mathematics, Umugiraneza et al. (2017:10) suggest that teachers should attend PD programmes such as workshops that integrate projects, simulations and investigations so that they have ample time to practise, implement new skills and to get assistance with their teaching. The attendance of PD by teachers would assist teachers to use multiple approaches in teaching mathematics.

Professional development of mathematics teachers can be done through reflection on activities that teachers aspire to learn. According to Biccard (2018:13), mathematics teachers can learn by reflecting on mathematics modelling tasks that allow them to view and interpret the aspects

of their own teaching differently. These activities increase their performance if they are done systematically. Singh and Mabasa (2015:168) and Dollar and Mede (2019:209) state that reflective activities are part of PD that can be used by student-teachers and in-service teachers to improve their teaching practices as well as to identify their weaknesses and strengths. The fact that teachers can view the progress of learning through reflection on modelling tasks implies that they can discover their own mistakes or negative practices that can need to be abandoned. Positive aspects can be embraced and improved on through continuous reflection on practice.

It is important that mathematics teachers should receive PD in mathematics in order to increase their competencies in teaching the subject. Smith (2015:145) highlights that mathematics teachers should be exposed to PD so that they can experience personal growth, improve classroom practice and increase their mathematical knowledge by sharing experiences with their cohorts through school-university partnerships. According to Smith (2015:145), when mathematics teachers partner with their cohorts, they share ideas that can assist them in teaching the subject better and learn from others. The researcher concurs with Smith that teachers need exposure to PD because that encourages and motivates them to study and to identify the gaps in their skills that are not easy to determine if there is no interaction with the cohorts.

The level of teaching mathematics can be improved by including mathematics teachers in projects. Realising that mathematics teachers need CPD in teaching mathematics, Wits University launched the Wits Maths Connect Secondary Project that focuses on teaching mathematics. According to Adler (2017: 2), this PD course aimed to improve teachers' mathematics pedagogical knowledge on aspects such as algebra, and some topics selected from the geometry and trigonometry curriculum. Teachers had to attend 16 days per annum and at the end of the course, their knowledge was greater than those who did not attend the course. In support of the above findings, Maher (2015:5) indicates that mathematics teachers can improve learners' performance by participating in PD. This shows that attendance at PD courses has a positive effect on the knowledge of teachers. Other universities should be encouraged to launch similar projects to bridge the gap in teaching mathematics in schools.

In South Africa, a discussion of the PD of mathematics teachers needs to consider the ANA results. Like other countries, South Africa administers the ANA to determine learners'

achievements in mathematics in schools. Spaull (2015: n.p) describes the ANA as a set of standardised literacy and numeracy tests focusing on Grades 1–6 and Grade 9. According to Spaull (2015: n.p), South Africa has two ANAs: the universal ANA that is written by all government schools annually and ANA that is administered to randomly sampled schools. The national assessment programme should be managed and administered by organisations that must ensure there is thorough planning, implementation and reporting in order be effective (Johnson, 2017:24). This indicates that the education system should ensure that all necessary requirements are put in place before they can implement the national assessment of learners in schools otherwise the tests would be a futile exercise.

In South Africa, the ANA test results are used as a basis for improving classroom performance and learners' achievement in all grades (DBE, 2016c:22). After the learners have written the ANA, their results are analysed to identify weaknesses and strengths (Baloyi, 2015:112; Johnson, 2017:31). Baloyi further indicates that item analysis should be a priority of the schools with a view to enhancing the ANA results using intervention strategies. The ANA results and report can also be a platform for the DBE to engage provinces and other stakeholders to formulate strategies for improving numeracy and literacy in order to improve ANA results in South African schools (DBE, 2016c:22; Modzuka, 2017:143).

Many researchers have provided various reaons for the low performance of learners in the ANA. The reasons given by Bansilal (2017:1) include:

- ANA tests are long, and most learners struggle to finish the question papers.
- Timing for writing the exam in September is not a good time as most teachers would still attempting to complete the syllabus.
- It comprises many higher order questions which are problematic for most learners, and this makes them struggle to answer the question papers correctly.

Some teachers who are expected to administer ANA test have not attended the ANA workshops that shed light on how the ANA test is administered and they are also not familiar with the purpose of implementing it (Ntuli, 2018:62). Ntuli (2018:64) also mentions that DBE lacks proper planning and monitoring of assessment. Other obstacles found by Baloyi (2015:109) include a shortage of qualified teachers, overcrowding of learners in classrooms, lack of content

knowledge, lack of supervision, inadequate syllabus coverage and lack of curriculum supervisors. This shows that poor performance in the ANA is caused by a number of issues that can be corrected provided the DBE engages other stakeholders who have an interest in the ANA.

Teachers should be engaged in PD so that they can administer the ANA test adequately. The DBE (2015c:1) shows that Grade 8 and 9 Mathematics teachers were released every Monday in 2015 to engage in PD but that was insufficient since it was done only for one year and it overlooked other grades that were involved in the ANA test. Van der Berg (2015:14) posits that since ANA test had previously been successfully administered, the development of teachers should have continued. Additionally, Baloyi (2015:106) mentions that teachers should be engaged in school-based and cluster workshops so that they can be developed on adequate pedagogical content knowledge as well as subject content knowledge. Furthermore, teachers need time to discuss issues related to the subjects as well as to share current information and update each other.

2.7 THE IMPORTANCE OF PROFESSIONAL DEVELOPMENT AND ITS IMPLICATIONS TO THE IMPROVEMENT OF EDUCATION

The role of PD cannot be overlooked in a teacher's career path. Paton et al. (2015:28) show that the effectiveness of PD is linked to teachers' participation in PD activities that developed their classroom practice and impact learners' learning. Teachers should participate in PD in order to improve their skills, content knowledge and methods of teaching. According to Jung and Brady (2016:277), PD provides teachers with time to discuss matters of concern with other teachers and to acquire effective classroom practices that would help their learners succeed in their studies. The researcher presumes that teachers from different schools could share experiences that could lead learners to learn with understanding. Furthermore, teachers could inadvertently spend years using the wrong approach to teaching. It is from these experiences that teachers can assess whether their teaching methods are effective or not; poor practices should be abandoned and positive experiences should be embraced.

The role of PD is to ensure that both initial and experienced teachers receive thorough training that would help them teach learners effectively. UNESCO (2015:3) is concerned about the shortage of teachers worldwide, resulting in unqualified teachers being employed. This suggests that the employment of unqualified teachers by most countries is not ideal but they

are forced to take this route in order to appoint the required number of teachers. This compromises the standard of education and dooms the performance of learners. In line with these challenges, UNESCO (2015:8) suggests that training of teachers should be done both before and during teachers' careers to eliminate the shortage of teachers and to keep teachers on track.

In the following paragraphs, the researcher discusses the PD of teachers through in-service training, pre-service training and induction. Teachers are frequently engaged in PD to keep them on track with current content knowledge and up-to-date approaches to teaching learners. Hence, the purpose of teacher development is to equip teachers with necessary skills and knowledge to teach learners.

2.7.1 Professional Development through Pre-Service Training

Tertiary institutions can assist prospective teachers to improve their knowledge of subjects such as MST, acquire content knowledge of their specialist subjects and develop positive attitudes before they start their full-time jobs. Looney et al. (2017:35) found that most pre-service mathematics teachers have a high level of anxiety and low self-esteem when it comes to solving mathematical problems; they believe mathematics is very difficult and it is not easy to understand, resulting in poor performance in their studies. According to Looney et al. (2017:36), the problem of pre-service teachers having a negative attitude to certain subjects is linked to their beliefs and they indicate that there are courses in tertiary institutions that can help teachers transform their attitudes and beliefs thereby fostering curriculum, instruction and classroom practice. The assumption is that nothing is too difficult for teachers to learn but their problem is their attitudes towards teaching mathematical activities. Therefore, teachers should change their negative thinking and become positive towards learning mathematics which would help them realise that the subject is simple and comprehensible.

In order to acquire skills required in workplace, it is vital that prospective teachers undergo pre-service training before they take up full-time jobs. According to Gokalp (2016:509), when prospective teachers were tested on classroom competences in teaching mathematics, it was found that they knew certain skills such as classroom communication, assessment, teaching methods and evaluation but they were not yet fully competent in the use of blended teaching techniques which is important when combined with teaching methods. In addition, they

struggle to manage classroom, instruction and content knowledge (Zhukova, 2018:110). This shows that pre-service teachers have certain skills before they go for pre-service training, but this does not suggest that they are competent in all skills. For that reason, educational authorities must ensure that prospective teachers first receive training before they become full-time workers.

The enrolment of prospective teachers at tertiary institutions provides them with the opportunity to learn teaching skills and other capabilities which are pre-requisites for teachers. Dollar and Mede (2019:209) reveal that pre-service programmes expose prospective teachers to reflective activities that help them identify their strengths and challenges, develop better understanding of teaching practice, classroom management and use of materials which helps them to be productive in the workplace. If teachers identify their weaknesses in time, they can seek assistance from other teachers who are knowledgeable and skillful to help overcome the challenges. Besides, teachers may have time to practise the activities repeatedly until they get used to them. According to Zhukova (2018:111), the mentorship that student-teachers receive gradually prepares them to become professional teachers.

The PD programmes followed by student-teachers during pre-service training can transform their beliefs and attitudes. According to Kirkgöz (2016:176), PD has the potential to improve prospective teachers' cognitive learning. It unlocks their understanding to solve problems in school-based practice teaching and helps them to generate ideas that are useful in STEM education. In addition, Azano and Stewart (2015:583) indicate that pre-service training helps prospective teachers to experience personal transformation and growth in their careers and confidence to teach mathematics and other subjects well. Prospective teachers should receive PD in the form of pre-service training so that they are motivated to learn, become innovative, self-motivated, and hardworking, and are able to manage day-to-day school activities and apply a range of classroom practices. This indicates that pre-service programmes are necessary because they impart basic knowledge and skills that are needed by prospective teachers to become productive teachers once they are employed.

Prospective teachers can do practice teaching in schools to supplement the skills acquired from TECs and universities. According to Azano and Stewart (2015:579), student-teachers in rural schools can converge with other clusters where they form subject clusters to discuss matters of concern with teaching their subjects, exchange their classroom practices and knowledge, and

attend workshops that enlighten them on issues such as setting quality assessments for learners, conducting experiments and improvisation. When student-teachers share information with other teachers from other clusters, they can learn various educational approaches that can equip them with professional capabilities. However, student-teachers who attend pre-service training in schools should be disciplined and knowledgeable so that experienced teachers will be motivated to mentor them and to guide them when they lose direction.

The universities can send student-teachers to do practicum in schools different to their culture to expose them to diversity backgrounds such as culture as well as the language of communication. According to Nkambule (2017: 199), Universities can send student-teachers from urban areas to do projects at rural schools in order to understand the diversity, culture, language and rural context that influence the behaviour of learners and the relationship that exists between teachers and learners. If pre-service training programmes expose student-teachers from urban areas to understanding cultural diversity, teachers would become acquainted with various settings and backgrounds, and this would help them to interact with various learners. Besides, it can be a strategy to attract student-teachers from urban areas to work in rural areas since there is a shortage of MST teachers in rural schools.

The implementation of PD can assist prospective teachers to teach lessons without fear. Stoehr (2017:135) mentions that many prospective teachers especially women are fearful, confused and nervous when they must teach mathematics. Teachers need thorough training to teach mathematics so that when they are in front of their learners, they are confident in teaching the subject. It is presumed that most teachers training universities and colleges have strategies to assist prospective teachers teach mathematics lessons without fear.

2.7.2 Professional Development Through In-service Training

The focus of in-service training is to improve the skills and knowledge of full-time teachers which have a direct link to learners' performance. If teachers do not participate in PD, their knowledge becomes outdated and this, in turn, affects learners 'performance negatively. This necessitates the implementation of PD that improves their teaching abilities. For example, Kanellopoulou and Darra (2018:83) mention that teachers who encounter challenges with teaching their specialised subjects can participate in lesson study which allows them to collaborate by sharing views, ideas, arguments and teaching techniques to improve their

teaching skills. However, it is important that PD is aligned with teachers' needs (Minor, Desimone, Lee & Hochberg 2016:22). After the educational authorities have conducted needs analysis of teachers, before they implement intervention strategies to develop the teachers, they must first ascertain whether the PD would be helpful to them; otherwise, the implementation of PD would be in vain.

Full-time teachers should be given latitude to choose topics that are challenging them while doing PD. They should be allowed to do so because they personally know their problems while facilitators may assume that they have challenges in certain areas and then offer programmes that do not address the teachers' needs. Polly (2015:252) and Paton et al. (2015:29) advise that teachers should be given ownership of PD by being allowed to choose topics that interest them and where they need support and to be part of the planning sessions to avoid friction that might ensue due to uncertainty about the nature of workshop. If teachers planned their own programmes, they would attend, support and implement the learning appropriately.

Collaborative and peer coaching PD can enhance the participation of teachers. Teachers should not engage in PD unilaterally and should interact with other teachers in order to get support from them. When teachers engage in collaborative PD and peer coaching, they can be motivated to improve their qualifications, increase their knowledge of mathematics, share their practices, interact with other trainees and even ask questions to help them on areas of uncertainty (Ma, Xin & Du, 2018:301; Phothongsunan, 2018:283; Smith, 2015:145). Teachers who participate in in-service training get the opportunity to learn from their peers especially on activities that are difficult for them. Those who have the expertise can assist slow learners to progress.

In-service training is an ongoing process and should be maintained to keep the teachers up to date. Schools should make sure that their teachers are frequently given PD that keeps them up to the required standards of the DBE. They should arrange meetings to update them on matters that affect their education so that they do not lag behind on emerging information. According to Paton et al. (2015:29), teachers should meet two days or more in a week at school or in workshops facilitated by an experienced teacher to discuss matters related to curriculum issues. Teachers can use this time to address concerns with their subjects such as lesson planning and can guide each other on how to set quality assessment tasks for their learners. Jung and Brady (2016:277) state that PD provides teachers with an opportunity to discuss different ways of

teaching mathematical problems in the classroom setting. If PD is done continuously, teachers may experience change when it comes to ways of approaching educational activities.

Effective PD brings changes to the teachers who engage in it. Teachers who participate in PD should improve their way of doing educational activities. They should not stay on the same level but should show progress in their teaching practice. When teachers show progress in their teaching activities, this would indicate that PD is fruitful or has changed their teaching for the better. According to Levi-Kerren and Patkin (2016: 26), and Polly et al. (2017: 121), PD should bring valuable changes to teachers who experience challenges with pedagogical content knowledge. This can be checked through the progress that teachers make. This indicates that any in-service training that does not show progress in teaching must be re-evaluated.

Professional development can be used to improve subject teaching in schools. Teachers who teach the same subject can come together to share their experience and knowledge of how to teach the subject. They can share resources such as textbooks and question papers while developing each other and this can lead them to know the subject better. According to Martin and González (2017:453) and Mumhure (2017:182), when mathematics teachers at various schools and districts come together, they can discuss mathematical problems; share resources that can help them understand the subject better, and share knowledge on teaching practice. Again, Thanheiser, Rosencrans, Melhuish, Fagan and Guyot (2017: 479) indicate that when PD is conducted over a long time, it enhances the knowledge and practice of the trainee. Teachers should collaborate as this gives them a platform to discuss and understand mathematics problems better since mathematics needs understanding and not memorising.

Teachers should learn multiple approaches of teaching in order to use them in teaching lessons to address the cognitive levels of various learners. These approaches can be acquired through PD. Alamri, Aldahmash and Alsharf (2018:102) emphasise that mathematics teachers should engage in PD in order to acquire multiple approaches of teaching as they assist in improving learners' performance, make teaching successful and interesting, instead of using a single approach. According to Gomez et al. (2015:461), teachers who participate in PD increase their content knowledge and change their beliefs and can engender a desire to innovate their teaching practice. Teachers should understand that learners of the twenty-first century need active approaches that keep them awake, help them to solve problems and to be innovative.

2.7.3 Professional Development of Teachers Through Induction

After student-teachers have completed their teacher's qualifications, they should be given induction by full-time teachers so that they can become acquainted with the school environment. Induction is very important to novice teachers because it helps them understand the school environment better. According to Zhukova (2018:110), when novice teachers arrive at their schools, they tend to focus on personal issues such as their image, status, performance and acceptance, and whether they are able to manage the classroom, content knowledge and instruction. It is for that reason that schools should not assume that new teachers know everything because they lack expertise in several areas. The schools should make sure that novice teachers are provided with induction that would help them feel that they are a part of the school. Zhukova (2018:111) posits that induction should be done by experienced teachers who can help novice teachers to cope with the new environment and curriculum and relate to new colleagues and mentor them to become professionals.

Novice teachers will inevitably come to school with their own understanding of curriculum content. To assist novice teachers, the schools should induct them on issues such as curriculum and classroom practice and they should be given only a few periods to teach so that they have time to concentrate on induction (Zeru & Jita, 2014:829). This shows that the teachers who are assigned to induct new teachers should be knowledgeable in terms of curriculum issues and should be teaching the same subjects as the novice teacher. Besides this, the teacher who provides induction should have good communication skills and be approachable so that the novice teacher feels free to communicate when they encounter a problem.

2.8 PROFESSIONAL DEVELOPMENT OF TEACHERS IN LIMPOPO PROVINCE

Like other provinces, Limpopo Province also executes PD programmes in order to improve the skills and competencies of teachers. The execution of these PD programmes is informed by the need to train teachers on matters that affect their teaching career. However, Limpopo is experiencing inadequate training on CAPS, which is coupled with piling teachers with a lot of paperwork which frustrates them (Molapo & Pillay, 2018:4). This implies that training of teachers on CAPS is a problem in Limpopo Province because most facilitators lack the ability to train teachers on how to implement the CAPS adequately. The following paragraphs explain various ways teachers are developed in Limpopo Province.

2.8.1 Initial Teacher Education Programmes

Prospective teachers enrol in initial teacher education programmes that are approved by SACE in order to study teaching. The universities that develop teachers in the Limpopo Province include the University of Venda, University of Limpopo and UNISA. These universities are approved to provide prospective teachers with qualifications such as Bachelor of Education (B.Ed.); Bachelor's degrees in specific subjects as well as the Postgraduate Certificate in Education. Teachers who study B.Ed. can specialise in Foundation Phase (Grade R–3); Intermediate Phase (Grades 4–6); Senior Phase (Grades 7–9) and in Further Education and Training qualifications which focus on Grades 10–12. The duration of the B.Ed. is four years while Bachelor's degrees take three to four years. Prospective teachers are frequently granted a Funza Lushaka bursary to meet their financial needs and on the completion of their studies are offered a job. In their first year of their studies, they are required to observe full-time teachers in schools in order to learn how they carry out teaching and learning and to acquire skills. During these times, they are also given the opportunity to teach learners, and this helps: them to interact with learners and to acquire educational competencies.

The Republic of South Africa (RSA) (2017:240) encourages teachers to engage in PD programmes that can assist them improve their skills and knowledge in order to improve the performance of learners in schools. Thus, teachers participate in various PD programmes that help them to improve their qualifications. According to RSA (n.d.:1), the Department of Education makes use of Continuous Professional Techers Development (CPTD) to develop teachers in their careers. Bernadine (2019:1) mentions that CPTD is the system that inspires educators to develop professionally. It comprises three forms of activities which include Type 1 activities (teacher-initiated); Type 2 activities (school-based) and Type 3 activities (externally initiated) and through participating in these programmes they should earn at least 150 points in a three-year cycle. These accumulated points are not specifically for promotion, but they assist the DBE to keep tabs on teachers who are actively engaged in PD and to monitor those who are lagging behind in their professional development.

2.8.2 Additional Certificates or Degrees

Teachers can either enrol for undergraduate advanced certificate courses or post-graduate courses such as master's degree and doctoral degrees with the above-mentioned universities or other universities outside the Limpopo Province. Besides, teachers being developed in initial teachers'education institutions, there are numerous teacher centres scattered around Limpopo districts that develop teachers in various programmes. These centres include Vhembe Teacher Centre, Giyani Science Centre, MASTEC Institute and Tivumbeni CPD. They develop teachers on the use of ICT, assist teachers to sign up with SACE and to upload their CPTD points and offer in-service training in subjects such as mathematics, science and commercial subjects. Centres like South African School Administration and Management System (SA-SAMS) and National Education Collaboration Trust (NECT) conduct workshops for various subjects. According to DBE (2017:48), the NECT has trained over 13 000 teachers in six provinces and it has also trained over 3 500 MST teachers.

2.8.3 Training by Teachers' Unions

Teachers' unions also develop teachers on the matters that affect their profession. According to RSA (2017:24), unions such as Suid Afrikaanse Onderwysersunie (the South African Teachers' Union), the National Professional Teachers' Organisation of South Africa and the South African Democratic Teachers' Unions initiate the development of their teachers at a fast rate. They make sure that when there are new developments that affect teachers, they call members to meetings to update them on policy issues so that their members should not be left behind with regard to new developments.

2.8.4 The Role of Information Communication Technology in Improving Professional Development

Information communication technology can be used to improve PD of teachers in schools. According to Alkamel and Chouthaiwale (2018:29), the role of ICT is to develop teachers and support them in subject content knowledge and teaching practice. The reason for teachers being forced to be acquainted with twenty-first century technology is that they are the agents of information and should transfer it to the learners (Idiegbeyan-ose, Llo & Isiakpona, 201523). The South African national education system has pledged to provide ICT infrastructure such

as laptops in all resource centres in the provinces so that teachers can access computers in order to use them to acquire skills and knowledge for teaching and learning (DBE, 2015b:15). The provision of ICT infrastructure by the DBE could assist most teachers since they are expensive to buy or not easy to get.

The use of ICT in teaching of mathematics cannot be under estimated. Khobo (2015:66) indicates that mathematics teachers should be trained on the use of ICT because it enables them to teach topics such as linear functions and the properties of graphs; it makes mathematics topics more interesting; it makes the drawing of graphs easier and quicker; and assists teachers to share ideas. Additionally, it improves learning (Das, 2019:97; Tondeur, Forkash-Baruch, Prestridge, Albion & Edirisinghe, 2016:10) and transforms education (Tondeur et al., 2016:118; Das, 2019:101). Mathematics teachers should be encouraged to use ICT so that they can acquire competencies that would allow them to use all types of technological resources in order to improve performance of learners in mathematics. Teachers can apply technological skills to teach the subject in a simple way as well as to access information and responses quickly.

Teachers should be provided with professional training on ICT in order to use it effectively. This is supported by Arikan et al. (2017:1845) who indicate that possession of computers and networks do not necessarily suggest that teachers are ICT literate and innovative. Instead, PD should be given to them to use ICT resources correctly. Furthermore, Csikos, Kovacs and Kereszty (2018:12) reiterate that teachers generally do not receive formal training on the use of ICT. The implication is that teachers should be encouraged to undergo formal training so that they can acquire skills to use ICT effectively.

ICT can help teachers to execute schoolwork as well as studying. Salmeron Aroca et al. (2022:13) mention that ICT literate teachers can use it for teaching and learning; empower learners in problem-solving and vocabulary; connect teachers with teachers from other schools to obtain educational information and collaborate on issues that affect teaching and learning. According to Ooko (2016:176), teaching and learning that can be carried out by ICT include audio graphic conference environment, audio graphic task-based environment on the web, digital scission environment, webinars, interactive programmes and other technology that use combined radio, print, audio and recording for distance learning. ICT can also be used to access learning information through google scholar (Ooko2016:178). This shows that ICT has

multiple forms of teachings and learning, meaning that PD in ICT are essential to teachers because they can help them to learn in different ways such as learning through video conference that allows someone to learn anywhere without going to the real place and they are also time effectiveness.

Teachers can also use ICT to improve quality of education and administration related duties. Some of the administrative duties that mathematics teachers can do through the use of ICT include improving the professional practice of which in the context of this study is mathematics; for reporting purpose; typing learners 'tests, assignments, portfolios, saving any valuable information and recording of marks (Finger, 2019:196). Teachers who use ICT for administrative purpose should be encouraged to do so because information stored in computers can be used in multiple folds for example, it can be shared by many people through memory sticks, copy and paste and if information contains errors can be edited unlike handwritten notes.

Projects that develop teachers on ICT exists in the Limpopo Province. For example, The University of the Witwatersrand works together with LDBE to train teachers on ICT. These teachers are selected from various districts to be given training at a particular centre. Teachers are taught how to operate computers effectively and to use them for teaching and learning, administration and classroom practice. At the beginning of the programme, teachers are given a laptop kit and manuals in order to use them for learning ICT. After the completion of the programme, they are awarded certificates.

2.8.5 The Implementation of IQMS

Thorough training on the IQMS can improve the implementation of PD in schools. According to More (2016:102), the IQMS can be helpful to teachers if training needs are identified and follow-up training is conducted by the department or district offices. Similar findings by Mthembu (2017: 91) indicate that training or workshopping of teachers should be continuous in the sense that it involves not only new teachers but all teachers which would assist in decreasing the confusion and incompetency shown by teachers in schools. During workshops, the facilitators should explain the processes of the IQMS so that teachers can identify their needs. Thorough training on the IQMS by district or department can assist teachers to use the IQMS properly while poorly conducted training has a negative impact on the implementation of the IQMS.

The role of the IQMS in schools in enhancing PD of teachers cannot be under estimated. The studies by More (2016:102) and Ngema (2016:169) have identified that most teachers are satisfied with the existence of the IQMS in schools because the process helps them to interact, to find support and to be mentored by their immediate seniors in the things such as subject teaching, subject content knowledge and classroom management. This is evidenced by Mthembu (2017:90) who indicates that the effective implementation of the IQMS improves the competencies of teachers and the performance of learners in schools. The school principals and district officials should monitor and support teachers in the implementation of the IQMS in order to increase the competencies of teachers and to help them overcome their individual challenges.

The existence of the IQMS in schools can help to improve the abilities of teachers. According to Mthembu (2017:90), the effective use of the IQMS can help teachers to identify their strengths and weaknesses regarding their career with a purpose to get professional intervention that would help to close the gaps. The scholar explains that the IQMS can help teachers to adapt to the changes in the curriculum since most teachers encounter difficulties in teaching learners effectively. The researcher agrees that the IQMS can assist teachers to identify their challenges and strengths during self-evaluation and during class observations by the DSG. This helps the DSG to know how to develop the teacher when they complete their Personal Growth Plan.

2.9 STRATEGIES OF IMPROVING PROFESSIONAL DEVELOPMENT IN AN ORGANISATION

Educational organisations should equip their teachers with various strategies to use in executing their teaching and learning. Because subjects are not the same, schools should expose their teachers to multiple approaches that are needed to improve the performance of learners. Teachers who are competent in using various strategies stand a better chance to develop their learners than those who do not apply a range of strategies. According to More (2016:100), the responsibility for developing teachers in schools is vested in the principals who send teachers to workshops, advise them to register with tertiary institutions and connect them with teachers who have the relevant expertise. The following paragraphs discuss the strategies that teachers need to execute learning and teaching in schools.

2.9.1 Lesson Study

Lesson study is a strategy that can be used to improve PD of teachers. According to Abdella (2015:225), lesson study involves the coming together of the teachers of the same subject to share ideas and support each other in relation to the subject. Teachers get time to be acquainted with the subject's Learner Teacher Support Materials (LTSM) and syllabus guide; and the lesson study also helps teachers to deliver lessons better as they get time to address problems in their approach to teaching. This indicates that schools should make sure that they encourage, motivate and facilitate teachers to interact with their cohorts from other schools in lesson study.

The study by Howard et al. (2016:12) is of the view that lesson study is productive when it comprises different teachers who can share diverse perspectives that include different grades, treating of different content areas and application of different approaches. The combination of teachers of different grades can assist teachers to understand lesson delivery better because teachers will learn from the perspectives of teachers across the grades. Besides, teaching of lessons by different teachers, lesson study can assist teachers to understand the subject better.

2.9.2 Cluster Meetings

Cluster meetings can improve the PD of teachers in schools. According to Ngema (2016:175), cluster meetings are good practice because teachers come together in grades in order to learn from one another and to do other school activities such as lesson planning, assessment programmes and discussions of concepts, skills and problems that are challenges in the subject. Cluster meetings comprising teachers of the same grades and subjects are productive in the sense that teachers can improve the skills and knowledge of teaching the subjects since they share their experiences. This should be supported by circuits and schools.

Cluster meetings can also be held in regions or districts in order to include as many teachers as possible. This implies that cluster meetings conducted at district level are productive because they include many teachers who come with different information than if cluster meetings are held at school level. Davydova, Dorozhkin and Polyanskova (2016:9218) indicate that the success of clusters at district or regional level depends on the sharing knowledge and assets; training of and retraining of teaching staff in new technologies for education and innovation; the development of rules, regulations and standards that would direct the cluster. The

development of rules in cluster meetings can assist teachers to have a common goal and to work together in harmony since the purpose of cluster meeting is to share knowledge and skills in the subject.

2.10 PROFESSIONAL DEVELOPMENT OF MATHEMATICS TEACHERS IN THE MOPANI DISTRICT AND CIRCUIT LEVEL.

Professional development of teachers in Mathematics in the Mopani District and circuits in the Mopani District takes place in many ways but this study would discuss four opportunities.

The first PD programme that trains mathematics teachers in the Mopani District is CAPS programme which started from 2012 till to date under the umbrella of National Curriculum Statement Grade R-12. The National Curriculum statements came in to replace two national statements which are Revised National Curriculum Statement Grade R-9, Government Gazette No. 23406 of 31 May 2002 and National Curriculum Statements Grade 10-12 Government Gazettes No. 25545 of October 2003 and No. 27594 of 17 May 2005. According to Maimela (2015:66), teachers should be capacitated on curriculum changes so that they can be in position to implement and to reduce fear and the feeling of incompetence. Before CAPS could be implemented, Mopani District through curriculum advisors had to train all teachers teaching mathematics and including other subjects so that teachers can get acquainted with what CAPS entails. Teachers are trained on mathematics to interpret aspects such as definitions, aims, skills, mathematics content area and clarification of content and assessment usage of work books as well as time allocation per week for each phase for example foundation phase has six periods, senior phase four and half, and teachers should know this so that they can use allocated time effectively.

As it has been alluded, PD of teachers is conducted by CAs who invite teachers to attend workshops through circulars that comprises subject, date, the grades involved and time of workshop. Teachers are also provided with supporting resources in the form of hardcopies and electronic discs so that they can print for themselves in schools and such resources include CAPS, work proujgrammes, mark sheets, assessment framework and other mathematics related documents.

Another programme that involves PD of teachers in mathematics is NECT working together with DBE to support learners to increase performance in mathematics. This programme was officially launched in 2017. It provides professional training of mathematics teachers through CAs who ensure that teachers use NECT programme effectively and be able to improve curriculum coverage in three subjects which are mathematics, Science and Languages. At the beginning of term one, all schools in the Mopani District are invited to the workshop where they are trained for term one and two work with regard to the usage of planner and trackers, content booklets, lesson plans and workbooks which are all provided by NECT.

Another programme that facilitates PD is Sasol Inzalo foundation that has partnered with DBE to improve the performance of learners in MST. The foundation has developed workbooks for grade 7 to 9 with the teachers' guides. The workbooks are for MST. The training for using the workbooks in the district was conducted by the CAs who were trained by Sasol Indzalo Foundation from the national. The workbooks are more productive than DBE workbooks because they work together with teachers' guides. The Sasol Indzalo foundation has also designed textbooks for grade 4 to 9 and CAs have been trained although the programme is not yet rolled out.

Mopani District and the circuits also invite a co-ordinator for IQMS per school to be developed in the implementation of IQMS in schools. After teachers have been trained, they report to their fellow teachers in their respective schools.

Teachers are also trained on CPTD conducted by SACE in the Limpopo Province. One teacher per school is given training and the school, appoint him or her as a school CPTD co-ordinator who also train other teachers and facilitate CPTD in schools. The CPTD co-ordinator reports all forms of PD activities done at school in the information system. These PD activities include school meetings, teacher development meetings and this score teachers with points for which all teachers are required to score at least the minimum of 150 points per three years circle.

Professional development of teachers also takes place in schools in each subject. More (2016:99) and Mahlangu (2016:170) agree that the responsibility of teacher development resides with Unions, School Management Team (SMT), IQMS, subject advisors and through donor assistance. Being the deputy-principal also heading Mathematics, I make sure that at the beginning of each term all Mathematics teachers are invited to the subject meeting to discuss

about all means that can be done to improve teaching and learning of the subject, teaching approaches, assessments and the use of resources and administration of mark sheets. Teachers are also developed on setting standardised formal tasks. After the teachers have set their formal tasks, they are mandated to first make sure that they are pre-moderated before writing and post-moderated after writing. Moderations of formal assessment tasks are done for quality purpose so that teachers should not give learners the work that is below the standard. Teachers who struggle to perform certain activities are helped so that they can improve it.

At times, unions invite teachers for workshop in a common venue to communicate issues that affect teaching and learning and educational policies.

Our SMTs especially the principals develop teachers in different ways that include teachers being delegated to perform work-related duties as part of PD; experts are invited to assist teachers who struggle to perform certain duties or teach subjects well; teachers are sent to workshops; teachers are invited to the school meetings by the SMTs where important information regarding teaching and learning are discussed, and teachers are advised to register with teacher education to improve their level of competencies. The principal also interacts with well performing schools to share knowledge and information with their teachers as part of PD.

Participation of teachers in the IQMS makes them to improve in the areas that are problematic to them including subject content, classroom practices as well as subject content knowledge. At the beginning of the year, the School Development Team (SDT) ensures that teachers come together in a formal staff meeting to review the IQMS work programme and committee. According to Mamabolo, Malatjie and Mphahlele (2022:5) and ELRC (2003:12), SDT is the committee based in school that comprises of selected teachers, SMT and principal whose role is to spearhed the implementation of the IQMS. Members who have completed their terms and those who have personal challenges are replaced by the new members to ensure that IQMS takes place without any challenge. The SDT in collaboration with SMT ensures that IQMS programme rollout by ensuring that Personal growth plan are checked to find out the weaknesses of teachers with a purpose to develop them. They also make sure that individual teachers have DSGs who are responsible for the development of teachers in the areas that encounter problems. For example, a Mathematics teacher should have DSGs who teach Mathematics so that they can develop the teachers well unlike if the DSGs teach different subjects as this would help them struggle to assist the teacher. The DSGs make sure that they

develop the teacher and at the end of day indicate the problems that have been resolved and failed to resolve. The problems that have been not solved are referred to the relevant structures such as SMT for further adjudication.

Before class observation, the SDTs and SMTs make sure that the IQMS timetable is in place. They make sure all teachers are included in the timetable and tht there are no clashes. Once that has been verified, the processes of pre-evaluation takes place. The most encountered challenge is that most teachers are afraid to be observed in classes by their DSGs, but the school make sure things go according to plan. The SMTs encourage teachers to be observed so that they can be developed correctly by addressing their identified weaknesses.

In addition to the IQMS, the schools participate in CPTD during school meetings in order to improve the competencies of teachers. There are times when the school has workshops to develop teachers on educational policies by using the expertise of teachers who have expertise in education management, law and policies. These workshops inform teachers on policies and help them to understand the importance of the policies. This has impacted the attitude and behaviour of the teachers positively.

2.11 THE CHALLENGES THAT CAN HINDER THE IMPLEMENTATION OF PROFESSIONAL DEVELOPMENT

Although there are several desirable ways that can propel PD in organisations, there are still several issues that can hinder the progress of PD. Schools should be aware of such problems so that they can address them. It is necessary to tackle hindrances that can disturb the smooth running of the PD programmes in schools as barriers can discourage, demotivate and deter the participants from implementing PD. In addition, this can lead the participants to discontinue following the programme. This should be avoided by following routes or avenues that would promote the implementation of PD. If remedial steps are not taken, the implementation of PD would be a futile exercise. The failure of PD programmes should be avoided as this would be a waste of resources, organisational commitment and time. The following paragraphs discuss some of the factors that can negatively affect the implementation of PD in organisations.

Workloads that are given to teachers can have a negative effect on the implementation of PD. The studies by Phothongsunan (2018:283) and More (2016:106) agree that an excessive

workload can demotivate teachers from implementing PD programmes as teachers are expected to teach many subjects and to carry out other school duties such as classroom management and administration which exhausts them. The schools should make sure that they allocate reasonable workloads to teachers so that they can implement PD programmes successfully because excessive workloads burden teachers and they become unproductive.

Professional development programmes that are conducted for short periods can hinder effective implementation. Mbatha (2016:26), Rasebotsa (2017:73) and Luningo (2015:128) are also concerned about workshops that are conducted for a short period but require a lot of work to be done. For example, teachers may be expected to learn the work for a week in one day and this is a problem because teachers may fail to grasp the information well resulting in the failure of the PD programme . Mpahla and Okeke (2015a:17) are of the view that facilitators develop teachers for a short time because of late coming. The researcher concurs with the scholars and believes the facilitators hasten the PD programmes in order to save time and costs forgetting that their programmes are not helping the teachers. The researcher's view is that facilitators should take their time to conduct PD so that teachers understand and implement the learning properly.

The notices that invite teachers to the workshop within a short space of time can hinder the implementation PD as teachers may fail to get them in time or arrive late in the meeting. According to Rasebotsa (2017:73), sometimes emails and SMSs are sent late after hours to invite teachers to the workshops and this makes teachers arrive late at the workshops. Consequently, teachers tend to lose valuable information that might be needed in the implementation of the programme (Rasebotsa 2017:73). Similar concern has been disclosed by More (2016:105) who claims that a lack of effective communication occurs in schools where teachers are not informed in time. As a result, valuable information is not communicated timeously to the staff. Invitations to the workshops should be done well in advance so that teachers can make proper plans and arrangements for transport since some teachers do not have their own transports.

Lack of adequate information from the workshops is likely to mislead teachers regarding the implementation of the learning they receive. According to Rasebotsa (2017:74), the lack of adequate information can be attributed to teachers who are delegated to attend meetings not giving proper reports and omitting crucial information that could drive the successful

implementation of the PD programme. The schools should delegate teachers who are committed and responsible to attend meetings so that they can give feedback to their cohorts. If teachers fail to provide genuine reports to their colleagues, implementation of the PD programmes is negatively affected and this is a waste of resources and time.

It is necessary that teachers who participate in PD programme should be given adequate support as failure to do so can hinder their progress. According to Mahlangu (2016:170), teacher development involves various stakeholders such as unions, SMTs, the IQMS and donor assistance. The studies by Luningo (2015:124) and Makhubele (2015:131) found that teachers do not get the necessary support from principals resulting in PD programmes malfunctioning. Principals of the schools should make sure that they monitor and support teachers when it comes to the implementation of PD because teachers are also human beings and when principals do not support them, teachers can get discouraged resulting in the failure of the PD programme.

Lack of LTSMs, infrastructure and equipment can affect PD programmes negatively. According to Makhubele (2015:30, 129), the schools in Limpopo Province have shortages of resources such as LTSM, infrastructure and equipment and this makes learning difficult because when classrooms are overcrowded, teachers struggle to teach well. In the same vein, Abdella (2015:225) states that a lack of adequate space makes the settings unworkable such as when teachers want to conduct student-centred research lessons, demonstrations and arranging tables. The provincial education systems should ensure that schools have sufficient resources so that learning programmes can take place without any challenges because the shortage of LTSM and adequate classrooms can affect the implementation of PD negatively and deprive learners of their right to quality education.

Facilitators' competence in facilitating PD programmes is essential as they can help teachers to understand the workshops and inspire them to learn. However, the study by Mpahla and Okeke (2015a:17) found that most facilitators do not have sufficient knowledge to develop teachers; as a result, teachers do not have confidence in them. This signifies that the DBE should employ capable facilitators by making sure that positions for the facilitators are openly advertised, that they are interviewed and that they should not be employed based on friendship or political deployment. Instead, prospective facilitators should be required to make

presentations to prove their competencies before they are appointed as inadequate selection and recruitment of facilitators hamper PD.

Lack of motivation by teachers due to poor salaries received and working conditions that are encountered in the workplace can inhibit effective implementation of PD. The discouragement of teachers due to poor salaries is supported by UNESCO (2015:8) who mentions that low salaries or poor living conditions of teachers forces them to seek extra jobs such as tutoring to supplement their income instead of participating in PD and this reduces work commitment and increases absenteeism. The DBE should derive strategies that will encourage teachers to participate in PD. For example, it can assess teachers on the implementation of PD and those who perform well could be provided with a PD allowance.

Poor English proficiency and commitment of learners can contribute to ineffective implementation of PD by teachers. Learners who are committed to learning encourage teachers to work hard and to implement PD enthusiastically. However, Abdella (2015:225) laments that learners' poor language proficiency can inhibit teachers from implementing PD adequately as learners would struggle to express their ideas and pronounce words correctly. The researcher concurs with the scholars that poor language proficiency can be a stumbling block to the implementation of PD by teachers; the suggestion is that schools should encourage learners to use English as a language of teaching and learning in whatever activity they do to promote and to improve language proficiency.

2.12 CHAPTER SUMMARY

This chapter dealt with PD of teachers with a view to improve the teaching of mathematics in the Mopani District. The literature review was used to understand how other countries work to implement PD and to improve mathematics that can lead to quality education. The methods of PD in developed and developing countries were presented both generally and in regard to mathematics teaching. The chapter also described various forms of PD that teachers can use to improve the quality of teaching and learning which includes teachers attending workshops, cluster meetings, lesson studies, the IQMS as well as self-development through TECs. It was mentioned that prospective teachers attend TEIs which provide them with necessary skills and knowledge that qualify them to become teachers and to execute efficient and effective teaching and learning. The study also discussed factors that can inhibit the implementation of PD and

the researcher contributed some suggestions that would lead to overcoming them. Factors that contribute to effective implementation of the study were mentioned with the purpose of using them so that PD should be effective and to make it success. The next chapter discusses a theoretical framework.

CHAPTER 3
THEORIES AND MODELS

3.1 INTRODUCTION

Chapter 2 presented the literature review on PD of teachers in various countries including South Africa in the Mopani District which is the focus of this study. This chapter discusses theories and models that support the PD of teachers in order to advance the study. It is important that a study should have a theoretical framework. According to Osanloo and Grant (2016:13), a theoretical framework is a blueprint that supports and guides the dissertation, and it provides the structures that assist the researcher to define the dissertation philosophically, epistemologically, methodologically and analytically. They further mention that the theoretical framework and literature can be developed in order to interpret the findings, support data, and underline the recommendations. The theories that are discussed in this chapter include Vygotsky's sociocultural theory and Guskey's theory of teacher change, all of which focus on the PD of teachers in schools. The chapter also discusses various models that emerged from the theories to make the discussion clear.

3.2 VYGOTSKY'S SOCIOCULTURAL THEORY

Vygotsky's sociocultural theory in this study is based on the work of Shabani (2016), and Shabani, Khatib and Ebadi (2010) who argue that even though Vygotsky's theory focuses on learners learning in their school settings, it can also be used to support the PD of teachers. Shabani (2016:1) maintains that Vygotsky's theory is based on the idea that the social origin of mental functions, unity behaviour and consciousness, mediation and psychological systems can be used to understand PD of teachers in their work environment. This theory is based on the ideology that human learning does not encompass a singular aspect; instead, other social interactions are involved that broaden the learning process. According to Shabani (2016:3), when social mediation works together with dialogic negotiation, higher forms of mental functioning are activated. In essence, this theory supports the view that social interactions or collaboration engagement activities alone are not enough to develop teachers; instead, they should relate to other activities that have a clear purpose or goal such as problem-solving and others (Shabani, 2016:3). This indicates that teachers need to interact with other teachers socially, physically and psychologically with the purpose of enhancing their learning.

The professional development models that are relevant to this study and have influence in the PD of teachers involve the study of Shabani (2016) and Shabani et al. (2010). These PD models include mediatory artefacts and technology, training, mentoring, involvement, study groups and inquiry or action research, individually guided activities, collaborative peers and mentors, scaffolding and mediatory artefacts and technology.

Table 3.1: Professional development within a Vygotskian theoretical framework

Key theoretical concepts	Related PD practices
Social interaction	Workshops, colloquia, seminars, mentoring, and / or study
Internalisation	Individual guided activities (video self-assessment; journal writing)
Mediation	Continuous follow-up support that includes the three types of mediators: Tools (materials); signs (newsletters and journals); and other humans (professional networks)
Psychological systems	Development of PD programmes that focus on changing teachers' attitudes as well as instructional practices

Source: Shabani (2016:7)

The model of PD of training focuses on presentations and practicum or internships. The trainees acquire information from teacher educators and trainers that relates to their career. Teachers are familiarised with their workplace activities to become professionals (Shabani, 2016:5). According to Zhukova (2018:100), teachers receive training at their workplaces because most of them complete their teacher education training not yet fully trained in their work-related activities. Furthermore, it is not the lack of training that makes the novice teachers not to be competent in their workplaces. The training offered to them by different trainers and support they get from colleagues confuse them to the extent that they become ineffective in their workplaces. To curb these problems, Zhukova (2018:111) suggests that experienced teachers should provide frequent systematic feedback and continuous support to the novice teachers so that they can acquire necessary skills. Levi-Kerren and Patkin (2016:25) propose that programme designers should consider or accept contributions suggsted by the trainees while designing their programmes so that they can address their needs. According to Cordingley et al. (2015:5), individual teachers have specific needs that raise a challenge to programme

*designers when they must design CPD lessons. This indicates that not all training offered by facilitators addresses the needs of the teachers, but focus on aspects that seem to be easy to them and side-line the difficult ones.

The mentoring model is closely connected to the Vygotsky‘s revolutionary concept of the Zone of Proximal Development (ZPD). It denotes that less knowledgeable people who are the novice teachers and trainees get PD by interacting with highly knowledgeable persons such as teacher educators and trainers (Shabani, 2016:6). The mentoring model holds that when teacher educators and trainers provide help to the novice teachers, they get pushed into the ZPD. According to Mumhure (2017:182), during training teachers are engaged in various activities that familiarise them with classroom functions such as syllabus interpretation, drafting schemes of work and assessment of learners. Some of the things that are taught to novice teachers include educational theories, pedagogical approaches and principles, behaviour of teaching and how institutions function (Loh, 2016:9). The scholar stresses that novice teachers should be engaged in matters that relate to their workplaces so that they can be prepared before they get there. This implies that novice teachers and full-time teachers should be engaged in the mentoring model so that they can be equipped with educational information and fully prepared for their work.

The scaffolding model can be used to develop teachers’ competencies. According to Shabani (2016:6), observed teachers make use of the trainers’ feedback to enhance their teaching practice and, in return, the trainers get time to observe teachers to help them in aspects that challenge them. Novice teachers in TEIs who encounter challenges in the use of e-learning can get support from their lectures (Richter 2016:59). This shows that experts or a trainers should have close interaction with their novices so that novices can be free to communicate when they need support. Cordingley et al. (2015:6) established that programme facilitators who are specialists in areas such as subject content, in-depth knowledge in PD processes and evaluation provide support to teachers who lack information and struggle to implement programmes. However, Shabani (2016:6) explains that in the classroom setting, collective scaffolding is more efficient than individual support. This suggests that group scaffolding is more productive than the individual scaffolding.

Professional development of teachers can also be done through collaboration with peers. Shabani (2016:6) mentions that trainees can acquire competencies that they need for their

career through collaborating with their own peers. According to the scholar, novice teachers can collaborate with their peers through discussions and research. In addition, teachers can collaborate with their peers online via the internet (Shabani et al., 2010:243). They can engage in journal writing to exchange their challenges with more experienced teachers. Ma et al. (2018:301) add that when teachers collaborate with their peers, they get a chance to ask each other questions and to exchange ideas as they are free to interact. The researcher concurs with this model in that it improves teacher's knowledge as it allows teachers to work on their own. In addition, it allows them to share ideas freely due to the absence of facilitators whose presence can sometimes be an obstacle.

The model of individually guided activities can help trainee teachers to enhance their skills. According to Shabani (2016:6), the model of individual guided activities denotes that all human thinking is social in origin and originates during the first encounter between individuals. The teacher trainees learn through self-analysis and personal reflection. For instance, the trainee teacher can develop their competencies by practising in front of a mirror or making a video recording that would later be viewed for reflection with a view to improving. The researcher believes this model is suitable for hard-working teachers who are determined to develop themselves using their own initiative.

Two models of study group and inquiry or action research can be used to enhance trainees' or teachers' skills. This model implies that cognitive development takes place in social interactions or collaboration (Shabani, 2016:6). According to Shabani et al. (2010:244), action research can be used to update the level of teaching by giving the trainees an opportunity to use different teaching methods in the class and later get feedback from the learners with a view to correcting the mistakes, revising and improving the teaching processes. They also suggest that trainees can phrase questions that can help to evaluate their teachings. They believe that questionnaires are reliable sources that can be used to get feedback from the learners and can also be used by teachers to improve their teaching practices. This implies that when teachers use questionnaires to develop their teaching abilities, they should use questions that would in turn assist them to improve their abilities rather than posing aimless questions.

Teachers can engage with mediatory artefacts and technology models to improve their use of technology. According to Shabani et al. (2010:244), efficient teaching and learning in the classroom depend on the presence of technological resources such as laboratory, computers,

video projectors and the ability to use them. Arikan et al. (2017:1845) mention that learning of technology is fraught with difficulties and struggles, but trainees have to confront it in order to become empowered and proficient in use of technology. According to Tondeur, Forkosh-Baruch, Prestridge, Albion and Edirisinghe (2016:118) and. Arikan et al. (2017:1845), teachers do not become technologically literate simply because their schools have computers and networks, but they must be taught how to operate them in order to use them in teaching. Hodge and Carbonara (2015:2) state that pre-service teachers can watch videos that show other teachers while teaching in the classroom or watch themselves in order to observe their mistakes which would assist them to grow and improve their professional knowledge. Lemoine, Yates and Richardson (2019:394) explain that teachers can acquire technological skills from universities through online learning in order to operate technological systems, use them for teaching and learning, access learning resources and put them into practice in the classroom. This shows that the development of teachers on the use of technology is necessary if not obligatory as the 4IR requires teachers to be technologically oriented in order to execute teaching activities well.

This study used Vygotsky ‘s theory because it directly addresses aspects that are suitable to advance PD of teachers in schools. It shows that interaction of two or more people are involved during learning. In relation to this study, facilators and supervisors interact with teachers during workshops and in the workplaces to provide them with suitable information required to advance teaching and learning in schools. This theory also involves various strategyies that are necessary for PD which includes training, mentoring, scalfolding, involvement and teacher change. Professional development of teachers involve training and mentoring of people where more knowledgeable people develop less knowledgeable people to improve their professional abilities. After the trainees received traning they are given regular support to strengthen their abilities. Trainees also have to reflect on the information received from the workshops and their workplaces to verify if they understood it or not. This theory also deals with teacher change. Teachers embrace practices that are learnt successfully and abondoned practices that are unsuccessful.

3.3 GUSKEY’S THEORY OF TEACHER CHANGE

Guskey’s theory of teacher change is the main theoretical framework of this study. The other theories discussed above exist to support it as they have crucial information that supplement

PD and teacher change. Guskey's theory is about PD and teacher change, and it addresses the PD of teachers in schools; hence it was selected to support the study. This theory was formulated by Guskey (1985) and has been used by many scholars in their studies. According to Guskey (2002:386), PD of teachers is conducted in schools to develop teachers on how to demonstrate new abilities proficiently and to promote quality teaching and learning. This theory is of the view that facilitators of the programmes should develop their students gradually so that they can have sufficient time and to learn new activities (Guskey 1985:59; Guskey 2002:386). According to Thanheiser et al. (2017:482) and Attard (2017:53), PD that extends over time allows the trainee to learn how to carry out classroom activities and to ask questions where they experience challenges. This implies that PD that is conducted for a short period counteracts the principles of Guskey's theory and should be avoided as it is likely to affect teacher development negatively.

Researchers such as Guskey (1985:59; 2002:386) and Paton et al. (2015:380) agree that change is gradual and learning is a difficult process as teachers are required to take on an extra workload and use their spare time for learning which sometimes subjects them to stress. According to Guskey (2002:386), PD brings certain anxiety to teachers especially when it comes to implementation. When teachers fail to implement innovations or practices correctly, they stressed that the learners and colleagues will look down on them, and this makes them reluctant to try new things unless they are sure that they can do it correctly. Thus, Paton et al. (2015:38) advise facilitators not to teach teachers too many programmes at the same time; instead, they should teach one subject at a time to avoid confusion and to allow them to assimilate and understand the information well.

This theory also acknowledges that there are no new programmes or initiatives that can be implemented in the same way for everyone as the context and people are different (Guskey, 2002:387). For that reason, Umugiraneza et al. (2017:11) encourage facilitators to provide PD programmes to teachers at their own workplaces so that they can learn while practising and get support while implementing learnt activities and methods. Mpahla and Okeke (2015a:18) also found that programmes that are not job-oriented do not produce good results for teachers' practices and learners' performance. Thus, Tariq and Jumani (2016:325) mention that programmes conducted in the workplace increase confidence and provide motivation for the teachers as they have time to reflect on their performance.

The implementation of new programmes brings change to teachers (Guskey, 2002:388). However, if change occurs before initial training, support and continued follow-up is still required for teachers to encourage their learning. The theory posits that support coupled with pressure is necessary to strengthen teachers who encounter anxiety of failure. At school level, school-based support teams should be available to support teachers who have learners with learning barriers (Mobara, 2017:166). This should be so because some teachers find it difficult to seek support from their colleagues (Tariq & Jumani, 2016:487).

Effective learning of new programmes should be followed by repetition and continued follow-up (Guskey, 2002:388). This theory emphasises the continual repetition of skills by teachers so that the programme can become part of them since learning is a process. It posits that repetition of programmes accelerates learning by teachers and sustains change which is often neglected. In line with this, some scholars provide suggestions that can be used to sustain new programmes. Ogbonaya, Mji and Mohapi (2016:711) mention that frequent training and retraining of teachers can sustain change while Darling-Hammond, Hyler and Gardner (2017:15) indicate that repetition of concepts or practices can be used to apply learning in the classroom context. This shows that repetition of learning activities contributes to effective learning by both teachers and learners. Thus, the use of repetition by teachers should be encouraged in schools.

The implementation of new programmes should be followed by regular feedback on student learning progress (Guskey, 2002:387). The feedback assists teachers to gauge whether they are still following the programme well or not. Darling-Hammond et al. (2017:13) mention that effective PD should include feedback to enhance the quality of learning by assessing the teachers' understanding of what they have learnt, receive input and apply changes. This theory shows that successful actions are reinforced and likely to be repeated and this helps the teacher to increase their skills and knowledge. Consequently, new practices are adopted, and the programme is implemented. However, if the implementation of new practices is unsuccessful, ultimately it will be abandoned. The programme should be applied with a view to enhancing teaching proficiency. The theory suggests that corrective measures can be applied to assessed teachers who encounter challenges in implementing innovations to help them enhance their teaching skills. Teachers who are more open, courageous to implement new innovations, feel confident about their classroom practices, manage learners and become successful are receptive to mastery learning (Guskey, 1987:11-12). Similarly, teachers who are not open to implement

new programmes; participate in school activities and fail when implementing activities encounter challenges in attaining mastery. According to Guskey (1985:58), proficiency learning is not attained by teachers being exposed to training and implementation of the programmes only but should be accompanied by successful implementation of the new programmes to give them courage. Less effective teachers can interact with teachers who are receptive to proficiency learning in order to improve their skills and knowledge as well as to change their attitude (Guskey, 1987:12). The fact that teachers who lack proficiency learning are encouraged to interact with receptive master teachers should be encouraged as this can encourage them to try new things.

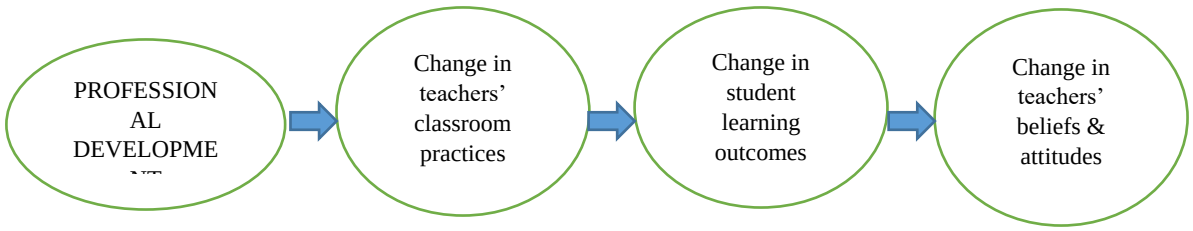

Figure 3.1: A model of teacher change

Source: (adapted from: Guskey 2002:383).

The model of teacher change represented in Figure 3.1 illustrates the sequence of changes that are likely to occur when teachers undergo PD programmes. According to this model, change in teachers' beliefs and attitudes occurs when teachers perceive improvement in learners' learning outcomes. Learners' learning outcomes involve a wide range of activities such as curricula, examination, assessment, school attendance and behaviour (Guskey, 1986:7; 2002:384). When teachers implement new programmes and become successful their attitudes and beliefs change because they have evidence that the programme works. The practices that are useful to the students' learning outcomes are retained and repeated while the practices that are unsuccessful are abandoned do not change teachers' attitude and beliefs. Teachers who consistently teach learners but do not experience improvement from them tend to believe their learners are incapable. But if they use other methods and become successful, their attitudes and beliefs change. This model is in line with the findings by Darling-Hammond et al. (2017:2) that indicate that effective implementation of PD leads to desirable changes in teachers' practices and student outcomes. Based on the model and the scholars' explanation, the

application of PD should be continued as it has an effect on changing teachers' attitude and beliefs as well as the students' learning outcomes.

Table 3.2: Summary of PD models used in this study and the approaches used to develop teachers.

Model	Approach used to develop teachers
Training	Presentations (by teacher educators, facilitators, or trainers) and practicum or internship (by teachers or trainees)
Mentoring	Less knowledgeable (teachers) interact with knowledgeable (facilitators)
Scaffolding	Use facilitators' feedback to improve teaching practice. Trainers observe trainees' mistakes and correct them
Involvement	Trainees collaborate or interact with peers
Individual guided activities	Self-analysis and personal reflection
Study group and inquiry or action research	Social interactions or collaboration
Mediatory artefacts and technology	Engagement in the use of technological resources
Teacher change	Trainees implement new practices after PD programme. Improvement of learners' learning outcomes embraced. Unsuccessful improvement of learners' learning outcomes abandoned

3.4 HOW THE THEORIES CONTRIBUTE TO PD OF TEACHERS IN MATHEMATICS IN THE PAST AND AT PRESENT

The use of Vygotsky sociocultural theory and Guskey's theory of teacher change in this study cannot be overlooked when it comes to how they impact the PD of teachers in mathematics. Using bottom-up and top-down approaches, teacher educators interacted with trainees in the past and are still interacting to improve their qualifications in matters such as classroom practices, subject content knowledge and learners' assessment. As has been indicated, these

theories have developed models which support their explanations and influence teacher development one way or another.

By following Vygotsky's sociocultural theory (Shabani, 2016:6), experts can use a mentoring model to develop teachers through collaboration or social interaction in the matters that affect their career. Thus, in their study on teacher perspectives on literacy and mathematics PD, Martin, Polly, Mraz and Algozzine (2018:104) highlight that the participation of teachers in PD in the previous three years had led to mathematics teachers deepening their understanding in content knowledge and learning engaging strategies. They mention that PD helped mathematics teachers to connect theory and apply pedagogics with greater understanding and this changed their attitude and beliefs for better. In the same breath, Lynch-Davis, Salinas, Crocker and Mawhinney (2015:277) show that lessons learnt in the Appalachian Mathematics partnership helped teachers to cope with curriculum change as they was able to teach teachers how to teach content subjects and pedagogical change. Eventually, mathematics teachers experienced improvement on issues such as assessment, learners' performance, decision-making about quality teaching approaches as well as curriculum implementation. Furthermore, the study by Polly et al. (2017:127) mentions that teacher development that focuses on number sense concepts and algebraic reasoning instils positive improvements in kindergarten teachers' mathematical content knowledge and in the learners' learning outcomes. The success of the PD programmes can be linked to Vygotsky's theory as this theory believes teacher development takes place through social interaction or collaboration between experts and trainees.

Professional development of teachers also contributes to improving individual teachers' classroom practices which is a challenge to most teachers (Looney et al., 2017:35). According to the scholars Looney et al. (2017:36), teacher programmes were created to change the attitudes and beliefs of mathematics teachers since their attitude towards mathematics was not good. At the end of the PD programme, all teachers who participated in the workshop were reported to have changed their attitudes. This was confirmed by Gomez et al. (2015:450) who indicate that there is good connection between willingness to experiment with new techniques and growth in knowledge and beliefs about the importance of teaching and learning mathematics. The researcher concurs with the scholars who indicate that trying new lessons is connected with growth of knowledge and beliefs. This practice is in line with Guskey's (2002:384) model of teacher change which posits that change is predicated on experientially

based learning processes. The model suggests that teachers should be eager to try new practices after undertaking PD programmes to test whether the knowledge and skills acquired during their PD has been actualised and can be transferred to new settings.

Chin et al. (2016:845) mention that mathematics teachers who participated in inquiry-based mathematics teaching competency PD programmes made positive progress in both their knowledge of mathematics enquiry and their related teaching practices. The outcome of the above programme impressed the teachers because the group meetings not only provided them with resources to implement inquiry-based mathematics teaching but also exposed them to the process of sharing information, discussing and reflecting on their teaching. This form of PD is supported by Ma et al. (2018:302) who mention that during PD teachers build relationships between practical knowledge and specific teaching context and learns from each other. This implies that when teachers participate in PD do not only get academic information but also get time to relate with other teachers who impart knowledge and motivate them on social life issues. Learning of adult learners from each other can be attributed to Vygotsky's theory through the model of involvement (Shabani 2016:6).

Professional development also plays important role in teaching mathematics teachers' various strategies of assessments that needed for their day to day work. Baloyi (2015:108) highlights that the use of various strategies by mathematics teachers can assist learners to respond appropriately to ANA question papers. While Umugiraneza et al. (2017:1) mention that teaching strategies and assessment practices are the basic factors that determine the performance of learners. Thus, Dayal and Cowie (2019:115) show that a two-day workshop with mathematics teachers was conducted in Fijian classrooms to provide them with guidelines for portfolio assessment in mathematics and to enlighten them on the numerous ways of assessing student learning. The workshop also helped them to develop teaching and learning tasks to be used as assessment options. They also learnt that the setting of higher order questions promoted the idea of learning mathematics in the context. Mathematics teachers also participated in PD that started at the beginning of the year and ended at the summer session. It was about empowering teachers on formative assessment to inform their teaching and improve learner mathematical performance (Polly et al., 2016:145). The outcome of this PD yielded satisfactory results as teachers could use various formative assessments to assess their learners and that made them excited and they felt empowered. According to Umugiraneza et al. (2017:10), the DBE is responsible for exploring classroom-based interventions that would help

teachers to assess learners appropriately. The researcher agrees with the scholars partially as the issue of assessment should not be left to the DBE alone; the schools, especially the SMT, should make sure that they provide necessary support to their teachers.

At present, mathematics teachers including teachers of other specialised subjects undergo various PD programmes in diverse levels ranging from school level to TEIs level. They use various approaches such as contacts, distance and on online learning to improve their competencies with a view to deliver quality education in schools. One of the PD programmes offered to teachers across the subjects is the use of English as the language of teaching and learning to improve the learning of mathematics. Teachers' ability to teach learners in English is necessary in schools because learners use it for learning across all school subjects. For example, they use English for communication and reading. Baloyi (2015:111) shows that ANA in mathematics aims to evaluate learners on reading, writing, and counting. According to the scholar, these aspects can help to promote the development and application of mathematical skills in interpreting the world and used in daily life. Thus, various scholars provide reasons that support the teaching of mathematics in schools. Chin et al. (2016: n.d) show that mathematics teachers engage in PD by reading literature, observing experienced teachers' teaching or participating as an observer and participating in inquiry teaching in order to be on par with current teaching practices. According to Prediger (2019:367), PD of mathematics teachers should be offered because it is the only means to share ideas and communicate in the classroom context. In addition, Peterson-Ahmed, Hovey and Peak (2018:13) highlight that initial teachers in their first year of pre-service training are engaged in reading since this is fundamental for their study and prepare them to become quality teachers. Besides being offered PD in pre-service training and workshops organised by the districts, in schools there are periods called 'reading for enjoyment' and 'drop all and read'. During these periods teachers engage learners in reading and they also must teach them appropriate reading skills. Based on the above information, teacher development in reading, especially mathematics teachers, should be emphasised as it helps to enhance learner performance in mathematics. Learners can use English to read questions with understanding and to respond correctly. It is not surprising that Guskey's (2002:384) model highlights that learning outcomes are broadly construed. According to Guskey, this explains that learning does not only comprise cognitive and achievement indices but also includes other forms of evidence that teachers can use to assess learners.

Vygotsky's theory uses the concept of social interaction to denote that learning involves more than one aspect of the social environment, meaning that various situations can be used to develop teachers. Thus, prospective teachers undergo pre-service training from the TEIs to prepare them to become competent on school activities. For example, the State University in Turkey develops pre-service elementary mathematics teachers in algebra teaching knowledge and this benefits them because they learn how to integrate content knowledge with the pedagogical content knowledge in the classroom context (Güler & Çelik, 2018:162). Dollar and Mede (2019:209) state that TEIs also engage prospective teachers in reflective activities, and this helps them to identify their strengths and weaknesses and improves their teaching skills and critical thinking while undergoing practical teaching. This shows that Guskey's model of teacher change closes gaps in teachers' knowledge by developing them in different areas of their subject specialisations. Even when most scholars present the positive side of PD in TEIs, it is good to reflect the challenges that exist with a view to correcting them. Thus Peterson-Ahmad, Hovey and Peak (2018:13) lament that generally the purpose of pre-service teachers undergoing TEIs is to acquire PD on issues such as classroom management, culture, diversity in schools and individualised education plans, but these are not adequately executed. New teachers often struggle to manage the behaviour of learners when they get to the school level. This shows that TEIs should be determined when it comes to training prospective teachers on these essential aspects of teaching because failure to do so would affect them negatively.

The training model based on Vygotsky's theory indicates that those teachers should be given training in order to be equipped with information regarding their career (Shabani, 2016:6). Shabani mentions that experts present PD programmes to the trainees to help them understand new practices well. Currently, districts are offering training to mathematics teachers to help them understand and cope with the implementation of the CAPS policy. The workshops last one or two days and most teachers struggle to understand it even though the training has been repeated on a quarterly basis since the inception of the programme. Although Ramabulana (2017:79) explains that PD programmes for the development of teachers on CAPS use a top-down approach meaning that teachers do not have input into how to implement it; however, teachers are happy that CAPS textbooks comprise lesson plans that make it easier for them to teach instead of having to prepare the lessons themselves. During workshops, teachers are orientated on how to use the textbooks as well as the teaching approaches required by the new

curriculum and setting of tests. The claim that training lasts for one or two days is a challenge because teachers do not develop an in-depth understanding of the programme.

There are other PD programmes conducted in schools that include the IQMS which develop teachers on areas related to teaching and learning as well as professional development. Makubung (2017:67) mentions that IQMS coordinators train teachers in schools by offering them courses, workshops and other training that are relevant to teacher PD as informed by the IQMS process. He mentions that the district officials also give support to the teachers by conducting school visits, on-site meetings, cluster meetings, one-on-one meetings, and sampling learners' books for moderation purposes. The other forms of teacher development offered to teachers in schools include supporting teachers to manage time; developing them on how to plan lessons; mentoring new teachers to manage their classrooms (Hugo, 2018:193). The training of teachers by IQMS coordinators and support provided by district officials are in line with Guskey's theory which suggests that during PD teachers should be given continuous follow-up and support (Guskey, 2002:388), and regular feedback (Guskey, 2002:387). The involvement model and individually guided activities model are also used by teachers when following their own studies with distance TEIs and performing group discussions (Shabani, 2016:6). According to Shabani (2016:6), the involvement model is a form of PD that helps teachers to acquire new knowledge and skills to solve educational problems by interacting with their peers, conducting research and participating in discussions. This model relates to Guskey's theory because its focus is developing teachers through various techniques. Teachers also study the use of computers through various institutions which is in line with the mediatory artefacts technology model. This shows that teachers are currently undergoing various PD programmes which are influenced by these theories, and these help them to face curriculum changes and improve their teaching for the better.

3.5 WHY THE RESEARCHER OPTED TO USE THESE THEORIES

There are some factors that led the researcher to choose these theories. Guskey's theory was selected as the main theoretical framework as it fully addresses PD of teachers and teacher change in schools. It explains the process of teacher change in detail by indicating that teachers who undergo PD programmes should engage in new practices to assess if the programmes work for them or not. The researcher's view is that the implementation of new practices is good practice for teachers who aspire to learn as this helps them to understand the programme. In

fact, if teachers struggle to implement PD can seek assistance or support from the facilitators to help them implement it correctly. The theory also encourages teachers to provide regular feedback to the learners so that they can see their mistakes with a view to correcting them. In addition, it also acknowledges that learning is gradual and difficult. Teachers are expected to spend extra time on learning and are also exposed to the anxiety of fearing failure. Thus, facilitators are advised not to rush their programmes and should also allow teachers to reflect on their work. The theory also involves collaboration between the experts and teachers. This makes workshops bear fruit as both experts and teachers exchange ideas during the workshops and teachers can also ask questions if they encounter challenges.

Vygotsky's sociocultural theory was included in this study because of its constructivist approach. It deals with the PD of teachers in schools and posits that teachers learn through social interaction or collaboration to broaden learning. For example, during teacher development, facilitators interact with teachers and they also give support to them so that the programmes become effective. Besides this, it PD includes strategies such as training, mentoring, scaffolding, engagement, individual guided activities, study groups and inquiry or action research and the use of mediatory artefacts and technology. All these strategies are important considerations in this study.

3.6 DISCOURSE OF THE THEORIES

The following sub-sections discuss aspects of the theories such as collaboration, ongoing support and feedback which the researcher believes it is necessary to discuss since they are key elements of PD.

3.6.1 Collaboration

Following Guskey's theory of teacher change (1985; 2002) and Vygotsky's sociocultural theory (Shabani, 2016), collaboration is the main way that facilitators use to interact with teachers. According to Tariq and Jumani (2016:486), collaboration involves sharing competencies such as pedagogical methods, new techniques of assessment and solving problems with the assistance of the experts, mentors, experienced teachers and educationalists. It takes place in a non-threatening environment; however, teachers should be motivated to be innovative and to move out of their comfort zone. Shabani (2016:6) mentions that Vygotsky's

sociocultural theory operates well if there is effective collaboration between the facilitator and the teacher. This means that the facilitators and teachers should respect one another so that they can operate in a peaceful environment to achieve their intended goal.

Most scholars concur that collaborative activities are essential in the improvement of teachers' qualifications. Svendsen (2016:313) mentions that school-based, collaborative teacher development programmes enhance teaching practice, thinking and changing teachers' attitudes to participate in collaborative activities. Teachers can network with colleagues from other schools to create a platform for them to meet at various times to discuss educational matters. This networking is practised for improving individual performance and learners' learning outcomes, which are often a challenge in the school environment (Abdella, 2015:222; Azano & Stewart, 2015:519; Kempen & Steyn, 2016:43). They further mention that their discussions with teachers from other schools also equipped them with new knowledge, classroom practices, and valuable information that are core to effective teaching such as conducting experiments and improvising as well as setting quality tests and examinations. The use of collaboration has a positive impact on transforming teachers' teaching and improving learners' learning (Darling-Hammond et al., 2017:7), and allows teachers to reflect on their own work, take risks and solve problems that confront them (Darling-Hammond et al., 2017:10). The fact that collaboration between facilitators and teachers results in the improvement of teachers' abilities implies that it is effective and, for that reason, it should be given priority in teacher development programmes.

Collaboration can operate at different levels. Teachers in the same school, grade, and department can share information, curriculum materials and assessment requirements (Ngema, 2016:176). They can use lesson study based on the subject teaching to share ideas, arguments, teaching techniques, and opinions to broaden their knowledge and promote their PD (Kanellopoulou & Darra, 2018:83). Abdella (2015:222) found that teachers who participated in the lesson study tended to include activities that were not previously used and they worked together to develop a sense of security. Abdella (2015:223) found that teachers who worked together in a lesson study felt more professional than before their participation in the lesson study; found opportunities to use the prescribed syllabus guide and learners' textbooks, and helped them to understand lessons which were previously difficult for them. Unlike other scholars, Howard, Akiba, Kuleshova, Wilkinson, and Farfan (2016:13) mention that lesson study is effective when teachers get information from different perspectives including different

grade levels, different content areas, as well as subject specialisations. The fact that collaboration can be used in different contexts and cn be used to develop teachers implies that it is an approach that can be trusted in PD programmes.

The implementation of collaboration enhances the level of motivation, commitment, confidence and innovation of teachers (Kempen & Steyn, 2016:43). According to Azano and Stewart (2015:583), the PD programmes that address teachers' personal needs motivate them to learn. As a result, they acquire more knowledge, skills, and confidence to teach mathematics. This shows that teachers require motivation and respect from facilitators in order to implement the programmes properly. Motivation and respect by facilitators are very important in any organisation because the lack of them can cause friction. Thus, Tariq and Jumani (2016:487) found that teachers do not see the value of working with facilitators and experienced teachers who do not value them.

3.6.2 Ongoing Support

After teachers have attended PD programmes and shown improvement, there should be continuous follow-up, support and pressure to maintain the initial training (Guskey, 2002: 388). According to Guskey, support accompanied by pressure is vital in mintaining the educational improvement and supporting teachers in difficult times. Provision of support by the facilitators is supported by Luningo (2015:127) who mentions that after the attendance of the workshops, teachers should be monitored to check if the skills and practices instilled in them during teacher development are implemented. Luningo mentions that if the teachers struggle to implement the programme, they should be given necessary support. According to Cordingley et al. (2015:6), facilitators have expertise in several areas including subject content, in-depth knowledge in PD process, monitoring and evaluation. This means that facilitators have adequate knowledge to support teachers in schools. Another form of support that can be given to teachers is on the use of technology. Thus, Arikan et al. (2017:1844) show that the use of technology is challenging but, if teachers can be given adequate support, they tend to develop technology awareness. This shows that regular monitoring and support should be given to teachers in schools in order to improve their abilities and to motivate them to learn.

In order for new programmes to be implemented adequately, they must form part of the teachers' repertoire of teaching skills (Guskey, 2002:388). According to Guskey, this should

be embedded in the programmes that continue and expand until new practices become habits. Teacher education institutions have programmes that require prospective teachers to undergo self-reflection in order to improve their teaching practice but some TEIs fail to conduct them correctly (Singh & Mabasa, 2015:168). Furthermore, teachers need to build their repertoire of formative assessment strategies that would help to provide regular feedback in order to improve learning outcomes of learners (Umugiraneza et al., 2017:10). The fact that teachers should undergo PD programmes that can help them to master their skills implies that PD programmes should be structured in a way that can develop them to master learning.

New practices need to be maintained by being given follow-up and support to avoid losing what has been learnt (Guskey, 2002:388). Guskey laments that new practices are ignored and that affects PD programmes negatively. This is supported by Ndebele et al. (2016a:326) who mention that workshops are conducted once without follow-up. As a result, teachers tend to forget activities that have been taught. According to Darling-Hammond et al. (2017:15), PD cannot be achieved in a single or short workshop if principls want to teachers to change; instead, more time needs to be allocted to assisting the teachers. Workshops without a supporting environment are problematic because teachers do not get time to master the teaching activities (Isabirye, 2015:233). The fact that workshops are conducted for a short time without proper follow-up signifies that the facilitators lack the commitment to assist teachers in schools, and this can hinder the progress of PD programmes if this is not sorted out immediately.

Professional development of teachers becomes effective if teachers are given follow-up and support in schools after attending workshop (Abdella, 2015:220). Teachers can attend a workshop once; thereafter, facilitators should visit schools to provide on-site support by doing class visits, moderating learners' books, and checking their files (Ndebele et al., 2016a:326). Teachers can also be developed and supported during staff meetings (Ngema, 2016:169). According to Bantwini (2019:226), most principals are aware that the success of their schools depends on their support; however, some principals find it difficult to support their teachers. Bantwini further mentions that through support teachers can overcome contextual problems, and assist novice teachers to master teaching strategies without going the route of trial-and-error. This shows that the support that is given to teachers in schools is more effective since it addresses the needs of teachers directly unlike programmes conducted for all schools at once without the consideration of their contexts.

3.6.3 Feedback

In order to sustain new practices and ensure enduring change, those who provide activities need to get feedback on the effects of their efforts (Guskey, 2002:387). According to Guskey, the activities that are delivered successfully tend to be reinforced and are likely to be repeated while unsuccessful actions tend to be diminished and are likely to be forsaken. Thus, Svendsen (2016:325) mentions that effective PD of teachers allows teachers to reflect on their own practices and to engage in discussion with other teachers and this helps them to improve their teaching skills. According to Darling-Hammond et al. (2017:14), feedback and reflection are tools that are used in mentoring and coaching, and they can also be used to improve the quality of learning by checking the understanding of what teachers learnt, receive input on and to make changes on the practices. Reflection can lead teachers to change their activities and to change challenging areas such as teacher orientation and teacher goals (Biccard, 2018:13). The fact that teachers participate in PD programmes that help them to reflect on their work after performing activities signifies that they are eager to get their feedback on their performance. Feedback is very important because it is a tool that informs the teacher involved in an activity if they have implemented an activity well or not although all teachers aspire to deliver new practices correctly. As matter of fact, if the implementation of the activity is not successful, the teacher would need to change the strategy to get it correct.

Teachers can participate in various teacher development programmes in order to sustain their new practices. They can observe one another while presenting lessons and during debriefing sessions can provide one another feedback and suggestions on how to improve teaching practice (Abdella, 2015:222). This practice is supported by Howard et al. (2016:13) who mention that teachers who teach the same subject such as mathematics can come together to share ideas about the subject and this can lead to the improvement of teaching strategies. This implies that new practices need frequent repetition in order to be sustained and they can be more successful if teachers work together as they would get a chance to discuss the activities and to assess one another.

According to Paton et al. (2015:39), implementing new practices is a difficult thing and needs endurance as this may require repetition before seeing improvement. On the other hand, Arikan et al. (2017:1844) found that learning technology requires teachers to be innovative in using technology. This implies that teachers should understand that learning new practices is

sometimes not an easy task as there are times they would be expected to work very hard in order to achieve their goals.

3.7 CHAPTER SUMMARY

This chapter discussed various models and theories that focus on the PD of teachers. The theories included Vygotsky's sociocultural theory and Guskey's theory of teacher change. The models emerged from the theories included teacher change, training, mentoring, scaffolding, involvement, individual guided activities, study group and inquiry or action research, mediatory artefacts and technology and teacher change. The chapter also discussed the contributions of theories to the PD of teachers in mathematics; motives for selecting the theories and a discourse on the theories which included collaboration, feedback and ongoing support. The next chapter focuses on research methodology.

CHAPTER 4
RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

The previous chapter discussed the theoretical framework. The theories included Vygotsky's sociocultural theory and Guskey's theory of teacher change. This chapter discusses the methodology that is used in this study. It also explains how data collection processes were conducted while investigating the role of PD of teachers in improving mathematics in rural public schools in the Mopani District. The other aspects that this chapter includes are data analysis, trustworthiness of the study and ethical considerations.

4.2 RESEARCH QUESTIONS GUIDING THE STUDY.

The main research question is formulated as follows*:* **What is the role of teacher PD in the improvement of mathematics achievement in rural schools?**

The following sub-questions were asked to support the main research question:

- How can teachers' professional development enhance knowledge about teaching of mathematics?
- What are the challenges hindering the professional development of teachers in rural public schools?
- How can mathematics teachers be inspired to engage in professional development?
- How does the professional development of teachers contribute to the improvement of learners' achievement in mathematics?
- What capabilities do teachers acquire during their participation in professional development?

4.3 RESEARCH PARADIGM

This study was aligned to the interpretative paradigm to understand the views of the participants. Creswell and Creswell (2018:8) mention that, in this approach, researchers ask the

participants broad and general questions in order to allow them explain their understanding of the social world and the participants are participate through social interaction. Researchers such as Maree (2017:61), Creswell and Creswell (2018:8) and Hesse-Biber (2017:50) agree that research strategies can be used to understand the research topic and how the participants construct meanings from the social world through social interaction.

According to Creswell and Creswell (2018:8), open-ended questions permit the researcher to focus on the information provided by the participants in their own surroundings. The participants were asked open-ended questions in order to encourage them to share more information. Interacting with the participants in their own environments enabled the researcher to understand the participants' personalities, historical experiences, culture and background (Creswell & Creswell, 2018:8; Maree, 2017:16). This study used semi-structured interviews to collect data from the participants. The researcher ensured that his beliefs and biases were side-lined in the interpretation of the participants' information. Cohen et al. (2018:19) are of the view that actions displayed by the participants during data collection and interacting with the participants in their own environment should be taken into consideration in order to retain the integrity of the information. The researcher ensured that all actions displayed by the participants were recorded and probed in order to get their opinions, experiences, and perspectives regarding the topic under study. Furthermore, Maree (2017:61) mentions that this research paradigm suggests that there are many realities that can be offered by the participants rather than a single explanation and these realities can vary across time and place. This implies that participants can have multiple ways of sharing their experiences and understanding on various issues which is not possible when using other approaches. The following sub-sections discusses the elements of the interpretative paradigm including its ontology, epistemology, and methodology.

4.3.1 Ontology

Maree (2017:52) explains that ontology relates to what is the truth. According to Maree (2017:57), one of the ontological positions that exist in qualitative research includes realism that claims that external truths exist independently of people' beliefs. This ontological stance suggests that there is a difference between what the world is and the world that can be explained or given a meaning by individual persons. However, studies by Cohen et al. (2018:288) and du Plooy-Celliers, Davis and Bezuidenhout (2014:29) found that human beings can construct

meanings of their own contexts and make sense of their own world and act through such interpretations. The researcher allowed the participants to construct their own truth about the phenomenon under study and to make sense out of it. Creswell (2013:20) posits that researchers who participate in qualitative research hold to particular truths. Thus, the researcher interacted with the participants in order to understand their multiple realities and to report them in the study. My stance as a researcher was to consider the multiple realities of the participants in order to make the study credible and trustworthy.

4.3.2 Epistemology

Maree (2017:67) mentions that epistemology involves mechanisms that researchers use to uncover the truth. For the researchers to acquire the truth, they must collaborate with the participants in their own environments (Cohen et al., 2018:288; Creswell, 2013:20). According to Cohen et al. (2018:288), interacting with respondents in their own situations allow the researcher to take all factors into account as they uncover the truth. Cohen et al. (2018:289) also explain that experiences, social reality and social phenomena and sometimes contradictory interpretation present multiple realities. Thus, the researcher interacted with the participants in their own context with the aim of discovering the truth about the issue under study. While interacting with the participants, the researcher took ethical considerations into account so that the participants could be free to divulge as much information as possible. In case some aspects were not fully explained, the researcher probed the participants in order to get them to explain more and to share their experiences.

Furthermore, Maree (2017:67) and Hesse-Biber (2017:34) agree that epistemology involves understanding the relationship between the researcher and researched participants and they work together to construct knowledge. In this study, researcher- participant relationships were developed by the show of respect to the participants and their settings. The researcher ensured that the participants were not silenced when responding to the questions. The researcher also ensured that he communicated with the participants before entering their settings to avoid intruding on their privacy. When participants are given proper respect, they tend to cooperate well with the researcher and provide full information. The researcher ensured that during interviews, full attention was paid to the participants. If the participants perceive that the researcher is interested and highly esteem their information, they are likely provide thick information. The participants were allowed to respond to the questions at their own pace as the

level of communication differed from one participant to another. They were given as much time as they needed to speak in order to discover emerging patterns, themes, and trends.

4.3.3 Methodology

Methodology is the technique used by the researcher to conduct the research and it sets out the rationale for employing selected methods and explains how they are used in the study (Hesse-Biber, 2017:34). Creswell (2013:22) mentions that the qualitative methodology is characterised as emerging, inductive, and guided by the researcher's experience in collecting and analysing data. According to Creswell (2013:20), research questions may be adapted during the research process to understand a research problem better. A synopsis of the methodology used in this study has been offered diagrammatically in Figure 4.1 along with the ordered, systematic approach of the research technique. This systematic process includes the aim, research pproach, epistemology, ontology, data collection and data analysis.

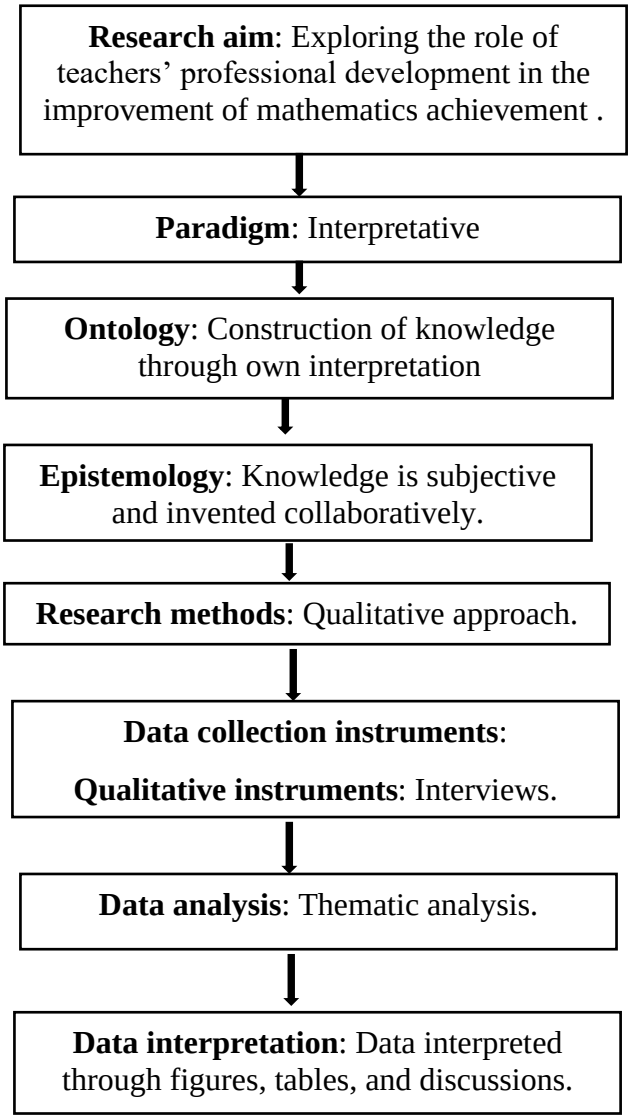

Figure 4.1: Research Methodology

4.4 RESEARCH APPROACH

The purpose of this study was to explore the role of PD in assisting teachers to improve mathematics achievement in rural public schools. In order to meet this purpose, qualitative research was used. According to Creswell and Creswell (2018:181), qualitative researchers do not study their respondents in a laboratory experiment: instead, they study them in their natural environment to experience the issue through social interaction. Leedy and Ormrod (2015:269) mention that qualitative research focuses on studying the complexity of the problem and does not try to manipulate it with the understanding that the phenomenon under study has many dimensions and layers. In addition, Creswell (2015b: 16) mentions that the qualitative approach

addresses a problem where the researcher does not know the variables and needs to acquire the participants' experiences through asking questions.

The researcher thus made sure that all the research processes were aligned to qualitative research methods. In the research proposal, the researcher stipulated all the aspects that would be used in the qualitative approach and provided the reasons for using them, for example, the sampling of the participants, data collection tools and the method of analysis. However, he was able to change the research questions or methods during the course of the study in order to direct the study or follow adjusted questions. In addition, unlike quantitative researchers, qualitative researchers collect and analyse data simultaneously (Maree 2017:83). The researcher collected and analysed data simultaneously while they were still fresh to detect gaps that might have occurred and to address them where necessary.

Cohen et al. (2018:289) state that the qualitative approach provides the researcher with thick descriptions; the participants are studied in their natural settings which encourages them to share information freely and behave naturally; and information is collected systematically and analysed inductively. This indicates that the researcher needs to be fully conversant with the research approach to conduct the research process. Conducting the research systematically assisted him to carry out the research process successfully. It also enabled the researcher to accumulate the required data. This must be so because the lack of knowledge and skills on research methods can affect the trustworthiness of the study negatively.

4.4.1 The Nature of Qualitative Research

Various researchers use the qualitative approach due to the nature of its characteristics. According to Merriam and Tisdell (2016:23) and Bell and Waters (2018:24), knowledge is constructed through social interaction with the individuals who create meanings from the social world, activities and experiences. Creswell and Creswell (2018:182) indicate that the participants are responsible for formulating meanings on the issue under study rather than relying on the meanings expressed by the scholars in the literature or the researcher. In order to accomplish these, qualitative researchers use words such as "how "and "what "while formulating the questions (Merriam & Tisdell, 2016:24). The use of "what" and "how" could motivate the participants to elaborate, provide detailed information and to give examples while

sharing their experiences. The questions that were asked to the participants guided them to share descriptive information rather than directing them to respond in “yes” or “no.”

4.4.2 The Advantages of Qualitative Research

Most scholars mentioned that the use of qualitative research has advantage to the researchers. According to Leedy and Ormrod (2015:271), some advantages of qualitative research include:-

- Gaining insight to topics which were previously not studied in full.
- Assisting qualitative researchers to formulate concepts that are in line with their topics.
- Containing ways that can be used by researchers to evaluate the effectiveness of particular practices and policies, and
- Assisting researchers to identify problems or issues that exist within the study.

Bell and Waters (2018: 26) and Creswell (2015a: 5) also stipulate the advantages of qualitative research as follows:-

- The researchers are able to reflect on their own experiences since they are responsible for the research process.
- It allows the researchers to sample few participants in a place of the population.
- Researchers can Change the focus of their studies in the middle of the study.
- It permits the experiences of the participants to dominate the study.
- The perspectives of the participants carry more weight than the ones of the researchers.

The qualitative approach was suitable for this study because the researcher was able to interact with the participants on the issues that affect PD of teachers in rural public schools in the Mopani District. The participants were given time to share their perspectives on how mathematics teachers can be developed in schools.

4.4.3 The Disadvantages of Qualitative Research

Qualitative research also has its disadvantages and for that reason researchers needs to be vigilant when using it. According to Creswell (2015a:5), the expertise of the researchers is given little consideration in favour of the participants' voice. Furthermore, Bell and Waters (2018:26) highlight the disadvantages of the qualitative research as follows:-

- The limited numbers of the participants makes it difficult to generalise the results to the population.
- The results are likely to be affected by the researcher's biasness.
- The process of gaining participants' agreement to participate requires more time.
- Research process can be complex resulting in more time required.

The researcher ensured that the study was free from biasness by making sure that processes such as member checking and prolonged engagement were observed. The participants who were located within a radius of 60 km were selected in order to save time since considerable time was needed for the data collection. The researcher also sought permission from the gatekeepers to avoid the study being delayed.

4.5 RESEARCH DESIGN

Research design deals with the strategies that are used by the researcher in selecting the participants and collecting and analysing data that are intended to answer the research questions (Bertram & Christensen, 2014:40). It is also aimed at assisting researchers to structure qualitative research projects and to understand how they can be carried out (Maree, 2017:72). Researchers like Leedy and Ormrod (2015:271), Cohen et al. (2018:109) and Bertram and Christiansen (2014:40) mention that there are no hard-and-fast rules for qualitative research design and there is no fixed plan that researchers have to follow. Thus, the researcher ensured that the general guidelines provided by educational research handbooks and other theses were followed. The researcher ensured that the study was structured and adopted topics that were suggested by experienced scholars in order to be in alignment with the qualitative approach. Reading of educational research also guided the researcher on how to structure the study within

the parameters of qualitative research; hence, it was crafted differently from quantitative research.

Furthermore, Creswell (2015b:25) explains that when researchers engage in research design, they first identify the research problem and then include other necessary aspects. Bertram and Christensen (2014:40) also mention that research design should comprise descriptions of how data will be collected and the processes that will be used to analyse data. After the researcher has formulated the research problem, various aspects of the study were considered. These aspects included a review of literature; developing the direction of the study by setting out the research questions; describing the research approach; and collecting, analysing and interpreting data. This indicates that this research project followed blueprints that are practical and informed by qualitative research guidelines in order to follow and accomplish the study successfully. According to Leavy (2017:31), researchers must ensure that there is a section that talks about ethical issues from the outset of the development of research topic. The section on ethical issues explained how the participants were protected against ethical issues and the strategies that were used to secure permissions from various settings.

4.5.1 Case Study Design

This study used case study as the research design. Merriam and Tisdell (2016:37) and du Plooy-Celliers et al. (2014:178) indicate that case study deals with detailed description and analysis of a bounded system. The study used a multiple case study. In terms of Cohen et al. (2018:378), a multiple case study involves studying a number of cases. In this study,the use of a multiple case study involves studying principals, teachers and CAs. They mention that this approach is applicable to qualitative research where the researcher collects and analyses data with the intention to search for the meaning and understanding the issue under study. Leedy and Ormrod (2015:271) also indicate that case study research deals with a real-life case or cases for a particular period using detailed multiple methods of data collection. Furthermore, Bertram and Christensen (2014:42) mention that case study is descriptive in nature as it explains what it is like to be in a particular situation and is also used to generate claims about factual information that needs to be proved through research. In case of this study, the cases that were used included mathematics teachers, school principals, and CAs who were responsible for developing mathematics teachers in the GET.

4.5.1.1 Characteristics of case study design

Like other qualitative research approaches, case study research has certain characteristics. Bell and Waters (2018:28) mention that case study approach is suitable for individual researchers as it allows them to investigate an issue in detail. According to them, the researcher has a chance to follow-up on matters that he does not understand and can put flesh on a survey. Cohen et al. (2018: 376) mention that case study deals with real people in a real environment and it can make readers understand the situation better, instead of providing them with an abstract explanation which could confuse them. According to Leedy and Ormrod (2015:170), case study can be used to investigate both simple and more complicated issues occurring at various levels ranging from individual persons to large organisations. In the current study, the researcher worked alone in order to have sufficient time to focus on the participants and to research the problem in full. The researcher believed that the involvement of many researchers could inhibit the purpose of the study since researchers' interests might vary from one researcher to another. Interacting with the individuals in their own environment also allowed the researcher to observe their actions since some participants also used actions while communicating. Since the participants belonged to different categories, the researcher could also compare their responses in order to understand the issue well.

Cohen et al. (2018:376) and Leedy and Ormrod (2015:271) concur that a single case can contain many variables and in order to determine these variables, multiple sources of data collection such as interviews, observations, audio-visual and past records can be used to acquire rich information. Bell and Waters (2018:29) mention that case study commonly uses observations and interviews but also acknowledge that other forms of data collection are important. The current study used interviews to collect data from the participants. The researcher believed that the use of interviews would allow him to obtain more data since he interacted with them face-to-face. The information was collected systematically using an interview guide while interviewing the participants. The use of interviews also allowed the researcher to interrogate the participants in order to provide more information unlike using other forms of data collections.

Terrell (2016:168) mentions that the information collected from various sources is used for data analysis. According to Creswell (2013:99), the process of data analysis in a case focuses on the description of the case which applies to both intrinsic case studies, typically undertaken

to learn about a unique phenomenon, as well as to instrumental case studies where a particular case is studied to gain a broader appreciation of an issue or phenomenon. The researcher used an instrumental case study. Creswell (2013.99) also mentions that specific situations or themes are studied in a case. As a result, the end product contains the description and the themes that have been found by the researcher. The fact that this study involves unique and number of participants means that participants were able to provide multiple realities, experiences and meanings. The researcher made sure that the participants were treated with respect in order to encourage them to share quality information.

4.5.1.2 Advantages of case study research

Case study research has advantages that are appealing to researchers. According to Lune and Berg (2017:180), the advantages of case study are:

- It is powerful because it is can make multiple issues and events easily understood by explaining them in different ways.
- It is able to provide the meaning, situations, and history of the issue under study which is not easy to accomplish with other approaches.
- It is able to capture facts that are typically missed by other approaches as it focuses on the uniqueness of the case.

4.5.1.3 Disadvantages of case study research

Case studies also have disadvantages that researchers need to be aware of as they can hamper the study. Lune and Berg (2017:180) mention that a case study can be problematic because the world is socially constructed. The fact that the world is socially constructed implies that participants can be tempted to provide descriptive information which is irrelevant to the study.

4.6 POPULATION AND SAMPLING

4.6.1 The Sampling Process

Cohen et al.(2018:202) mention that sampling is a process used by researchers to select a number of people from a particular population for study purposes. According to the author (2018:202), a sample comprises a few people representing the entire population. According to Yin (2016:93), sampling involves selection of few number of subjects intended to solve a specific issue in the study. Instead of choosing objects to study, the researcher opted to select people in order to acquire descriptive information (Creswell & Creswell, 2018:151). These participants were selected from the population using snowballing and purposeful sampling on the basis of their expertise, unique knowledge with regard to the issue under study and their teaching experience in their work positions. They were selected before data collection began (Creswell, 2013:98). This current study sampled six mathematics teachers, six principals and two CAs responsible for the development of mathematics teachers in GET. Each group of the participants were chosen to represent the entire population on the basis of their working years' experience and being relevant to this study. The intention of sampling them was to collect data that could answer the research questions.

The researcher sampled only a few participants so that more time could be dedicated to interacting with the participants and reflecting on the research process. The participants who seemed to be relevant, unique and experienced in terms of undesrtanding the issue under study were chosen in order to acquire thick information.

Cohen et al. (2018: 202) indicate that the choice of a sampling strategy is done at an early stage of the study. They mention that sampling is intended to indicate how the researcher plans to select the participants and collect data. Merriam and Tisdell (2016:96) mention that qualitative research means that various locations can be visited to observe and interview people, to observe activities and events and to explore relevant documents. According to them, researchers have the freedom to select the participants whom they want to observe and interview as well as the study sites, the type of data they want collect and the time to interact with them. In the research proposal, the researcher stipulated the type of the participants that would be sampled in the study.

Yin (2016:95), Creswell (2015b:208) and Bertram and Christiansen (2014:63) indicate that in qualitative research there is no predetermined size for a sample because the sites and participants differ from one study to another. According to Bertram and Christiansen (2014:63), the size of the sample and the sites selected depend on the intention of the study and the data collection methods used. Typically, the number of cases studied in qualitative research are fewer than those used in quantitative research (Creswell, 2015b:208). The researcher planned to collect data from few participants belonging to various groups in order to acquire descriptive information and to have sufficient time to interact with them

In qualitative research, cases are selected to represent the population and to provide the thick information and there is no generalisation to the broader population (Yin, 2016:95). Furthermore, sampling is flexible and it allows the researcher to collect data until new themes and topics have emerged (Cohen et al., 2018:386). Leedy and Ormrod (2015:280) also mention that the subjects selected for sampling need should have certain characteristics. This study selected participants according to their job descriptions. The participants included experienced mathematics teachers, school principals, and CAs from different categories. The researcher believed that sampling of cases belonging to various groups would enable him to acquire multiple realities from their own perspectives.

4.6.2 Problems with Sampling

Like other methods in qualitative approach, sampling has shortcomings. Some of the challenges encountered by researchers include failing to choose suitable candidates and the correct number of units of analysis to participate in the study (Yin, 2016:93). To avoid selecting inappropriate participants, the researcher ensured that participants' sampling did not deviate from the plan made in the research proposal. The researcher also made sure that a balanced number of the participants were selected instead of selecting too many participants or too few participants. Too many participants were avoided since it would require more time for collecting and analysing data. Too few participants could also present a challenge in not getting sufficient data to answer the research questions.

4.6.3 Sampling Strategy

4.6.4.1 Purposive sampling

This study used purposive sampling to sample cases and sites. Leavy (2017:79) and Yin (2016:93) mention that purposive sampling is a technique used by the researchers to handpick the best participants who can provide outstanding data to achive the aim of the study. Furthermore, Cohen et al. (2018:218) indicate that purposive sampling involves the selection of participants who have special qualities and knowledge to answer research questions in order to engage them in the study. Lune and Berg (2017:39) also mention that purposive sampling is sometimes done after field investigations have been conducted to add participants who can provide certain characteristics in the study.

In order to obtain thick information about the study, the participants were handpicked from three categories of the population of educators in the Mopani District. The population groups included mathematics teachers, school principals, and CAs responsible for developing mathematics teachers in the GET band. The use of purposive sampling allowed the researcher to select the best participants who were able to provide quality data on the topic under study. They needed to be knowledgeable, committed and have good reputation in terms of their jobs.

4.6.4.2 Snowball sampling

Leavy (2017:80) describes snowball sampling as chain sampling in which the first identified participant refers the researcher to another participant. According to Maree (2017:198) and Cohen et al. (2018:220), this form of sampling is used by researchers to access the population which is difficult to get to and it also used when a researcher wants to use interconnected groups. Creswell (2015b:208) and Lune and Berg (2017:39) add that snowball sampling is also used in circumstances where the researcher struggles to identify the subjects due to the complexity of the phenomenon under study. This study first selected the principals of the schools as the participants. The principals were then requested to identify mathematics teachers who could yield useful data about the study since they knew them better. The researcher opted to use this approach in order to find suitable participants who could provide rich information for the study.

4.6.4 Population

McMillan and Schumacher (2014:5) describe a population as a set of people or events from which a sample is selected and to which the findings can be generalised. The population of this study was selected from principals, mathematics teachers and CAs working within Mopani East District. Mopani East District comprises several circuits which have primary and secondary schools. Mopani East district consists of 302 public primary schools from which the targeted population was selected. For this study, the population was selected from primary schools that were close to the researchers' residential area within a proximity of 60 km to minimise costs. The participating principals in the sudy were sampled from the larger population of principals in the Mopani East district with an enrolment of 500 or more learners, which are regarded as large schools. The reason for selecting primary schools with large enrolments was that they had more information regarding the professional development of teachers, since they have a chance to develop more teachers than smaller schools. In addition to principals, the study also selected Grade 6 mathematics teachers in the GET band with five years or more teaching experience. Moreover, the study also selcted CAs who supervised mathematics in the GET band in the Mopani East district.

4.6.5 Research Sample and Site

The researcher purposefully selected **six principals** with five years or more working experience from schools with a large enrolment in rural public schools in the Mopani East district. Through snowballing, each school principal was requested to identify one Grade 6 mathematics teacher with five years working experience in the GET band from rural public schools. In the selection of the participants, gender equality was taken into consideration. Among the six principals, three were women and the other three were men. The same applied in the selection of the mathematics teachers. In addition, the researcher selected one male and one female CAs (two) who supervised mathematics in the GET band in order to obtain information on how they conducted PD programmes with mathematics teachers and how they supported them. The selection of the participants considered factors such as geography, time and availability. These factors are briefly explained in the sub-sections below.

4.6.6 Geographic Location of the Participants

The researcher planned to conduct the study in the Mopani District in order to understand how mathematics teachers are developed in terms of PD. The Mopani District was also selected in order to understand the challenges encountered in implementing PD by mathematics teachers in rural schools. The researcher selected the participants working within the proximity of 60 kilometres in order to reach them as soon as possible when he wanted to interact with them. This was done in order to save the researcher's time and economise on fuel since the researcher had to collect data from a number of the participants. It also helped the researcher to avert the chance of getting unnecessarily tired. Collecting data from nearby settlements of Mopani District also gave the researcher a chance to complete the study in a stipulated time since it had time frame for completion.

After the researcher had identified the participants, he arranged to meet them in their own environment in order to collect data. The reason for meeting the participants in their natural settings was to acquire detailed information and to understand the study better. The participants were asked questions aimed at answering research questions. They were interrogated so that they could provide their own experiences and meaning about the study as the purpose of the study was to understand the problem better. The participants' responses were not altered with the understanding that a single problem can be interpreted in many ways. The interview questions were phrased in a manner that they could answer the research questions easily.

4.7 DATA COLLECTION

Data collection refers to the special ways used by researchers to gather information available in the environment (Merriam & Tisdell, 2016:108). Creswell and Creswell (2018:185) mention that the procedures of data collection involve setting the boundaries for the study through the use of protocols for recording information during semi-structured interviews and observations. They mention that researchers deliberately choose the environment in which thick information can be accumulated based on the issue under study. According to Creswell (2015b:204), researchers need to get permission before entering the environment planned to collect data; follow ethical considerations while interacting with the participants; and decide the form of information that would be required to answer the research questions. This study used semi-structured interviews to collect data from the participants. The subsequent sub-sections discuss

interviews followed by their benefits, shortcomings, procedures for collecting data and semi-structured interviews.

4.7.1 The Researcher as a Key Instrument

According to Creswell and Creswell (2018:181), qualitative researchers are key instruments in their research; they collect data on their own through interviewing, studying the behaviour of the participants and scrutinising documents. Furthermore, qualitative researchers collect information from the participants through by recording data during the process of the study (Creswell, 2015b:17). The researcher personally selected the participants, and collected and analysed the data.

4.7.2 Piloting

Bell and Waters (2018:222) maintain that interview protocols need to be arranged in time, tested and asking of questions should be piloted before administered to the interviewees. Before the researcher's ethics application was sent to the ethics committee for approval, the researcher constructed the interview protocol (Appendix K) to be assessed by the supervisor. The interview schedule comprised various levels of questions intended to interview the potential participants that would be selected. The supervisor meticulously checked the questions if they were in order, unbiased, unambiguous, and suitable to collect rich and descriptive data from the interviewees.

Three days before the start of real interviews, three friends were interviewed for practice purpose. This practice was in line with Merriam and Tisdell (2016:125) and Leedy and Ormrod (2015: 282) who mention that the best way for the novice researchers to learn to ask questions and probe responses is through participating in pilot interviewing before time. In addition, Yin (2016:144) indicates that mastering of asking questions and probing answers before the actual interviews helps the interviewer to communicate freely with the interviewee. Thus, the researcher ensured that different forms of questioning the participants were practised.

First, the researcher practised asking questions contained in the interview guide in order. The questions were repeatedly asked in order to master the pronunciation and to say them without seeing them and hesitating. While practising, the researcher sought feedback from another

person to adjudicate if it was correctly done or not. If there was no other person to assist, an audio recording was used. This helped to ensure the interview flowed without boring the interviewee or wasting time. The researcher also ensured that questions asking for yes or no answers were avoided.

The researcher also practised probing questions. Various ways of probing such as yes, yes; nodding of head; and how come and so on were practised. However, the researcher ensured that on the actual day they were used sparingly.

Yin (2016:180) also mention that the researcher needs to be certain that at the end of an interview, any recording device would produce quality sound and pictures. The current study used an audio device to record the information provided by the participants. The researcher ensured that issues having potential to hinder quality sound of an audio device were avoided. This was done by studying how the audio device worked or functioned. First, the researcher read the device's manual in order to become acquainted with it. Secondly, the researcher learnt how to operate it practically in terms of recording, pausing, playing the recording, numbering the recordings and transcribing the information. Finally, the researcher recorded himself and replayed the recording to ensure that it was clear.

4.7.3 Interviews

Creswell (2015b:219) mentions that researchers need to identify an interview strategy that would enable them to capture participants' views and to respond to the research question. For that purpose semi-structured interviews were used. Maree (2017:92) indicates that interviews involve two-way communication between the researcher and participant where the participant is asked questions as a means of collecting data in order to understand their views, beliefs, meanings, behaviour and opinions. According to Merriam and Tisdell (2016:108), interviews are the best qualitative approach to collect data and they involve one- on- one conversations in which one person gets information from another one. Yin (2016:142) and Merriam and Tisdell (2016: 93) mention that the purpose of conducting interviews is to understand the world through an eye of the interviewee and it is the best source of data collection if used properly.

The participants were asked to participate in the interviews after they had been sampled. The researcher checked that the venues and times were suitable for respective participants. The

participants were interviewed individually in their own natural settings where they would feel more comfortable in answering questions. The stance of the researcher was to observe the behaviour of the participants, listen, and record their responses. The participants answered questions using their own words while the researcher was listening, taking notes, and recording the interview. The researcher also took note of the participants' descriptions, their reasons for their opinions and how they shared experiences. The researcher observed their behaviour in order to understand the interaction better (Yin, 2016:142).

4.7.3.1 Advantages and disadvantages of interviews

Qualitative research interviews have strengths that help them user-friendly to the researchers. According to Creswell (2015b: 216), the advantages of interviews involve the followings:-

- They provide thick and detailed information without observing the participants directly.
- They allow the participants to provide detailed information about the issue under study.
- The interviewer determines the type of information required from the interviewee by asking questions that relate to the study.

In addition, Bertram and Christensen (2014:83) mention that interviews are good because they:

- allow the researchers to ask questions directly to the participants and to clarify them if necessary which is not possible when using written questionnaires.
- permit researchers to follow up or ask additional questions on responses that need clarification.
- make it easier for the interviewees to respond to the interviewers through talking rather than writing long responses to the questionnaires.
- allow interviewers to acquire rich and descriptive data which is not always possible with written questionnaires.
- allow the interviewing of small numbers of participants to provide data.

The fact that researchers can decide and construct the type of questions that want to ask participants guided the researcher to construct the questions that were in line with the research questions. The questions were formulated to address various categories of participants in order to obtain varied information.

Qualitative research interviews also have drawbacks which can hamper the fruitful collection of data if interviewers are not careful of them. Creswell (2015b:217) explains that interviews may have the following weaknesses:

- The interviews contain information that is screened or sifted by the interviewers.
- The interviews may be unreliable as the interviewees provide information that they wish to share.
- The responses provided by the interviewees are likely to be affected by the presence of the interviewer.
- The outcome of the interviews may be vague and not insightful.
- The instruments to be used in the interviews maybe problematic.

4.7.2.1 The interview process

Leavy (2017: 139) and Yin (2016:142) mention that interviews are inductive or open-ended in a sense that the participants can use their own language; talk for a long time and describe their situaton as much as they can; and they can direct the conversation while responding to the questions. To persuade the participants sharing more information, the researcher used an interview guide (Appendix K) with pre-planned questions to probe in a way they would be hard-pressed to clarify and expand their explanations (Howitt and Crammer, 2017:384). The participants were asked open-ended questions so that they can express themselves as much as possible. Each question had a space for writing comments during the interview process. During interview sessions, the participants were given more time to speak than the researcher in order to acquire as much information as possible. Responses that were deemed shallow were probed to encourage the participants to clarify them. According to McMillan and Schumacher (2014:355), participants should be interviewed in their own language rather than a foreign language. The researcher allowed the participants to express themselves in their own language in order to express their thoughts freely. In case some participants preferred to be interviewed

in their own language other than English such responses were converted in English. The participants were thus allowed to share information in their own language in case they were not comfortable speaking in English. This was basically to encourage the participants to divulge as much information as they could since the purpose of the interview was to get the viewpoints of the participants. During the interview sessions, the researcher ensured that all the information was audio recorded and supplemented this with hand-written notes.

Yin (2016:147) advises researchers to be tactical when they start conducting their interviews by not starting them haphazardly. Merriam and Tisdell (2016; 127) suggest that researchers should start their interviews slowly and that participants be asked descriptive questions about themselves and the events based on the issue under study.

Howitt and Crammer (2017:385) caution researchers to be mindful when choosing settings to interview the participants as each one is different. Some information needs to be collected in private while other information can be collected in public. Furthermore, Leavy (2017:140) shows that qualitative research interviews rely on building good relationships with the participants by listening to them while speaking; paying attention and maintaining eye contact and probing them to show that their information is valued. In this study, the participants were given latitude to choose the time and place that they would prefer to be interviewed in order to share the information freely. Communicating the arrangements regarding the venue helped the researcher to accommodate the participants' needs as failure to do this could negatively affect the researcher- participant relationship. Good relationships with the participants were also developed by ensuring that, during the interview sessions, the researcher was an active listener; did not interrupt the participants; and probed some of the answers to show that he was listening and valuing the information provided.

To ensure that the information collected from the participants was credible and trustworthy, the researcher frequently interacted with them to verify his understanding. If the information was interpreted incorrectly, it was corrected. The researcher was also transparent to the participants so that they would freely provide information without any intimidation. According to Creswell and Creswell (2018:190), during interview process the information is recorded using instruments such as audiotaping, videotaping, and handwritten notes. Permission must be sought from the particpants before any recordings are done.

All the information enquired from the interviewees was recorded. Merriam and Tisdell (2016:131) mention that the most common way of recording interview data is audio recording, notes taking and sometimes video recordings are used. Before the researcher used recording devices, he first asked permission from the participants. If the participants did not have any objection, the devices were positioned accordingly and turned on to record the interview session. The researcher ensured that all the instruments were used properly so that they could capture all provided data. Merriam and Tisdell (2016:131) also mention that the use of video recording is useful in recording interviews as it is able to capture nonverbal behaviour but it is very difficult to use.

The audio-recording of information assisted the researcher to remember the information provided by the participants and not misinterpreting them. Furthermore, the researcher communicated bias issues within the study. Leedy and Ormrod (2015:106) insist that researchers should desist from claiming that their studies are impartial instead they must explain believes that can have potential to lead the study to be bias. The researcher communicated past experiences, believes and attitudes that shaped the findings. Lastly, the researcher ensured that the transcripts did not contain obvious mistakes (Creswell & Creswell, 2018:202). After transcribing data, the researcher ensured that all transcripts were read meticulously in order to correct any error existing within them.

The subsequent sub-paragraph discusses in-depth semi-structured interviews.

4.7.2.2 In-depth semi-structured interviews

Merriam and Tisdell (2016:110) and Lune and Berg (2017:69) mention that semi-structured interviews are open-ended, less structured in nature and operate in the middle of between structured and unstructured interviews. McMillan and Schumacher (2014:381) also mention that this form of interview is flexible and uses open-response questions to acquire information on respondents' meaning; how the respondents view the world and make sense of their lives. Furthermore, Leavy (2017:139) mentions that the questions asked in semi-structured interviews do not have predetermined responses such as yes or no. Hesse-Biber (2017:152) indicates that participants have information and knowledge that researchers might not have anticipated.

Furthermore, this form of interview permits researchers to use follow-up questions or probes on the responses of the participants (Flick 2018:233). Merriam and Tisdell (2016:111) mention that researchers can respond to the responses of the respondents in case of the emerging of new themes and ideas on the issue. In addition, Lune and Berg (2017:70) highlight that researchers can probe the responses to the prepared questions in order to elicit additional information by asking questions such as "could you tell me more about that?" In the current study, the researcher used words such as "I have heard you saying words such as these. Can you explain more?" The researcher asked such questions to encourage the participants to share additional information. Probing was also used if the researcher found emerging new ideas, themes and when he wanted clarity on certain responses. The researcher interrogated the participants in order obtain quality information until a point of data saturation was reached.

The researcher was also neutral in the sense that aspects such as researcher's biasness, preferences, body language and expression were avoided as these may confuse the participants (Yin, 2016:146). Merriam and Tisdell (2016:129) acknowledge that interviewer-respondent interaction is a complicated issue but state that it must be well managed.

At the end of an interview session, the researcher thanked the interviewees, reassuring them the confidentiality of their data and asked them if they had any concluding words (Yin, 2016:147).

4.8 DATA ANALYSIS

This study used qualitative data analysis to analyse data collected from the participants. McMillan and Schumacher (2014:395) mention that qualitative data analysis is an inductive process that focuses on the arrangement of data into categories and scrutinises the relationships between the categories. Merriam and Tisdell (2016:195) state that data qualitative analysis involves interpreting the data. According to Maree (2017:109) and Creswell (2015b:237), data analysis is conducted either during data collection or after the researcher has completed collecting the data. Data analysis in this study was done after the data collection had been completed.

After the researcher had collected data, he transcribed the interviews verbatim in order to perform data analysis. In order to speed up the transcription process, the researcher used an

instrument that was able to play back, fast-forward, wind back, and pause the recording. The information was coded and similar information was arranged into categories. The researcher tried to search for specific meanings and perspectives from the participants' responses. The researcher repeatedly read data and analysed them in order to gain insight and understand the study better (Creswell, 2015b:237). Furthermore, the researcher also made sense out data in order to get the interpretation of the study. The researcher frequently moved back and forth through their field notes and transcriptions to determine if the data were accurate (Creswell, 2015b:237). If gaps were found, the researcher requested permission from the participants to recollect additional information. The researcher also verified from the participants if information provided was in order or not. All information not in order was corrected.

Creswell and Creswell (2018:95) state that researchers should avoid reporting information that supports their personal bias but must also include information that refutes such bias. The researcher included all the challenges encountered and how were they addressed. The reason for doing this was to increase the trustworthiness of the study. Bertram and Christiansen (2014:116) mention that data provided by the participants are voluminous so researchers need to compress the information to make data analysis manageable. The current study compressed data by organising and coding them, and created themes from the similar codes and categories. The researcher examined the data provided by school principals and the CAs in order to determine how they involved mathematics teachers in the PD of Mathematics.

Furthermore, McMillan and Schumacher (2014:395) indicate that there is no predetermined procedure in conducting data analysis. However, this study followed the steps proposed by Creswell and Creswell (2018:193) and Creswell (2015b:237) to analyse data. The steps include organising data, transcribing data, coding data, generating themes and detecting patterns. The researcher ensured that all collected data were transcribed to become useable information. The data were summarised and organised in computer files in order to be easily found when needed. The information was coded and similar information was grouped together to create themes and sub-themes. Although themes and codes differed in terms of number of words, most of them contained between two and four words. The researcher also studied patterns and the relationships existing between codes and themes in order to assign meanings.

4.9 TRUSTWORTHINESS OF THE STUDY

Creswell and Creswell (2018:199) use the concepts validity and reliability to denote trustworthiness. Bell and Waters (2018:140) mention that trustworthiness is a degree in which similar results are found if a test or procedure is administered under constant situation in subsequent situations. Researchers are advised to check the reliability and validity of their studies (Creswell & Creswell, 2018:199).

According to McMillan and Schumacher (2014:114), trustworthiness refers to the way in which the researcher reflects on the data collected and findings to examine if they are reasonable, accurate, and credible through the use of certain procedures. In order to ensure that this study was trustworthy, the researcher used various strategies.

First, the researcher used member checking to validate the information provided by the participants. Creswell (2013:252) mentions that before the information is returned to the participants to check accuracy, the researcher first collects the data, interprets them, and then draws conclusions. Leedy and Ormrod (2015:106) indicate that the researcher takes the polished or semi-polished data back to the participants to be verified. The researcher checked his understanding during the interviews in cases where the participants provided unclear responses. The participants were probed to explain in detail and to check if the provided statements were correct or not. The participants were also contacted after the completion of the data analysis in order to check if the information provided had been well-interpreted or not. The researcher allowed the participants to go through the draft notes and make changes where necessary.

The researcher also provided a thick, rich explanation of the data. According to Creswell and Creswell (2018:199), rich, thick description provides readers with the audit trail that led the researcher to the findings. The researcher shared detailed information about the participants and the environment in which the interviews were conducted in order to make readers understand the findings better. Furthermore, prolonged engagement with the participants was used during data collection. Merriam and Tisdell (2016:246) explain that the researcher gets closer to the participants for particular period in order to accumulate as much information as possible about the phenomenon under study. Ongoing observations and prolonged engagement focused on building rapport with the participants; investigating themes that were unclear and to ensure data saturation on the topic under study.

4.10 ETHICAL CONSIDERATIONS

The researcher ensured that the study met and satisfied all ethical requirements since it used humans as the subject of the study. The forthcoming paragraphs will provide a detailed explanation of the strategies used by the researcher to meet the ethical issues as required by the university.

4.10.1 Ethical Clearance

Before researchers engage in actual research, approval is required from various gatekeepers in order to access settings and study the participants (Creswell & Creswell, 2018:92). The researcher first obtained ethical clearance from the Unisa Ethics Committee (Appendix B). He needed to provide evidence of his registration (Appendix A). The researcher then wrote letters to the various people in authority such as the Limpopo Department of Education (Appendix C), in order to request permission to access their sites and study the participants before interviews commenced. The letters stated the reason for requesting permission as well as the dates and times the researcher intended to visit the sites.

4.10.2 Informed Consent

The researcher also used various ethical standards to ensure that the study followed appropriate procedures. Firstly, the principle of informed consent was considered. According to Creswell and Creswell (2018:93), researchers have an obligation to disclose the information about the purpose of the study; not enforcing the participant to participate in the study and to sign informed consent. Thus, before the researcher started collecting data, the participants were requested to complete informed consent form that contained issues pertaining the nature of the study, procedures, possible benefits and any anticipated risks.

According Leavy (2017:36), informed consent is administered to the participants before the beginning of the research and it contains their rights (Appendix G, H, I and J). Leedy and Ormrod (2015:121) maintain that when participants are recruited for a study, they should be informed about the nature of the study so that they can make an informed decision about their participation. The researcher explained the type of the study to the participants. The

information that was communicated to participants included the focus of the study; time that would be spent during data collection; particulars of the researcher and the supervisors; the procedures for conducting the interview; potential risks and the benefits of the study and confidentiality of their information. Participants were also informed that participation was voluntary and that they could withdraw from the study at any time they wish to do so without any penalty.

The principle of confidentiality and anonymity was also considered. Cohen et al. (2018:130), mention that the principle of confidentiality means not divulging the information of the participants by the researchers who are also directed to be honest with their participants. The researcher ensured that the names of the participants and other information that might reveal the identity of the participants were concealed. The researcher also avoided discussing any information regarding the participants in the public. The participants who were described in the study were given pseudonyms so that readers were not able to identify their names. The researcher ensured that the audiotapes containing participants' information were destroyed after being transcribed. The interview transcripts were kept safe in a locked place by the researcher for five years and after that they would be destroyed.

The researcher ensured that the principle of privacy was respected. According to Cohen et al. (2018:128), privacy involves various aspects such as data and their collection, the way questions are asked, reporting and distribution as these present many possibilities for researchers to invade participants' privacy. Leedy and Ormrod (2015:123) mention that participants' privacy should be respected when dealing with human research. They mention that participants of particular gender or background could become irritated when asked questions that concern their privacy. The researcher avoided asking questions that were personal to the participants as they might infringe their rights and invade their privacy.

The researcher respect the sites of the participants as much as possible (Creswell & Creswell, 2018:93). Before the interviews, the participants were contacted respectively to arrange suitable times and venues for conducting interviews. The arrangements were scheduled outside school workings hours not to disturb the smooth running of the schools or their workplaces. The researcher did so in order to be sure about the venue and time preferred by the participants. The researcher created a good relationship with the participants; avoided using disrespectful and harmful words; listened to the participants when sharing information; was genuine and

asked questions where necessary to show that the researcher was interested in their perspectives.

The researcher also ensured that the findings were correctly reported. According to Creswell (2015b: 24), reports which are designed to favour the aspirations of the researchers should be avoided as they are deceitful to the readers. The researcher ensured that the findings were not altered to appeal to the readers as this was against research ethics principles.

Lastly, the researcher avoided plagiarism. Creswell (2015b:24) indicates that plagiarism of other scholars should be avoided and the use of their information must be given credit. The researcher made sure that all the information cited from other scholars was cited by indicating the author, date of publication and acknowledged in the reference list. Acknowledgement of other scholars' work was made to make the study acceptable to the readers.

4.11 CHAPTER SUMMARY

This chapter discussed the methodology that was used in this study. It discussed the research paradigm including its elements which are ontology, epistemology, and methodology. It further discussed the qualitative research approach together with its drawbacks and advantages. It also discussed the pilot study, the data collection method, namely, semi-structured interviews, and the data collection process. The other aspects that were discussed in this study involved the research design, sampling; data analysis; trustworthiness and ethical considerations. The next chapter, Chapter 5, presents the data and data analysis.

CHAPTER 5
DATA PRESENTATION AND ANALYSIS

5.1 INTRODUCTION

This chapter presents the data collected through interviews with mathematics teachers, school principals, and mathematics CAs. The available literature suggests that teachers in schools are challenged by the lack of support and resources. These, according to the literature, negatively affect teachers when it comes to implementing the PD programmes due to the lack of required support. The rationale for collecting data was to acquire responses from the participants to explore the role of teacher PD in the improvement of mathematics achievement in rural schools. The researcher also wanted to understand the challenges that can hinder mathematics teachers from participating in PD; the strategies that can be used to inspire mathematics teachers to engage in PD; teachers' capabilities acquired during their participation in PD programmes, and how PD contributes to the performance of learners. This chapter also presents the biographical information of teachers who participated in this study in order to understand the category of teachers existing in the rural schools in the Mopani District.

The first five themes originated from the research questions while the last two themes were emergent and were produced from the participants further interactions with the researcher through follow-up questioning and probing.

- How teachers' PD enhances knowledge about teaching of mathematics.
- The challenges hindering the PD of teachers in rural public schools.
- How mathematics teachers can be inspired to engage in PD.
- How the PD of teachers can contribute to the improvement of learners achievement in mathematics.
- The capabilities that teachers can acquire during their participation in PD.
- The strategies that can be used to curb problems in PD implementation.
- Teachers' recommendations on how they can engage in PD in mathematics.

Each theme is accompanied by a number of sub-themes which are discussed to make information comprehensible and to provide detailed information to the readers. The forthcoming section presents a reflection on the data collection process and analysis.

5.2 REFLECTION ON DATA COLLECTION PROCESS AND ANALYSIS

5.2.1 Data Collection Process

In this study, data were collected through qualitative semi-structured interviews. Prior to conducting interviews, the researcher arranged with the participants to decide on suitable venues and times for conducting the interviews. Most of the participants indicated that they would like to be interviewed after work hours at their own workplaces. Following their responses, the researcher asked for permission from the school principals and the circuit manager in order to access them.

The researcher initially piloted the interview protocol using a selected small sample of principals, CA, and teachers. The selected participants who took part in the pilot study were not those who participated in the main study. The researcher also practised operating a voice recorder to avoid failures during the interviews.

On the actual day of the interviews, the researcher also phoned the participants to check whether they were still ready for the interviews or not. Those who were ready agreed and the researcher went to interview them. Some of them postponed their appointments due to emergency personal commitments but they were later interviewed while few of them withdrew their agreement to participate in the interviews. They were then replaced with other suitable participants.

Leavy (2017:36) mentions that informed consent forms should be administered to the participants before the start of the interviews. Thus, the researcher presented and read consent forms to the participants (Appendix J). They were informed that participation in the study was voluntary and that they could terminate their participation at any time during the study without any penalty. They were also told that their names would be kept secret to protect their identities. The researcher also sought permissions to record them during interviews and they all agreed to be recorded.

When it came to responding to the interview questions, school principals and CAs could answer the questions with ease but with teachers it was different. Most of them had rich information but they struggled to share it in English until the researcher requested them to speak in their own home language and that helped them to answer the questions well. Data were collected and analysed concurrently. Data was analysed immediately after collection while it was still fresh. The researcher also conducted member checking to validate the information. Semi-polished information was taken to the participants to check whether the information provided was correct or not. All the participants agreed that the information they had provided was correctly transcribed.

5.2.2 Data Analysis Process

As indicated, the study used qualitative analysis to analyse data that were personally collected from the participants. According to Leedy and Ormrod (2015:215), qualitative analysis involves interpretative view in which the researcher examines data in order to find the meanings and the perspectives from the participants by considering their attitude and perceptions. During data analysis, the researcher considered participants' perceptions and actions to interpret data. The process was also inductive whereby data were collected from the participants until a point of data saturation was reached. "Data saturation is the point in a research process where enough data has been collected to draw necessary conclusions, and any further data collection will not produce value-added insights" (Quantilope, 2022). The study used the steps proposed by Creswell and Creswell (2018:193) and Creswell (2015b:237) to analyse and interpret data which include organising data, transcribing data, coding data, generating themes, and patterns.

5.2.2.1 Organising data

Before data were analysed, they were first arranged in file folders on the computer. They were organised into chunks that could be easily read while analysing the study. The researcher also kept the copy of information in separate files in case the computer became corrupted.

5.2.2.2 Transcribing data

The information that was collected from the participants through semi-structured interviews was transcribed from voice to text documents. The data were retrieved from the voice recorder and field notes that were used during the interviews. The transcripts were then typed and saved on the computer. The information was arranged in five columns that included questions and sub-questions, responses, segments, comments, themes and sub-themes.

5.2.2.3 Coding data

According to Creswell (2015b:242), coding involves segmenting and arranging data in order to form themes. The information typed under responses was read repeatedly in order to make sense out of it. Thereafter, the researcher highlighted or coloured the information that related to the sub-research questions. Information that was irrelevant to the study was ignored. Similar information was highlighted with similar colours and was segmented in two to six words segments which were placed under the segments column. Comments were also written in the relevant columns.

5.2.2.4 Generating themes, and patterns.

After the information was coded or categorised into similar information, themes were generated according to the information that directly answered the research questions. The researcher also studied the patterns and the relationships existing between codes and themes to assign meanings. Five themes emerged from data collected through the main research question and sub-questions and an additional two emerged as cross themes, making a total of seven themes. These themes were aligned to the research questions which are as follows:

- How can teachers' PD enhance knowledge about teaching of mathematics?
- What are the challenges hindering the PD of teachers in rural public schools?
- How can mathematics teachers be inspired to engage in PD?
- How does the PD of teachers contribute to the improvement of learners' achievement in mathematics?
- What capabilities do teachers acquire during their participation in PD?

- What are the strategies that can be used to curb problems in PD implementation?
- What are teachers' recommendations on how they can engage in PD in mathematics?

5.3 BIOGRAPHICAL INFORMATION OF THE TEACHERS

The biographical information of the teachers included gender, the year when they started teaching, age, subject specialisations, professional qualifications, additional qualifications awarded to the teacher, and enjoyment in teaching the subject. There were six teachers who are identified as teacher 1, 2, 3, 4, 5, and 6. Their information is depicted in the table below.

Table 5.1: Biographical information of the teachers participated in the study

ITEM	TEACHER 1	TEACHER 2	TEACHER 3	TEACHER 4	TEACHER 5	TEACHER 6
Gender	Female	Female	Female	Male	Male	Male
Year started teaching	2014	1997	2008	2012	1989	1995
Age	54	48	53	37	56	52
Subject specialisations.	Mathematics English Natural sciences and Life orientation	English Xitsonga Geography and Biology	Life Orientation Natural Sciences Social Sciences and English	Mathematics and physical Sciences	Mathematics and Geography	Mathematics and Physical Sciences
Professional qualifications	National Professional Diploma in Education (NPDE)	Senior Primary Teachers' Diploma	National Professional Diploma in education	Senior Primary Teachers' Diploma	Secondary Teachers' Diploma	Senior Secondary Diploma
Award of additional qualifications to the teacher.	Yes	Yes	Yes	No	Yes	Yes

ITEM	TEACHER 1	TEACHER 2	TEACHER 3	TEACHER 4	TEACHER 5	TEACHER 6
Additional qualifications awarded to the teacher.	ACE in Life orientation	• Further Diploma In Education Management • B.TechEducational Management • Certificate in Theology	• Advanced Certificate in Life orientation • Adult Basic Education and Training Certificate • Adult Basic Education and Training Diploma	None	• Advance Certificate in Education • Bachelor of Arts in Education	Adult Basic Education and Training Certificate
Enjoyment in teaching mathematics.	The teacher enjoys teaching mathematics. She likes teaching learners at school and assists community	The teacher is content in teaching mathematics. She likes using concrete objects and other resources to teach the subject. She also applies group teaching in order to assist slow learners.	The teacher likes teaching mathematics because her learners pass it very well. They understand her teaching style and	The teacher likes teaching mathematics because it is easy and simple to teach.	The teacher enjoys teaching mathematics. He likes teaching shapes since they are found everywhere.	The teacher enjoys teaching mathematics because it involves counting of objects.

ITEM	TEACHER 1	TEACHER 2	TEACHER 3	TEACHER 4	TEACHER 5	TEACHER 6
	members who need help in the subject.		enjoy interacting with her.			

All teachers interviewed in this study were teaching mathematics in rural public primary schools in the Mopani District of Limpopo Province. Teacher 1, 2 and 3 were women and were aged between 47 and 54. Teacher 4, 5 and 6 were men and both teacher 4 and 6 were over 51 years of age while teacher 5 was younger than 40 years. The indication is that all the teachers except teacher 5 were all old and they would leave the system within a few years. Only teacher 5 was still young and had some more years to work as a teacher and to improve his qualifications. This implies that the DBE should start training additional mathematics teachers in time to curb the shortage of teachers in the subject when the available teachers go on retirement.

Teacher 1, 4, 5, and 6 had mathematics as one of their major subjects meaning that they were qualified to teach mathematics. Teachers 2 and 3 did not have mathematics as a teaching subject meaning that they were not qualified to teach mathematics. This indicates that some teachers teach mathematics without the proper qualifications and this might contribute to the poor performance of learners in mathematics. It can also be deduced that currently there is a shortage of mathematics teachers in rural schools of Mopani District since teachers who specialised in other subjects were allocated mathematics as a teaching subject. All teachers teaching mathematics except Teacher 5 had furthered their studies with various institutions but none of them furthered their studies in mathematics. This suggests that teachers who teach mathematics in rural schools of Mopani District are reluctant to further their studies in mathematics. Instead they improve themselves in subjects that seem easy to them rather than in mathematics. It can also be deduced that they improve their qualifications in order to get cash bonuses instead of adding value to their teaching subjects. Teacher 5 did not bother to improve his qualifications. It could be concluded that he lacks interest to study. It can also be concluded that he was not efficient in teaching the subject when it comes to the issues such as assessments and methodologies since he was reluctant to study.

In terms of enjoyment in teaching mathematics, all of them seemed enjoy teaching the subject although their reasons differed. Their reasons included that mathematics is very simple to teach; the use of concrete objects and resources helped slow learners to understand the subject better; learners understood the subject better than other subjects and most topics were taught using shapes which are found everywhere. This indicates that most of the teachers liked teaching mathematics. It can be concluded that they attended their periods well and supported

their learners if they encountered challenges in the subject. It can also be concluded that their learners enjoyed learning and understood the subject well.

Furthermore, Teachers 4 and 6 had a Secondary Teachers Diploma. This suggests that they may be having a challenge in delivering subject content and teaching methodology to the learners in primary schools since they had been trained to teach secondary school learners. It can also be concluded that some learners struggled to understand their lessons well due to the level of training teachers had received from TEIs.

5.4 RESEARCH QUESTIONS AND THEMES

The information collected was analysed based on the research questions, themes, and sub-themes as shown in Table 5.2.

Table 5.2: Research questions, themes and sub-themes of the study

Research questions	Themes	Sub-themes
1. How can teachers' PD enhance knowledge about teaching of mathematics?	**Theme 1: How teachers' PD enhance knowledge about teaching of mathematics**	**1.1. Teachers** 1.1.1. Strategies that mathematics teachers engage in to improve their qualifications. 1.1.2. Strategies that teachers believe can assist them to develop their profession. **1.2. Principals** 1.2.1. Strategies that principals use to develop teachers in their profession. 1.2.2. How principals manage PD in schools. **1.3. Curriculum advisors** 1.3.1. Activities that CAs do to develop teachers in schools. 1.3.2. Advices that CAs give teachers to implement PD. 1.3.3. How CAs interact with teachers during PD. 1.3.4. Strategies used by CAs to improve the qualifications of mathematics teachers
2. What are the challenges hindering PD of teachers in rural public schools?	**Theme2: The challenges hindering the PD of teachers in rural public schools**	**2.1. Teachers** 2.1.1. Challenges that teachers experience when participating in PD in mathematics. 2.1.2. Challenges encountered by teachers when implementing PD in schools. **2.2. Principals** 2.2.1. Challenges encountered by principals when teachers implementing PD. **2.3. Curriculum advisors**

Research questions	Themes	Sub-themes
		2.3.1. Challenges encountered by CAs when implementing PD in schools. **2.3.2.** Challenges encountered by CAs when implementing PD in the district
3. How can mathematics teachers be inspired to engage in PD?	**Theme 3: How mathematics teachers can be inspired to engage in PD**	**3.1. Teachers** Strategies that can be used to inspire teachers to participate in PD. **3.2. Principals** 3.2.1. How principals inspire mathematics to participate in PD. **3.3. Curriculum advisors** **3.3.1.** How CAs encourage teachers to participate in their PD programmes**.**
4. How does the PD of teachers contribute to the improvement of learners' achievement in mathematics?	**Theme 4: How the PD of teachers can contribute to the improvement of learners achievement in mathematics**	**4.1. Principals** 4.1.1. The value added by PD to the performance of learners in mathematics**.** **4.2. Curriculum advisors** 4.2.1. How PD of teachers contribute to the performance of learners in mathematics.
5. What capabilities do teachers acquire during their participation in PD?	**Theme 5: The capabilities that teachers acquire during their participation in PD**	**5.1 Principals** **5.2 Curriculum advisors**
6. What are the strategies that can be used to curb problems	**Theme 6: The strategies that can be used to curb**	**6.1 Principals** 6.1.1. Strategies that can be used to curb problems in PD implementation.

Research questions	Themes	Sub-themes
in PD implementation?	**problems in PD implementation**	
7. What are the teachers' recommendations on how they can engage in PD in mathematics?	**Theme7: Teachers recommendations on how they can engage in PD in mathematics**	**7.1 Teachers** 7.1.1 Teachers' recommendations on how they engage in their PD in mathematics. **7.2 Principals** 7.2.1 Principals 'recommendations on how mathematics teachers can improve their subject. **7.3 Curriculum advisors** 7.3.1 Curriculum advisors 'recommendation on further developing teachers in mathematics.

5.5 DISCUSSION OF FINDINGS ACCORDING TO THE THEMES

The following sections discuss the themes and sub-themes regarding the implications for PD of teachers with the intention of improving mathematics in rural public schools of Mopani District. The findings of the study regarding teachers' improvement of mathematics achievement in rural schools of Mopani District generated themes, which readily aligned to the research questions. These themes are:

- how teachers enhance their qualifications in terms of PD in mathematics;
- the challenges that teachers experience when participating in PD in mathematics;
- how mathematics teachers are inspired to engage in PD;
- how PD of teachers contributes to the performance of learners; and
- teachers' capabilities acquired during their participation in PD programmes.

In addition to these themes, the study generated new and emergent themes, which were produced from the interaction of the participants with the research questions as well as the researchers' probing and follow-up. The emerging themes are:

- the strategies that can be used to curb problems in professional development implementation; and
- recommendations on how teachers can engage in PD in mathematics.

These emergent themes provide new literature related to the topic in the field of PD. The findings contributed by teachers, principals, and CAs are discussed systematically one after another.

This section focuses on the interpretations of the findings regarding their meanings. The interpretations of the findings will involve the researcher's own perception of reality in relations to the findings coupled with substantiation from literature as discussed in Chapter 2.

5.5.1 Theme 1: How Teachers' Professional Development Enhance Knowledge about teaching of Mathematics

5.5.1.1 Teachers

These sub-themes emerged from the teachers verbal statements obtained through interviews. The interview transcripts were analysed through inductive analysis to provide the sub-themes discussed below.

- *The strategies that mathematics teachers engage in to improve their qualifications*

The study indicated that mathematics teachers use various strategies to improve their qualifications. The strategies include enrolling studies with accredited institutions; attending workshops, and attending subject meetings.

- *Enrolling studies with accredited institutions*

Enrolling in studies with accredited institutions was revealed as one of the strategies that mathematics teachers used to enhance their qualifications. The findings of this study appears that most teachers enrol with universities around the the country. Most of the teachers mentioned that they enrolled with universities such as UNISA to acquire more skills and competencies in the subject. According to the teachers, they enrolled for short and long courses in mathematics in the form of certificate and diploma programmes.
Teacher 6:

> *I need to enrol for short and long courses in mathematics in order to become knowledgeable in the subject. Teachers who do not further their studies are shallow minded and they do not provide quality information to their learners.*

Another teacher indicated that some teachers opted to enrol for Bachelor of Science in Mathematics instead of enrolling for general qualifications such as Bachelor of Science in Education. According to some teachers, when they registered for the courses, they acquired more information and skills in relations to mathematics.

Teacher 3:

I will further my studies by registering Bachelor of Science in Mathematics. When you do Bachelor of Science is not the same like when you do Bachelor of Science in Education.

Most of the teachers indicated that they had registered for courses that offer certificates, diploma, and degrees in mathematics.

Teacher 5:

> *I can enrol for short and long courses such as advance certificates, diploma, and degrees in mathematics with higher institutions. This will help me learning new things that I do not know since things keeps on changing.*

It seems that enrolling to study with institutions of higher learning by educators is regarded as an avenue that may improve their knowledge of the mathematics subject. The finding is supported by Maass et al. (2017:10) who indicated that when mathematics teachers engage in these programmes, they become more proficient in the subject. The idea is that when teachers enrol with institutions of higher education, they acquire thick information with regard to their teaching subjects, and this helps them to teach learners effectively.

- *Attending workshops*

Attending workshops was another strategy used by mathematics teachers to improve their qualifications. According to most of the teachers, they attended workshops at circuit and district level and this helped them to gain knowledge in aspects that challenge them. Some teachers indicated that the workshops help them to solve problems such as subject content and classroom practices.

Teacher 6:

> *When we attend departmental workshops, we gain knowledge in aspects such as subject content and classroom practices which are challenges to most of us.*

Some teachers also declared that when they were supposed to attend workshops, principals should inform them in time so that they could have time to make arrangements. They further mentioned that they should be provided with money for transport since their schools were far from the workshop venues.

Teacher 4:

> *When there are workshops, principals should inform us in time so that we can arrange ourselves in time. It is very disturbing to be told about the meeting on a day of attending the meeting while having some plans to do. It is like we are not professionals and this should be avoided by all costs.*

This shows shows that when teachers attended the workshops, they improved their profession in the areas that were troubling them. The finding also suggests that when there are workshops, principals should inform them in time so that they could organise themselves in time and the school should transport them not to use their own money. This finding is aligned to Shabani's (2016:6) training model underpinned by Vygotsky's theory which denotes that teachers should be given training that develops them on the issues that involve their profession. Furthermore, Adedeji (2018:317) mentions that teachers should always receive training and retraining programmes in order to help them master their teaching of mathematics curriculum in schools.

- *Attending subject meetings*

Attending subject meetings emerged as another strategy used by teachers to improve their qualifications. One of the teachers mentioned that they attended subject meetings when organised by the schools. These subject meetings were organised by their immediate seniors who supervise the teaching subjects. Some teachers also indicated that they attended group discussions in order to acquire new skills with regard to the techniques of teaching mathematics..

Teacher 4*:*

> *I will attend subject meetings organised at school level. When we attend them, they help us to understand the subject better because we get time to share information*

regarding the subject. We also get time to ask questions if we are not sure about some procedures.

Teacher 6:

I also attend teachers' group discussions in order to acquire new skills regarding teaching mathematics. They are very effective because they involve various capable people coming from different schools

This suggests that when teachers attended subject meetings, they had the opportunity to share knowledge and skills regarding the subject in aspects such as teaching methodologies, setting of formal assessment tasks and lesson preparation. It also suggests that teachers who struggled in the subject were helped with the issues that challenged them. African et al. (2018: 102), who indicated that mathematics teachers should engage in CPD in order to acquire multiple approaches to teaching learners and craft subject lesson plans instead of using a single approach, supports the finding

- *Strategies that teachers believe can assist them in developing their profession.*

It was found that various strategies could be used to develop teachers in their profession. Those strategies included attending PD programmes; regular practice of mathematical problems; participation in professional bodies, and enrolling with institutions of higher education.

- *Attending PD programmes*

Attending PD programmes by teachers was another strategy that could assist to develop them in the profession. According to one of the teachers, the DBE invited them to the PD programmes that had a bearing on improving their profession in terms of classroom practices. The teacher also indicated that at school level, they could also be developed during staff meetings where they received feedback from the departmental meetings. The teacher further indicated that they are trained to use modern resources to meet the needs of twenty-first century skills since some resources required training.

Teacher 1*:*

> *Our immediate seniors invite us to the subject meetings where they guide us using things like teaching the subject and setting questions. They also help us to understand the subject policies since they are very difficult to understand.*

Teacher 3*:*

> *During subject meetings, teachers who attended departmental workshops report to us the information they accumulated from the workshops. Our immediate seniors also encourage us to use teaching resources while teaching to help learners understand topics.*

The finding suggests that the DBE was taking a frontline role in providing teacher PD. This was evident in teachers' comments regarding the DBE invitations for teachers to attend PD. In addition, the finding suggests that teachers received PD at school level through staff meetings. They also indicated that training of teachers is very important in schools and it should not be taken for granted that teachers know everything in a fast-changing technologically driven world. According to Kempen and Steyn (2016:43), when teachers collaborate with teachers from other schools, they become equipped with new knowledge, classroom practices, and valuable information, which are important in teaching the subject.

- *Regular practising of mathematical problems*

Regular practising of mathematical problems is another strategy that assists teachers to develop in their profession. Most teachers indicated that they made sure that they did not go to sleep without practising two or more mathematical problems that provoked their thinking. They also indicated that teachers should study Bachelor of Science Mathematics books that display a number of activities and guide them on how to get the answers. These worked well if the teachers had an interest in learning the subject. They should allocate more hours to study mathematics than attending other personal issues. The finding also revealed that teachers collaborate with other teachers who are knowledgeable in the subject to share skills.

Teacher 3:

> *I will give myself time to practice mathematical problems since mathematics needs regular practice in order to know it better. At most I prefer using Bachelor of Science books when practising mathematical problems because they contain many mathematical problems.*

Teacher 4:

> *I will interact with other mathematics teachers in order to share skills and knowledge with them. Before I go to sleep, I practise a few mathematical problems and this helps me to understand the subject better.*

It seems that collaboration amongst mathematics teachers and constant practising of mathematics problems can benefit teachers to improve their delivery of the subject. It can also be concluded that regular practice of mathematical problems is important because teachers get time to do trial-and-error exercises until they know how to solve the problem correctly. This is supported by Ma et al. (2018:302) who indicate that mathematics teachers work on their own and learn from other teachers in order to improve their knowledge.

- *Participation in professional bodies*

Participation in professional bodies is another strategy that assists to develop teachers in their profession. Most teachers mentioned that they register their learners in mathematics competitions such as the Association for Mathematics Education of South Africa (AMESA) in order to gauge their level of proficiency. According to them, if learners perform poorly it shows that the teacher responsible for teaching them lacks knowledge in the subject and needs to improve. The study also revealed that when teachers participated in competitions they benefits in learning from one another.

Teacher 4:

> *I can enter my learners in mathematics competitions such as AMESA in order to gauge the performance of my learners. If my learners perform lowly it would means I have to improve myself.*

The finding suggests that participation in national and international competitions assists in comparing the level of performance of learners with that of their counterparts. It might mean that when teachers find high levels of discrepancy in learners' performance, they could be motivated to intensify the delivery of the subject to achieve improvement. Participation in professional bodies is also supported by Australian Government Department of Education and Training (2016:6) who indicate that teacher programmes in are funded by the state in order to allow middle schools to send teachers to conferences, which have ability to develop them in their career.

5.5.1.2 Principals

The sub-themes that emerged from the strategies used by principals included developing teachers in their profession, and managing teacher PD in their schools.

- *The strategies that principals use in developing teachers in their profession.*

The principals used various strategies to develop teachers in schools. Some of these strategies included convening regular staff meetings; encouraging teachers to hold subject meetings; encouraging teachers to attend workshops; encouraging teachers to enrol with institutions of higher education; inviting subject specialists to the school, and developing PD plans for the teachers.

- *Convening regular staff meetings*

Convening regular staff meeting is a strategy that principals use in developing teachers in their profession. Some of the principals indicated that the aim of convening staff meetings was to provide feedback to the teachers on their school-related issues. According to them, teachers

were engaged in discussions and they were given an opportunity to raise their concerns, frustrations, and successes regarding their profession.

Principal 1*:*

> *Firstly, I make sure that I convene staff meetings. These staff meetings are often aimed at providing feedback on teachers'work. I also use these staff meetings to engage teachers in discussing their work-related duties. I also give them time to raise their concerns, frustrations and successes regarding their profession.*

This suggests that when principals convened regular meetings with teachers in schools they were given the chance to share and discuss professional issues with them. As a result, teachers became knowledgeable on the issues regarding their profession. The finding is in line with Maimela (2015:655). According to the scholar, teachers should be capacitated on issues regarding their profession so that they can implement them freely, reduce fear and the feeling of incompetence.

- *Encouraging teachers to hold subject meetings*

Encouraging teachers to hold subject meetings is another strategy that principals employ to develop teachers in their profession. Most of the principals indicated that they encouraged their HoDs to conduct monthly or quarterly subject meetings in order to assess performance of learners in their subjects. Another principal indicated that principals mandated HoDs who supervise particular subjects to hold subject meetings with teachers in their specific subjects. The HoDs together with their teachers discussed issues relating to improving their subjects including lesson preparations, assessment curriculum coverage, and general teaching and learning.

Principal 1:

> *I always encourage HoDs to hold meetings in their subject meetings. During the meetings, the HoDs share information regarding the subject and these help them to improve in the subjects.*

Principal 2:

> *We encourage HoDs to conduct monthly and quarterly subject meetings in order to assess the progress in their subjects. This helps them to review if they are still aligned to the subject policies because it is mandatory to follow them.*

Principal 5*:*

> *Teachers belonging to various subjects formulate subject* meetings *and the immediate seniors provide feedback to me once in two weeks' time.*

The assumption is that if teachers attended subject meetings monthly, they would be able to get solutions to problems that challenged them when it is still time to attend them. The finding is reinforced by Paton et al. (2015:29) who stipulated that teachers should meet two days or more in a week in a school setting to discuss curriculum-related issues and the meeting should be led by experienced teachers. The idea is that the principals should encourage teachers to hold subject meetings in order to help one another to do school activities that challenge them with a view to improving the performance of learners. This might mean that principals regard holding meetings including subject meetings as a sure way of further developing teachers in their various subjects

- *Encouraging teachers to attend workshops*

Encouraging teachers to attend workshops is another strategy that principals use to develop teachers in their profession. The principals believe that when teachers attend workshops they can acquire extensive knowledge in the profession. According to one of the principals, teachers attended department workshops at circuit, district, and provincial level where they were further developed to excel in their subjects. The principals also mentioned that the experienced subject specialists who conducted presentations on various issues related to teaching and learning such as lesson planning, lesson presentation and assessment facilitated the departmental workshops.

Principal 1*:*

> *I also encourage teachers to attend departmental workshops that are organised at circuit, district, and provincial levels where they are further developed to master their teaching subjects. They should attend workshops because they are facilitated by facilitators that are knowledgeable in the numbers of areas.*

This indicates that principals encouraged teachers to attend workshops organised by the department to be developed by specialist facilitators on matters relating to their subjects. The finding is partially contrary to Umugiraneza et al. (2017:11) who maintained that facilitators should conduct workshops for the teachers in their own workplaces so that they could learn in practice and get support from them.

- *Encouraging teachers to enrol with institutions of higher education*

Encouraging teachers to enrol with institutions of higher education is another strategy that principals use to develop teachers in their profession. According to the findings, principals actively encouraged teachers to further their studies by registering with institutions of higher learning such as the colleges and universities in order to improve their knowledge of their subjects. Some principals indicated that they regularly encouraged teachers to further their studies based on their teaching subjects. The principals also mentioned that they encouraged teachers to study education management because it was easier to work with such teachers. According to them, teachers who studied education management were confident when teaching their learners and made positive contributions to the school.

Principal 1*:*

> *I encourage teachers to engage in lifelong learning by registering with institutions of higher learning in order to further develop themselves.*

Principal 6*:*

> *It is my role as a principal to encourage teachers to enrol with higher institutions in order to improve their qualifications. They must be interested in order to improve their qualifications.*

Another principal indicated that teachers needed to be motivated in order to be committed to their studies. Thus, the principal indicated that she led by example as she had done a number of qualifications including an honours degree in mathematics to show that it was possible to go beyond a basic undergraduate degree and learn more.

Principal 3*:*

> *I will motivate my teachers to be committed in their own personal PD. I will register myself with institutions of higher learning in order to encourage them participating in lifelong learning and this will encourage them to learn.*

The findings suggested that principals indeed play a positive role by encouraging their teachers to enrol and further their studies as a means of developing them in their various subject. The assumption is that when teachers gain new knowledge through their studies, it will have a direct impact on the improvement of their subject delivery, which could lead to improved learner performance in mathematics. The findings support Shabani (2016:6) who indicated that highly informative teachers should encourage less knowledgeable teachers to participate in PD.

- *Inviting subject specialists to the schools*

Inviting subject specialists to the schools is another strategy that principals use to develop teachers in their profession. The study revealed that various experts were invited to come and develop teachers in schools. Some principals articulated that motivational speakers were invited twice a year to motivate teachers on the matters that challenged them when it came to teaching and learning, and improving their professional abilities. They also mentioned that subject specialists were invited to schools to develop teachers in their subjects.

Principal 1*:*

> *sometimes I invite subject specialist to visit the school to develop teachers in their subjects.*

Principal 2:

> *I also invite motivational speakers twice a year to motivate teachers on matters that challenge in terms of their teaching and learning and improving their professional abilities.*

The belief is that when motivational speakers and subject specialists are invited in schools, they could encourage teachers to work hard and, as a result, the performance of learners could improve. Another principal indicated that some principals arranged with their fellow local principals within their local cluster to organise peer teaching. According to the principal, teachers who had knowledge in a subject and whose learners had high pass rates were engaged to work with their teachers in order to improve their own knowledge of the subject.

Principal 6:

> *Some principals in our district arrange with their sister principals within their local cluster to organise peer teaching. They arrange teachers who have knowledge in a subject and whose learners perform well are engaged to develop their teachers in order to improve their own knowledge of the subject.*

The suggestion is that when specialist such as curriculum advisors and motivational speakers visit schools directly, it has a much bigger impact than when teachers attend trainings and workshop at the DBE premises. This is because, at the school level, teachers have a greater opportunity to ask questions for clarity and the specialists can focus only on a small group instead of teaching a large group of teachers. My belief is that engaging in a one-on-one session coupled with a small focus group is a way of delivering information. Ngema (2016:169) supported the findings. According to the scholar, teachers are happy when are developed in schools because the development allow them to get support in issues such as subject teaching, subject content knowledge and classroom management.

- *Developing PD plans for teachers*

Developing PD plans for teachers is another strategy that principals use to develop teachers in their profession. One of the principals indicated that teachers need to know their subject matter well and use appropriate methods for teaching. In order to achieve this, the principals first assessed teachers in their subjects they were allocated to teach. They did this by conducting class visits and checking learners' performance in their subjects. This assisted the principal to identify gaps in the knowledge in the subject. At the end, the principal sat down with the teacher and gave him feedback about his findings. The teacher was then told about the need to develop a plan together but the teacher became the owner of it. The aim of the plan would be to address the gaps identified during class visit. The principals monitored progress on the plan and they requested the HoDs supervising the teacher's subjects to monitor them.

Principal 5:

> *Teacher development is very important for teachers to remain relevant in their subjects. They should know their subject matters and methods we use in an appropriate way. First, I assess teachers in the subjects they are allocated to teach; conduct class visit and learners' performance in their subjects.*

It seems that the principals first studied the qualifications of teachers in order to help them. The finding is supported by More (2016:102) who indicated that PD programmes are helpful if training needs are identified and follow-up training is conducted.

- *How principals manage PD in their schools*

The study found that the principals use various ways to manage teachers in their schools. Some of the ways included implementing IQMS and QMS; delegating teachers to perform specific duties, and motivating teachers to participate in their own PD.

- *Implementing IQMS and quality management system*

Implementing IQMS and QMS in schools is one of the mechanisms used by principals to manage PD in schools. According to some principals, the IQMS and QMS are the departmental initiatives that help them to manage PD of teachers on annual basis. The principals indicated that they developed management plans that contained all the activities, dates, and human resource enlisted in carrying out PD through the whole year. They also concurred that their roles in the PD often involved the delegation of the actual activities of teacher development to the HoDs and deputy principals while they assumed the responsibility of overseeing.

Principal 1*:*

> *In my school PD is aligned with teacher development strategies such as IQMS and recently implemented QMS. They help me to manage PD of teachers on annual basis. My role as a principal involves delegating HoDs and deputy principals to perform certain duties while assume the responsibility of oversee.*

This might suggest that, when implemented correctly, the QMS and IQMS may serve the purpose of evaluating teachers' weaknesses and addressing them. Acording to Mthembu (2017:90) , the process of IQMS helps to reveal the weaknesses and strengths of teachers with a view to develop them in their profession supported the finding.

- *Delegating teachers to perform specific duties*

Delegating teachers to perform specific duties by principals is another way that principals use to manage teacher PD. Some principals indicated that they involved school management teams SMTs and senior teachers in the management of the PD. According to the principals, the SMTs and senior teachers were actively involved in the development of class visit time tables and lesson observations. They further indicated that their roles were to observe and provide constructive feedback as a way of developing their colleagues. Some few principals indicated that they received feedback on challenges and successes on the PD through SMT meetings, while teachers received their feedback through on one-on-one meetings, subject meetings, and staff meetings. Another principal mentioned that mathematics teachers were delegated to perform roles such as petty cash officers, finance officers and SA-SAMS officers.

Principal 1*:*

> *I also involve SMTs and senior teachers as in the management of PD. As a principal, I receive feedback on the challenges and successes of the PD through SMT meetings while teachers get their feedbacks in the subject meetings:*

Principal 3*:*

> *I give my teachers administrative work. As for mathematics teachers I appoint them on activities such as petty cash officers, finance officers, and SA-SAMS. They also know that they are appointed on the positions based on their knowledge having in mathematics and this encourage them to work harder.*

The assumption is that delegating responsibilities and roles to subordinates is a good way of further developing them. It is also a good strategy to relieve one of high work overload. Darling-Hammond et al. (2017:14) support the finding. According to the scholars, feedback and reflection are used to mentor and monitor teachers and can also be used to check the quality of learning by checking what the teachers learnt, receive input on and to make changes on the practices. The researcher's opinion is that when teachers participate in school activities they get a chance to acquire knowledge and skills on managing school finances; rules and regulations pertaining to admission; developing quarterly schedules, and learner academic reports and they can transfer them to the other staff.

- *Motivating teachers to participate in their own professional developments*

Motivating teachers to participate in their own PD is another activity used by principals to manage PD in schools. One of the principals mentioned that it was very difficult to know the teachers' subjects qualifications especially in relations to subjects that they were not teaching. The principal highlighted that he would not know unless he checked the teachers' subject specialisations and talked to them about developing themselves. The belief is that the role of the principals is to monitor how teachers develop themselves since PD are conducted at different levels. In addition, my assumption is that principals motivated teachers to study and gave them support where necessary. They also checked the performance of teachers frequently because if they did not support them they were likely leave the profession in time.

Principal 4:

> *As a principal, I am in a unique position whose role is to influence the teachers in a* positive way.

Principal 5:

> *As a principal, my role is to motivate them studying and giving them support where necessary. I frequently check their performance because if I do not interact with them, they are likely to become dropouts at the going of time.*

It seems that motivating teachers to undergo PD is a sure way of improving their performance, which could also lead to improvement in learners' academic performance. The finding concurs with Mobara (2017:166) who mentioned that at the school level, the SMT should be available to support teachers who have learners with learning barriers.

5.5.1.3 Curriculum advisors

The sub-themes emerged from the CAs comprised activities that CAs do to develop teachers in mathematics; advice that CAs give teachers in implementing PD; how CAs interact with teachers during PD, and the strategies used by CAs to improve the performance of mathematics teachers.

- *Activities that CAs do to develop teachers in mathematics*

The study found that CAs use various strategies to develop teachers in mathematics. These strategies included inviting teachers to the workshops; developing materials for the teachers; conducting school visits, and training HoDs to support teachers.

- *Inviting teachers to the workshops*

Inviting teachers to workshops is an activity that CAs use to develop mathematics teachers. According to one of the CAs, developing teachers in mathematics was one of their core responsibilities. The CA revealed that when there were changes to the curriculum, they called

teachers to workshops and trained them; in fact, it was their responsibility to do so. The CA also mentioned that if there was urgent information, they invited teachers to subject meetings that were conducted for two or three hours a day. Another CA mentioned that they did advocacy and induction in new matters. The study also revealed that CAs were responsible for training and supporting teachers on the implementation of CAPS. It also indicated that CAs trained teachers on how to adapt their Annual Teaching Plans (ATPs) because curriculum content had been reduced due to COVID-19.

Curriculum Advisor 1*:*

> *Development of teachers in mathematics is one of our core responsibilities as CAs. If there are some changes that replace the old curriculum, we call teachers to the workshops and train them how to implement it. Again, if there is quick information, we invite teachers to the subject meetings that are done within two to three hours for a day.*

Curriculum Advisor 2*:*

> *Now that CAPS has been introduced, we are expected to workshop teachers in its implementation. Furthermore, curriculum has been reduced due to COVID 19 and as CAs, we train teachers in order to know what is expected from them and the usage of ATPs.*

The finding suggests that workshops play a significant role in the development of teachers within the circuit through the commitment of CAs. My understanding is that through these workshops, CAs are able to deliver valuable information that is related to teachers' academic delivery.

The finding is in line with Mthembu (2017:91) who indicated that training should decrease confusion and incompetency shown by teachers in schools.

- *Developing materials to teachers*

Developing materials for teachers is another activity that CAs use to develop teachers in mathematics. According to one CA, they sometimes developed resource materials in order to develop teachers in their profession. They invited teachers to the workshops to train them on how to use the materials. The participant indicated that CAs sometimes distributed materials to the schools. The CA also mentioned that they encouraged teachers to read the materials but they were reluctant to read them. He argued that teachers did not read subject-related information because they were lazy to do so and they always wanted to be told how to do things. The CA further mentioned that the materials were normally done for Grade 8 and 9 especially on the topics that were challenging to teachers.

Curriculum Advisor 1*:*

> *We sometimes develop materials that can assist in terms of teacher development. Teachers are invited to the workshops to be trained on how the materials are used. We distribute materials to schools and encourage them to read the materials but unfortunately, our teachers do not want to read.*

This suggests that CAs develop materials to assist teachers on the topics that are more challenging to them in order to make the subject matter more understandable during teaching and learning. The finding was in line with McAleavy et al. (2018:35) who stated that resource materials yielded good results when delivering classroom practices and they should be used to make lessons understandable.

- *Conducting school visits*

The study found that conducting school visits by CAs was another activity used to develop teachers in mathematics. According to some CAs, when they did school visits, they checked how teachers assessed learners. They also checked other forms of activities such as controlling the workbooks of the learners and moderating the work of teachers by their colleagues.The CAs indicated that when they moderated the learners' books, they found either good practices or gaps. If they found gaps, they showed the teachers how things were done correctly and they

gave them necessary support. It was also mentioned that when the CAs visited the schools they had a chance to find out if teachers followed schedules or pace setters while teaching learners.

Curriculum Advisor 1*:*

> *I also develop teachers when we do school visits. At school, we check how teachers assess learners. We also check the other forms of activities such as controlling the workbooks of learners and moderation of their work by their immediate seniors. In case teachers indicate that they have a problem in doing something we assist them on how to it. We also provide materials in case they do not have them.*

The assumption is that when CAs visit schools they get chance to check on the challenges that teachers encounter in schools, assist them and provide materials in case they do not have them. Hugo (2018:193) supported the finding. According to the scholar, at school level, teachers are supported in managing time; planning their lessons, and assisting new teachers. In addition, teachers are also supported to manage their classrooms.

- *Training heads of department to support teachers*

Training HoDs to support teachers is another activity that CAs can use in developing teachers in their careers. Most of the CAs indicated that they trained HoDs to master the subject content, methodology and support them at the process. According to them, they trained HoDs to train their fellow teachers because most school had many teachers who taught mathematics. The CAs mentioned that when HoDs were trained, whoever attended should transfer that knowledge to their colleagues.

Curriculum Advisor 2*:*

> *We also train HoDs on monitoring and support in order to support teachers in their schools. We become mentors of the teachers in everything that they are doing in school level. We train them in order train their fellow teachers in their own schools because it is not possible for the schools that have many mathematics teachers to send them to the workshop simultaneously.*

The suggestion is that when the CAs in schools develop HoDs this helps them to develop and support their fellow teachers more easily. The assumption is that when teachers are trained by their own SMT, they might have a better grasp of the information than when they are trained in an unfamiliar environment by strangers. Svendsen (2016:313) who indicated that school-based, collaborative teacher development programmes increase teaching practice efficacy, thinking and changing teachers' attitudes to participating in collaborative activities, supporteds the finding.

- *The guidance that CAs give teachers in implementing PD*

The study found that advice that CAs give to teachers to implement PD includes mastering the curriculum content; enrolling for short courses; reading subject-related information, and participating in cluster meetings.

❖ *Mastering curriculum content*

Mastering curriculum content was found to be advice that CAs give teachers when implementing PD. One of the CAs highlighted that teachers need to have current and relevant knowledge of the curriculum since it kept on changing. The CA indicated that some of the content had been phased out and new content had been introduced and because of this, teachers must always be knowledgeable regarding the content of the subjects they taught. He argued that most teachers did not give themselves time to learn and this made them lag behind when it came to mastering curriculum issues. For example, he said that, previously, Roman numerals were included in the curriculum but now they were no longer taught to learners.

Curriculum Advisor 1:

> *Teachers should be current and relevant to the curriculum because things keep on changing. Some of the content has been phased out and some is brought back and this should be known by teachers. Most teachers do not give themselves time to learn and this makes them to lag behind when it comes to curriculum issues.*

This may suggest that it is the responsibility of CAs to ensure that teachers are well-equipped in terms of the content they teach. CAs should achieve this through constant provision of

information to teachers, through meetings and workshops. The frequent renewal of information can assist teachers to stay abreast of the constantly changing education trends, which could lead to improvement in the way they deliver information to learners. The finding concurs with Guskey's (1987:11-12) theory of teacher change which posits that teachers who are more open, courageous in implementing new programmes and feel confident about their classroom practices, become successful in mastering the curriculum content.

- *Enrolling for short courses*

Enrolling for short courses was another suggestion that CAs gave teachers in implementing PD. In relation to the collected data, teachers seemed to be advised to enrol for short courses rather than enrolling for tiresome and energy-sapping degrees. One of the CAs pointed out that teachers should do short courses on the subjects they taught and this would help to capacitate them. The CA also lamented that most teachers never did curricular and transformation geometry in their training and this contribute to lack of knowledge in the subject.

Curriculum Advisor 1:

> *One other thing that teachers must have are short courses that are best not degrees. When they do short courses on the subjects they are teaching, it helps them to get capacitated because the information that they acquire while studying would help them to improve their teaching subjects. Most teachers did not do curricular and transformation geometry in their training and this contribute to the poor knowledge in the subject.*

This might mean that when teachers enrol for short courses, it affords them the opportunity to acquire knowledge more quickly than enrolling for degrees that could be time-consuming. It might also mean that short courses have the ability to provide knowledge that teachers can use immediately after acquisition, which has the potential benefit of having up-to-date facts about the subject. The finding is supported by Zhukova (2018:100) who indicated that teachers are forced to participate in PD programmes in their workplaces because most of them complete education training but are not yet fully developed in their work-related activities.

- *Reading subject related information*

Reading subject-related information is another suggestion that CAs gave to teachers in implementing PD. Teachers seemed to be encouraged to read subject-related materials in order in to improve their subject knowledge. One of the CAs stated that teachers were encouraged to read information related to their subject; however, the CA complained that, in most cases, teachers were reluctant to read. According to the CA, it was very difficult to teach 'an old dog new tricks' because development deals with change. The CA lamented that if teachers did not read new information, they would continue sticking to old practices. The CA further advised teachers to read information and to attend subject meetings in order to discuss conepts that were taught in workshops and to ensure that programmes are implemented.

Curriculum Advisor 2*:*

> *We encourage our teachers to read information but it is a problem because they do not want to read it. If they do not like reading new information, they are likely to use outdated information because information keeps on changing. We also encourage teachers to attend subject meeting so that they can discuss issues dealt in the workshops and to help one another.*

The suggestion is that when teachers develop the culture of reading information in the subject, they are likely to acquire more information and skills that are needed in improving the performance of learners.The finding suggests that reading information that is related to the subject one teaches is a sure way of improving oneself. My understanding is that when teachers improve themselves through gaining new knowledge in line with their subjects, it might translate to improvements in learners' academic performance. In line with the finding, Hodge and Carbonara (2015:2) proposed that teachers should watch videos that show other teachers teaching in the classroom in order to grow and improve their professional knowledge.

❖ *Participating in cluster meetings*

Participation in cluster meetings was also recommended by the CAs. The study found that teachers were advised to participate in cluster meetings to discuss new developments. According to one of the CAs, teachers from different schools should attend cluster meetings to get time to plan and do assessment activities regarding their subjects together. The CA believed

that those who are knowledgeable in the subject should share knowledge and skills with other teachers.

Curriculum Advisor 2*:*

> *"We also encourage teachers to conduct cluster meetings where they can further discuss new developments. As CAs we believe that when various schools come together they can assist one another while planning and doing assessment activities.*

Curriculum Advisor 1:

> *We encourage teachers to attend cluster meetings because this provides the*m *with time to discuss and get solutions to the problems that challenge them in schools.*

The assumption is that when teachers from various schools attend cluster meetings they get the opportunity to share good practices and skills that they need at schools. They can also discuss school issues that are challenging them to improve their teaching and learning. The finding is reinforced by Howard, Akiba, Kuleshova, Wilkinson and Farfan (2016:13) who indicate that teachers teaching the same subject such as mathematics come together to share ideas about the subject.

- *How CAs interact with teachers during PD*

The study found that CAs interacted with teachers in various ways as a form of PD. Some of these ways included training teachers on certain topics; guiding teachers on how to teach certain topics correctly; approaching questions in mathematics and giving feedback on evaluation of teachers' practice.

❖ *Training teachers on specific topics*

Training teachers on specific topics is one of the strategies that CAs used to interact with teachers during PD. One of the CAs highlighted that when they want to develop teachers they prepared slides to help them present the kind of development programme they intended to present. The CA also indicated that they sometimes grouped teachers in groups during training to discuss issues that are part of the training. The CA also indicated that they requested teachers

to give feedback and demonstrate certain methods for presenting some topics. According to the CAs, teachers should be given time to present and give feedback because they use different methods in their classrooms.

Curriculum Advisor 1:

> *We prepare slides to help us present the kind of development we intend to put forward before our teachers. During training, we sometimes group teachers in groups to discuss things that are part of the training. We group teachers together because we understand that school A and school B do not do things the same. We also request teachers to give feedback and demonstrate certain methods for presenting certain topics*

The idea is that when CAs provide training to teachers about implementing new programmes, they prepare themselves to implement the programmes regardless of how challenging they might be. This will also motivate them to implement the programmes in due time because they would have accumulated the necessary skills and knowledge. In turn, other teachers acquire new methods to understand the programme better. The finding is in line with Darling-Hammond et al. (2017:130) who stated that effective PD should include feedback to enhance the quality of learning by assessing the understanding of what the teachers have learnt and to apply changes.

❖ *When guiding teachers to use the correct methods to teach learners*

Guiding teachers to use the correct methods to teach learners is another strategy that CAs use when interacting with teachers during PD. One of the CAs mentioned that when they are in the workshops, they may present a problem and ask the teachers to solve it. According to the CA, a teacher might volunteer suggestions for methods that could be used. Another teacher might say that was not how to solve the problem and would present their own method of solving it. Consequently, they could end up having more than 10 ways of solving the problem. At the end, the CA would guide teachers on the correct method to teach learners. The CA also indicated that teachers would be told that in mathematics that the end product was no important but that the value lay in the process of arriving at an answer.

Curriculum Advisor 2:

> *If we are in the workshop, I can come with the problem and ask any teacher to come and solve it. Teachers will volunteer and use various methods to solve the problem. As a CA, my role is to guide teachers that this method can be good but for learners can be done this way. We guide teachers to use suitable steps when solving particular mathematical problem rather writing an answer only*

This suggests that during workshops CAs should guide teachers to use the appropriate methods when teaching learners since some methods are not suitable for the learners or beyond the standard of learners. They guide teachers to use suitable steps to solve the problems rather than simply writing out an answer without explaining the steps to get there. In addition, if teachers were given time to solve a problem, they would present various teaching methods that they used in schools. As a result, teachers would get to know various methods of solving particular problems. The finding is also supported by Ogbonaya, Mji and Mohapi (2016:11) who indicate that regular training and retraining of teachers can sustain change.

❖ *Approaching questions in mathematics*

The study also found that the CAs interacted with teachers during PD when teaching them to approach questions in mathematics. It seems as if teachers did not guide learners to approach questions when writing tasks; hence, learners performed badly. One of the CAs indicated that learners failed to answer questions during exams because they did not know how to approach the question. The CA emphasised that the approach was very important. He further indicated that when learners were given a problem, they must be taught to look at a problem as a whole before answering the question.

Curriculum advisor 2:

> *Most learners do not fail because they lack information but they do not have approach to answer the questions. During PD, we discuss with teachers how to approach questions. The approach is very important when teachers have a problem and they have to look at it as a whole. As we develop teachers, we expect them to do the same with their learners. Some of these teachers do have honours and masters' degrees but*

their learners cannot pass because they lack procedures. This means the degrees are useless because they do not benefit learners.

This implies that CAs should continually engage teachers in PD programmes that would help them to teach learners suitable approaches to answering questions during assessments. This would assist to reduce the poor performance of learners since most learners had the information but did not know how to approach the question. The finding is supported by Wen and Wu (2017:82) who indicate that teachers need continuous and persistent training on curriculum knowledge and pedagogical design.

❖ *Giving feedback on evaluation of teachers' work*

Giving feedback on teachers' work was found to be another technique that CAs used when interacting with teachers during PD. It appeared that when CAs evaluated teachers' work, they were able to identify the challenges that teachers encountered. One of the CAs indicated that when teachers submitted their files for moderation, the CAs moderated their question papers and record sheets. According to the CA, these prepared them on how to interact with teachers because some of them set question papers which were not standardised and transferred incorrect marks to the mark sheets. The CA indicated that during the workshops, they communicated with teachers to set standardised question papers that addressed all cognitive levels and to be watchful when transferring marks to the learners' records.

Curriculum Advisor 1:

Another thing is feedback on their moderated work. When teachers submit their files for moderations, we moderate their question papers, record sheets and all others. These prepare us to interact with them during workshops because some of them set question papers which are not standardised. We tell teachers that when they set question papers should address various cognitive levels. When they go back to their schools will be knowing how to set question paper well. They must know the aim that they want to achieve when setting the question papers. That is why we do not expect teachers to give learners similar problems. We tell them to give learners two or three problems instead of giving them hundred similar questions.

Curriculum advisor2*:*

> *We interact with teachers on the issue of transferring marks of learners. Teachers are told that when they transfer learners' marks should make sure they enter them correctly. We tell them that when they enter incorrect marks for the learners they are directly destroying their futures.*

This suggests that when CAs moderated teachers' files, they were able to detect challenges encountered by teachers. As a result, they could address the gaps with them during workshops and by providing feedback. The finding is supported Luningo (2015:127) who indicates that facilitators should provide support to teachers who struggle to implement PD programmes correctly.

- *Strategies used by CAs to improve the performance of mathematics teachers*

The study revealed that CAs used various strategies to improve teachers' performance in mathematics. The strategies comprise encouraging teachers to upgrade their qualifications, and training them through the MASTEC programme.

❖ *Encouraging teachers to upgrade their qualifications*

Encouraging teachers to upgrade their qualifications was one of the strategies used by CAs to improve perfrmance in the teaching of mathematics. According to one of the CAs, teachers were encouraged to upgrade their qualifications because most of them were under-qualified. The CA lamented that most mathematics teachers in primary schools were not qualified and they were allocated teaching subjects on the basis that they had learnt mathematics in Grade 12. The CA also mentioned that some teachers had been trained as primary teachers and had learnt mathematics as an ancillary subject. Another CA mentioned that she always encouraged teachers to further their studies so that they could develop an in-depth knowledge of the subject.

Curriculum Advisor 1:

> *We encourage teachers to upgrade their qualifications because currently most of the teachers in primary schools, grade 8 and 9 are not qualified. They are just allocated*

mathematics as a teaching subject because they learnt it in grade 12. This affects them when they have to teach higher classes because they do not have sufficient knowledge and skills to teach the subject.

Curriculum Advisor 2:

We encourage teachers to further their studies. We tell them the reason for encouraging them but some say they are fine. Teachers have an element of laziness that is why they need to be encouraged studying. They forget that when they improve their qualifications, they are helping themselves.

The assumption is that most teachers who teach mathematics in schools are not qualified. They do not have skills and knowledge to teach the subject well. They are allocated the subject on the basis that there are no other teachers who can teach the subject. It is, thus, no surprise why learners under perform in most schools in the Mopani District. The researcher's opinion is that CAs should organise PD programmes to assist teachers on the aspects that seem to be challenging to them. This would help them acquire skills and knowledge to teach the subject effectively. The finding is supported by Looney et al. (2017:36) who suggested that teachers should be encouraged to follow PD programmes that focus on changing their attitude and beliefs in mathematics to become better teachers.

❖ *Training teachers through the MASTEC programme*

Training teachers through MASTEC programme was another strategy that was used by CAs to improve the qualifications of mathematics teachers. It appears that teachers who were trained in MASTEC were selected from various schools. According to one of the CAs, mathematics teachers were identified from different schools in order to be given training for about three weeks. One CA mentioned that the programme trains teachers in MST and, at the end of the programme, they are given certificates indicating the skills achieved. The other CA indicated that when the programme was offered, teachers were given time to apply and suitable candidates were selected. The CA also indicated that the programme was run at the provincial level and this helped to reach as many teachers as possible. The researcher's opinion is that when teachers attend PD in MASTEC for three weeks they get time to learn and practise the activities unlike if they attend one-day workshops at district level. The CAs also get sufficient time to develop teachers on the topics that challenge them.

Curriculum Advisor 1:

> *One of the strategies used by the Limpopo Provincial DBE is training teachers through MASTEC programme. We select mathematics teachers from different schools in order to give them training for about three weeks depending on how the programme is organised. When the programme is active, teachers who are willing are given time to apply and we identify suitable candidates from them. This programme trains teachers in mathematics, natural sciences and technology and this helps to reach as many teachers as possible. It trains teachers on issues such as teaching practices, lesson preparations and integrate the subject with technology since we live in the world of technology.*

The finding concurs with Mishal and Patkin (2016:253) who indicated that mathematics teachers should be engaged in PD programmes that involve areas such as didactic knowledge and subject matter content.

5.5.2 Theme 2: The Challenges Hindering Professional Development of Mathematics Teachers in Rural Public Schools

5.5.2.1 Teachers

The sub-themes that emerged from the teachers' interviews comprised challenges encountered by teachers when participating in PD in mathematics, and challenges encountered by teachers when implementing PD in mathematics.

- *Challenges encountered by teachers when participating in PD in mathematics*

The study found different challenges that teachers experience when participating in PD in mathematics.

❖ *Lack of ability to implement PD programmes*

Lack of ability to implement PD programmes was found to be one of the challenges teachers experienced when participating in teacher development in mathematics. It appears that most teachers did not have ability to perform their day-to-day activities well. One of the teachers mentioned that some teachers still had problems when it came to teaching some mathematical aspects even after they had attended workshops. According to the teacher, most teachers struggled to teach aspects such as fractions and word problems, and to prepare lessons in mathematics. The teacher also highlighted that teachers had a problem with forgetting to implement some steps.

Teacher 2:

> *We have challenges of teaching topics such as fractions, word problems in mathematics and lesson preparations. Even when we have attended workshops after some few days we forget all the steps that should be followed.*

This indicates that CAs responsible for developing teachers in mathematics do not have sufficient skills in training teachers. The fact that teachers still struggle to implement PD programmes and forgot to include some steps signified that they did not understand the programme well. PD needs to be practical so that trainees should remember what to do. Similar findings were revealed by Mpahla and Okeke (2015a:17) in saying that most facilitators did not have adequate knowledge to develop teachers. As a result, they did not have confidence in them.

❖ *Attending workshops late hours*

Attending workshops after hours was found to be another challenge that teachers encountered when participating in PD. One of the teachers indicated that the DBE invited teachers to afternoon workshops when they were already tired because they first had to go to work. According to the teacher, it was very hard for them to pay attention and they missed valuable information because they were not able to pay attention.

Teacher 4:

> *The DoE call us to the workshops in the afternoons when we are already tired. This makes us to sleep when the facilitators are busy facilitating more especially when the weather is very hot.*

The researcher suggests that teachers should be called to PD programmes in the mornings when they are still fresh so that they can understand the activities well. Attending workshops in the afternoon when teachers were already tired made the PD fruitless because teachers would sleep during the workshop because they were exhausted.

❖ *Shortage of mathematics CAs*

Shortage of mathematics CAs was found to be another challenge that teachers encountered when participating in PD. One of the teachers lamented that the DBE should employ additional mathematics CAs in the Mopani District so they could get adequate support. According to the teacher, the Mopani East District had only two mathematics CAs who were responsible for the whole district and they also assisted in the Tzaneen district. The teacher stated that both Mopani and the Tzaneen district had many schools and it was very difficult for the CAs to service them effectively. Throughout the year, they were busy with workshops, moderation and continuous assessment. As a result, they do not get enough time to support in schools.

Teacher 4*:*

> *The DoE should employ additional CAs in order to come and support us in schools. In our district we have only two CAs who are responsible for developing teachers in mathematics.*

Teacher 3:

> *We are worried about the shortage of Mathematics CAs in our district. Two Mathematics CAs are not enough to service both Mopani District and Tzaneen district because all these two districts have numerous schools and teachers. They can't*

workshop us, moderate us works, and give adequate support to us as they should being two. No ways, the DBE should employ more Mathematics CAs if they want to see things going in schools.

This indicates that Mopani District has a shortage of Mathematics CAs meaning that mathematics teachers struggle to get adequate support from them and affect the performance of learners in mathematics negatively. The shortage of CAs is also confirmed by OECD (2018:7) which indicates the scarcity of CAs involves those are responsible for MST.

❖ *Lack of teachers' salary improvement*

Lack of teachers' salary improvement was found to be another challenge that demoralise teachers to participate in PD. It appears that the low salaries of teachers affect teachers' improvement of qualifications negatively. One of the teachers highlighted that currently there is a shortage of mathematics teachers in the district because most teachers do not want to specialise in the subject. The teacher indicated that those having passed mathematics well in Grade 12 follow other occupations rather than teaching because they allege that teaching is poorly paid. The teacher also mentioned that teachers who are currently teaching mathematics are stagnant. They do not want to further their studies in mathematics because they claim it is a waste of time and money. The teacher suggested that when teachers completed their courses the DBE should increase their salaries so that they could be encouraged to study up to masters' degree level in mathematics. The teacher also lamented that when teachers completed their studies, their salaries did not increase, and they only occasionally received a cash bonus.

Teacher 4:

Lack of teachers' salary improvement is a serious concern because it affects the profession negatively. Since from the inception of democratic government when teachers improve their qualifications they do not get any improvement of salary and this discourages us. We use a lot of money to study as well as our time but this is not considered. I admire those who have chosen other field of works other than teaching after passing their grade 12 because their jobs pay them better salaries. The DoE should make sure it improves teachers' salaries when teachers improve their studies

especially in mathematics. Currently most teachers do not want to further their studies because their salaries are not improved after the completion of the study.

The researcher believes the DBE should improve mathematics teachers' salaries after they have completed their studies to encourage teachers to further their studies and participate in PD programmes in mathematics. This might motivate teachers to remain in teaching and motivate other people to enrol for a teaching qualification at university after passing Grade 12. If teachers' salaries were improved it would also motivte teachers to work harder. As a result, the performance of learners' should improve drastically. The low salaries of teachers were condemned by Kukano (2020:139). who stated that poor salaries paid to teachers made teaching as a profession to lose dignity.

❖ *Difficult working condition*

Difficult working condition were found to be another problem hindering the participation of teachers in PD in mathematics. It seems that the working conditions in public schools are not adequate for learning and teaching. One of the teachers lamented that learners's rights were over-empasised which contributed to ill-discipline in schools. According to the teacher, there were some learners who came to school with cell phones and when teachers were busy teaching, they watched pornography. The teacher believed that learners came to school with cell phones because they knew that they would not punished because corporal punishment has been abolished. Another teacher mentioned that some learners bullied other learners during learning and teaching. Instead of teachers delivering lessons freely, they spent much time calling learners to be orderly.

Teacher 5*:*

Learning and teaching in schools are no longer effective because the working condition is no longer favourable. Our learners our piled with many rights and this weakens discipline in schools. Learners behave anyhow. Some of them come with cell phones to schools and when teachers are busy teaching they watch pornography.

Teacher 5:

> *Other learners fight or bully their fellow learners while we are busy teaching because they know that we cannot punish them. These make us spending more time in calming learners to behave well than working.*

This shows that the DbE should revise the policies that it uses to manage learners. The fact that learners come with cell phones to watch pornography and disrespect teachers in schools signifies that there is disorder in schools and it should be restored in order to realise effective learning and teaching. This would minimise the misuse of rights by learners and the performance of learners would improve. The finding contravenes Kukano (2020:138) who found that teachers should have a good working environment that encouraged them to working without leaving the profession. The implication is that when teachers work in a peaceful environment, they are motivated to work and their learners benefitfrom this.

❖ *Negative attitude of learners towards mathematics*

A negative attitude of learners towards mathematics was found to be another challenge that teachers encountered when participating in PD in mathematics. According to some teachers, some learners do not want to learn mathematics and they claimed it was very difficult. The teachers mentioned that after giving a lesson, students often had all the answers wrong. Students maintained that mathematics was a very difficult subject.

Teacher 3:

> *Some learners have negative attitude towards learning mathematics. Even if I try to use various strategies acquired from the workshops, some learners still struggle to perform well in the subject. Sometimes I teach them slowly but at the end when I do assessments only three quarter of the learners would seem to be understanding and when you check the root cause, you will find that it is their negative attitude towards the subject.*

Teacher 5:

> *Another challenge, some learners indicate that mathematics is very difficult and this makes them to develop negative attitude towards the subject. It is very difficult to teach learners who have negative attitude towards the subject because they do not see the importance of learning the subject.*

It can be concluded that teaching learners who had a negative attitude was a challenge because they believed mathematics was very difficult. This meant that they did not bother to work harder in the subject although some learners who were serious worked harder and performed well. The understanding is that teaching learners who have a negative attitude towards the subject is a challenge because they struggle even to understand simple mathematical problems.

❖ *Too many responsibilities given to the teachers*

Too many responsibilities given to teachers was found to be another challenge that hinders teachers from participating in PD in mathematics. One of the teachers inndicated that teachers did not get time to plan their work properly due to the paperwork they had to complete. The teacher mentioned that during the workshops, teachers were given more work to do at schools while some duties were added via emails and circulars.

Teacher 3:

> *We are given too many responsibilities to do as teachers and some of them are irrelevant to our profession. For example, we are mandated to feed learners during break times. At schools there are many responsibilities that we perform such as extra-mural activities. We do not get time to plan for our work properly due to a lot paperwork given to us. During workshops we are given too much paperwork and some of the works are send to schools via emails. There is a lot of recording than teaching.*

Teacher 5:

> *We are given many duties and these affect us negatively when it comes to curriculum delivery. At school we participate in various committees such as coaching learners'*

football, controlling school stock, writing lesson plans for our teaching subjects, and controlling class registers. This responsibilities are tiring us. As a result, we struggle to excel in our positions.

The assumption is that teachers spend more time doing paperwork than teaching. Another teacher also indicated that mathematics teachers failed to follow the steps that are stipulated by the DBE due to the volume of work that has to be covered. Mathematics teachers are given a lot of work to do within a short space of time and this limits them from completing their work schedules. Consequently, some steps are compromised in order to speed up the completion of the syllabus and, as a result, some learners struggled to understand some topics. The finding is supported by Molapo and Pillay (2018:4) who indicated that teachers were piled with a lot of work.

- *Challenges encountered by teachers when implementing PD in schools.*

The study established that there were various challenges that teachers encountered when implementing PD in schools. Some of these challenges are discussed in the sub-sections below.

❖ *Overcrowding of learners in classes*

Overcrowding of learners in classes was found to be a challenge encountered by teachers when implementing PD in schools. One of the teachers stated that overcrowding of learners made it difficult to fully implement the programme due to ill-discipline of learners who frequently made a noise during teaching. The teacher also lamented that overcrowding of learners limited movement in the classrooms and this made teaching and learning difficult. Another teacher indicated that many of the classes had 60 learners and when teachers were busy teaching, learners did not concentrate.

Teacher 1:

Overcrowding of learners is a problem to us. It is very difficult to fully implement the programme due to ill-discipline of learners who frequently make noise during teaching. We also do not get sufficient space especially when we want to move around and check the progress of learners learning and teaching.

Teacher 6:

> *Overcrowding of learners in our classes is still a problem and it hinders the implementation of PD. My mathematics classes have an average capacity of 60 learners and when I'm teaching some learners do not concentrate. They play and some go an extent of not writing homework and classwork.*

The idea is that when classes are overcrowded learners become ill-disciplined. They made a noise; decided not to work knowing that they could hide among other learners and the teacher would also struggle to move around the class when wanting to check their work and support them. The finding is supported by Makhubele (2015:129) who stated that the schools in Limpopo Province had a shortage of resources such as classrooms.

❖ *Lack of resources*

The lack of resources was another challenge encountered by teachers when implementing PD in schools. A few teachers mentioned that in their schools they did not have resources to use for mathematics topics and that made teaching and learning very difficult. According to the teachers, they had requested the school to purchase resources for them but it was not willing to do so. The teachers mentioned that this was a problem for them because they struggled to teach some topics when they did not have resources. Another teacher articulated that, in his school, the school preferred using money to cater for refreshments at meetings, to provide transport, and to address school projects rather than to address curriculum issues.

Teacher 2:

> *Lack of resources in our school is a problem. In my school most resources for teaching mathematics are not available. When we request the school to purchase them for us it seems to be reluctant. This is a problem because we fail to teach some lessons which need specific resources.*

Teacher 3*:*

> *The first challenge is a lack of resources. Mathematics needs resources to use during learning and teaching. Unfortunately principals do not want to release funds to buy*

resource materials. Teaching learners without proper resources such as measuring tapes, watches and compasses is a problem because without them teachers are bound to theorise the lessons instead of using the correct LTSM.

Teacher 6*:*

At most the school is reluctant to provide us with transport fee when going to the workshops. The school finance officer indicates to us the school cannot finance us when going to the workshops because it has many things to perform. Sometimes the workshops take a long time to the extent we become hungry and we end up using our monies which are not refunded.

The idea is that schools do not purchase resources for the teachers and this makes teaching and learning difficult for the teachers. The finding contradicts Makhubele (2015:30) who indicated that schools should purchase LTSM and other equipment, in order to improve the performance of learners in schools hence the results are poor due to lack of resources.

❖ *Lack of teamwork in schools*

Lack of teamwork in schools was found to be another challenge encountered by teachers when implementing PD. It appears that the lack teamwork is prevalent in schools and it affects the implementation of PD negatively. One of the teachers articulated that when mathematics HoDs advised mathematics teachers to meet every Friday to share knowledge and skills about the implementation of mathematical aspects, some teachers were reluctant. When others met, they do not come to the meetings and claimed that they were committed to other school issues. Some teachers indicate that they do have teachers' guides and they will read for themselves.

Teacher 5:

The lack of teamwork affects the implementation of PD programmes negatively. When the HoDs advise us to meet every Friday in our subject meetings in order to share skills and knowledge, some teachers refuse to come. They indicate that they do not have time to attend subject meetings because they have more school work to do. Some

teachers also indicate that they do not see a necessity of working as a group since each teacher can work on their own.

The indication was that some teachers were not cooperative; resisted PD and were reluctant to attend PD programmes. This might decrease the team spirit which is necessary in school settings to improve teaching and learning. If teachers do not attend PD, they are likely to lag behind on new information and for that reason school should ensure that they attend school-based PD to increase their abilities. According to More (2016:711), teacher development should encourage teamwork, cooperation, and good relationships to enhance performance.

Little time to implement PD *programmes*

Little time to implement PD programmes was found be another challenge encountered by teachers. It appeared that, when teachers had insufficient time to implement PD, teaching was affected negatively. One of the teachers mentioned that their work schedules contain many topics to be covered within a short space of time. According to the teacher, this was a problem because they failed to finish the prescribed syllabus and when the district set the question papers, their learners failed.

Teacher 6*:*

We do not have enough time to teach and assess our learners in appropriate time. Our work schedules contain a lot of topics to be covered within a very short space of time and we fail to complete the work for the term because our learners are slow learners. When we fail to finish the prescribed syllabus it is a problem because at the end of each term the district set question papers that learners did not finish the work. Consequently, teachers are blamed when learners fail. The DBE and people turn to say teachers are not teaching forgetting that the time allocated for the term was very little.

The assumption is that when time is short, teachers are bound to hurry their lessons in order to complete their work schedules in time. Teachers might complete the schedule for the sake of compliance but some learners may fail to understand the activities due to the lack of time

teachers spent on explaining and helping them. A similar finding was found by Manqele (2017:186) who indicated that teacher development programmes should be prolonged in order to give teachers more time to learn.

5.5.2.2 Principals

The sub-theme emerged from the principals was challenges encountered by principals when implementing PD. The study found that principals encountered various challenges when developing teachers in their profession. Some of the challenges included lack of the use of technology; a shortage of mathematics teachers; a lack of support of mathematics teachers; and a lack of resources .

- *Lack of teachers' use of technology*

Another problem was the use of technology by some teachers. One of the principals commented that teachers were reluctant to improve their qualifications because they did not know how to use technology.

Principal 1:

> *Some teachers seem to be having low interest when it comes to participating in PD programmes. They claim that they are close to the retirement and when there are workshops the school should send younger generations. They indicate that their brains are no longer active and sending them to the workshops is a waste of resources.*

Principal 3:

> *Some teachers indicate they do not want to participate in PD programmes because they do not have skills and knowledge of using computers. They indicate most of the assignments are written via computers and send through emails. We do not know these things and we can cope even if we can register.*

The assumption is that most teachers cannot use computers. However, such teachers need to be exposed to ICT since it is needed, not only for teaching but also in day-to-day school activities. They should be encouraged to register for short courses that could equip them with

computer skills. The finding is supported by Phothongsunan (2018:283) who indicated that when teachers engaged in PD collaboratively and peer coaching they were motivation to improve their studies.

❖ *Shortage of mathematics teachers*

A shortage of mathematics teachers was found to be another challenge that principals encountered when implementing PD. According to the finding, most teachers were not qualified to teach mathematics as a subject. Some principals indicated that most teachers who were teaching mathematics did not have the necessary qualifications for the subject and preferred to teach lower grades. The principals mentioned that when these learners reached higher grades, they would be no longer be interested in mathematics. They indicated that most teachers preferred teaching Maths Literacy because they believed it was easier than pure mathematics. The study also found that teachers who were supposed to be teaching in Foundation Phase were sometimes found teaching in secondary schools and vice versa. It seems that a shortage of mathematics teachers would have a detrimental effect on the performance of learners in mathematics. When there are not enough mathematics teachers, schools would be forced to allocate the subjects to unqualified teachers who did not have a clue about the subject. This would result in learners failing the subject. UNESCO (2015:3) supported the finding. According to UNESCO, a shortage of mathematics teachers is a worldwide issue where unqualified teachers are employed in the place of qualified teachers.

Principal 3:

> *Most teachers in schools do not have qualifications to teach mathematics and it is the reason they prefer teaching lower grades.*

Principal 6:

> *The first challenge is the shortage of mathematics teachers in rural schools. It is possible for a teacher who has secondary qualifications to be seconded in foundation phase of vice versa due to the shortage of mathematics teachers. Another challenge is that some teachers teaching mathematics are not trained to teach the subject.*

❖ *Lack of support of mathematics teachers by curriculum advisors*

Lack of support of mathematics teachers was another challenge encountered by the principals when implementing PD. One of the principals mentioned that schools did not have enough support from DBE to support teachers. The principal indicated that it was rare for the CAs to visit schools. They probably went to the schools once a year. Another principal also highlighted that schools did not have suitable HoDs who were qualified to supervise mathematics. The finding suggests that the lack of support by the DBE in terms of providing schools with suitably qualified CAs might indicate that there were not enough CAs to meet the needs of the large number of schools. On the other hand, the unavailability of CAs to support teachers in schools might have a negative effect on the performance of both teachers and learners, and this might cause poor learner performance. According to Tariq and Jumani (2016:487), lack of support was prevalent at school level because it was very difficult to get support from the authorities.

Principal 5*:*

> *We do not have enough support from the DBE. To cite an example, I do not know how many times curriculum advisors visit our schools in a year. They sometimes visit us once but one can see that they do not have time to support teachers.*

Principal 3*:*

> *Lack of support more especially to mathematics teachers is still our major concern. It is very rare to see Mathematics CAs coming to our schools. They only speak to mathematics via circulars. Our schools also encounter a lack of HoDs who are qualified to supervise mathematics in schools, like my school.*

❖ *Too many responsibilities given to the teacher*

Too many responsibilities given to teachers was another challenge that principals encountered when implementing PD in schools. One of the principals indicated that most teachers were unhappy about the many responsibilities given to them and this mades them quit the profession. According to the principal, paperwork exceeded the work of teaching and teachers were not trained to deal with it.

Principal 5:

> *As principals, we are worried about too much responsibilities that are given to teachers because they forbid them to teach learners well. Instead of teachers helping learners who are having learning challenges, they find themselves doing other responsibilities different from teaching learners which they are not trained to do them. Our learners cannot read and write because teachers are piled with more paperwork. Paperwork is more than the work that teachers should do. Most teachers quit the system due strenuous work that teachers encounter in schools..*

In terms of the finding, it seems that these multiple responsibilities given to the teachers hinder effective implementation of PD in schools. My view as the researcher is that when teachers are over-loaded with responsibilities, they might have work burnout, leaving them exhausted and demotivated. If this occurred, teachers would experience low energy levels and would demonstrate poor performance, which obviously would result in poor learner performance. The finding is supported by More (2016:106) who stated that teachers are allocated too many teaching subjects and other school duties such as classroom management and administrative work, which exhausts them.

❖ *Lack of resource materials*

Lack of resource materials was another challenge encountered by principals when implementing PD. According to one of the principals, resources were needed to ensure effective teaching and learning in schools. Most of the principals indicated that the DBE should ensure that it purchased kits and equipment for mathematics. Another principal lamented that the DBE had channelled funds that were supposed to be used for educational materials to managing the COVID-19 pandemic, resulting in the lack of mathematics resources for teaching and learning.

Principal 6:

> *Lack of resources is a challenge when it comes to the implementation of PD. Due to COVID 19 disease, the DBE has reduced our budgets in schools to manage CONVID*

19 disease. This make makes us to struggle purchasing educational resources and without them, it is very difficult to teach learners.

Principal 3*:*

In order to implement a particular programme, resources are needed specifically for that. For example, the kit and equipment for mathematics should be available to promote effective teaching and learning.

The finding indicates that no effective teaching and learning in mathematics can take place without the required resources. The lack of resources would cause low-level teaching and learning, which could lead to poor learner performance and a loss of confidence. The finding is in line with Dollar and Mede (2019:209) who indicated that teachers should be exposed to resource materials to promote effective teaching in schools.

5.5.2.3 Curriculum advisors

The theme, challenges hindering the PD of Mathematics teachers in rural public schools produced two sub-themes from the interviews with CAs. The first sub-theme that emerged was challenges encountered by CAs when teachers implement PD programmes in schools, and challenges encountered by curriculum advisors when conducting PD in the district.

- *Challenges encountered by CAs when teachers implement PD in schools*

There are various challenges that CAs encountered when teachers implemented PD in schools. These challenges included lack of resources; unqualfiied teachers failling to implement PD activities; teachers failing to cope with changes in the curriculum; lack of support for teachers and reshuffling of teachers in the subject. The other challenges included late distribution of invitation letters to workshops; limited time to conduct PD activities and lack of transport.

❖ *Lack of resources*

Lack of resources by teachers during the implementation of PD was a challenge found by CAs. It appears that teachers did not get resource materials to assist them when implementing PD in

schools. One of the CAs mentioned that a lack of resources forced teachers to teach learners in an abstract form instead of at a concrete level. According to the CA, denying a learner the opportunity to learn at a concrete level was a barrier to learning. The CA also indicated that every teacher expected to have resource materials to help them deliver the subject matter to the learners in a comprehensible way.

Curriculum Advisor 1:

> *Another problem is a lack of resources. The lack of resources forces teachers to teach learners in an abstract form instead of concrete level. Further denying learners to learn a concrete level is a barrier to learning*.

Curriculum Advisor 2:

> *Lack of resources make learning and teaching difficult in schools. When teachers are teaching, they expect to get teaching aids such as fraction walls, counters, and building blocks when teaching geometry patterns and unfortunately it is very to get such materials in schools.*

It was very hard for teachers to teach learners without teaching resources. Schools should make sure that they provide resources so that teachers did not need to improvise resources when they had to teach some topics in mathematics. Besides, learners understood more by viewing practical things than working from a theory.

❖ *Unqualified teachers failing to implement* PD

Unqualified teachers failing to implement PD was found be another challenge encountered by teachers when implementing PD in schools. One of the CAs indicated that teachers who did not specialise in mathematics struggled to teach some of the concepts. As a result, they choose concepts or topics that they felt comfortable to teach. According to the CA, when they visited teachers who encountered such challenges to their schools. they found them teaching the four basic operations for the whole year. The teacher would not teach other aspects of mathematics such as fractions, shapes, exponents, and measurements. Sometimes when the teacher tried to do this, when the CAs checked learners' books, they found the exercises done incorrectly.

Curriculum Advisor 1*:*

> *Teachers who are not qualified have serious problem when they are supposed to implement the programme itself. They struggle to teach some of the concepts. As a result, they choose to teach concepts which they feel comfortable to teach. When we visit schools, we find them only teaching four basic operations the whole year. They do not try to teach other topics. If they happen to teach them, they make a number of mistakes.*

The idea is that teachers who are not qualified to teach mathematics find it very difficult to teach some mathematical aspects. As a result, they only focused on similar aspects because they lacked knowledge to teach others. In line with the finding, Guskey's (1987:12) theory of teacher change suggests that less capable teachers should collaborate with capable teachers in order to improve their skills and knowledge and to master their teaching subjects.

❖ *Teachers failing to cope with changing curriculum*

Teachers failing to cope with changing curriculum appeared to be another challenge encountered by teachers when implementing PD in schools. According to one of the CAs, some teachers were still using outcomes-based education concepts such as "learning outcome 1" which did not correlate with the CAPS.

This suggests that when new curriculum was introduced, teachers struggled to adopt it since they were not yet acquainted with its terminologies. In this situation, CAs should ensure that teachers are fully developed and motivated to use new curriculum. They should also give them continual support so that they could implement the curriculum easily. According to Paton et al. (2015:380), change is gradual and learning is difficult; hence, teachers should use their spare time to embrace it.

Curriculum advisor 2*:*

> *Changing of curriculum to most teachers is a problem to comply with it. For example, there are still teachers who still use outcomes based education concepts such as Learning Outcome Number One which is not applicable with National Curriculum*

Statement. They struggle to understand how new curriculum operates and it this affects the implementation of PD programmes negatively.

❖ *Teachers lacking support*

Lack of support was found to be another challenge encountered by teachers when implementing PD. One of the CAs mentioned that when people did something someone should be available to assist with keeping things in order, providing guidance, and instilling confidence. According to the CA, if teachers struggled to carry out school activities, someone who was knowledgeable should be available to support them so that they did not lose hope.

Curriculum Advisor 2*:*

Teachers lack support from their immediate seniors. When teachers doing something there must be an immediate person who will assist to keep things in order and instil order. For example, a teacher who fails to type a square root is likely to be discouraged unless he or she gets support from someone.

This implies that teachers should always be given necessary support by their immediate supervisors. At school level, the SMTs should ensure that there were school-based workshops and support so that teachers could implement PD programmes accordingly. At district level, CAs should also have a programme to assist their teachers at district level and at school level. This would motivate teachers to implement the PD even when it was tough provided they received support from both SMTs and CAs. In line with the finding, Bantwini (2019:226) argued that most principals were aware that the success of their schools depended on their support but some principals found it difficult to support their teachers.

- *Challenges encountered by CAs when conducting PD in the district*

The challenges encountered by CAs when conducting PD in the district included reshuffling of teachers in the subject; late distribution of invitation letters to the workshops; limited time to conduct PD programmes, and lack of transport for teachers.

❖ *Reshuffling of teachers in the subject`*

Reshuffling of teachers in the subject was another challenge encountered by CAs when conducting PD in the district. One of the CAs indicated that teachers were frequently reshuffled or allocated new subjects annually and this disrupted the work of the CAs when they were supposed to monitor and support them. The CA stated that when they did school visits, they found teachers who were not sure of what to do because they had been allocated new subjects without the necessary documents. The CA also indicated that sometimes when they visited schools, they found teachers who were new from the universities or teachers' colleges. The teachers would tell them that they were not given anything.

Curriculum Advisor 1:

> *Changing of teachers in the subject on yearly basis is a problem. Teachers are frequently allocated new subject in schools and this disturbs us when we have to monitor and support them. When we conduct school visits we found teachers who are not sure what to do because when they were*

This shows that when teachers retired or changed their subjects, handover of documents was not done. Immediate seniors should make sure that handover exists in their schools to curb the uncertainty of teachers about their subjects. It seems that reshuffling of teachers during subject allocation also had a detrimental effect on the performance of teachers and derailed the work of the CAs. This might cause poor performance amongst teachers, which would translate to poor learner performance. The finding contradicts the purpose of PD. According to Mumhure (2017:182), teachers are developed in order to master their subjects and familiarise themselves with classroom functions such as syllabus interpretation, drafting schemes of work and assessment of learners.

> *given a new subject were not given necessary documents. Sometimes when we go to schools we find new teachers from the universities or the teachers' colleges who have not given proper documents for the subject and this frustrates us when we have to develop them.*

❖ *Late distribution of invitation letters to the workshops.*

Late distribution of invitation letters for the workshops by the district was another challenge encountered by CAs when conducting PD in the district. One of the CAs was worried that sometimes the district sent invitation letters to teachers very late and this made them fail to attend the workshops. The CA argued that if a large number of teachers failed to attend the workshops, most schools would be affected. The CA also argued that such schools would encounter problems when it came to the implementation of the curriculum because teachers did not have information that could lead them to deliver the curriculum adequately.

Curriculum advisor 1*:*

> *Late distribution of invitation letters to schools is a problem. Sometimes due to late distribution of invitations, the turn up in the workshop becomes poor. This means if the numbers of teachers fail to attend the workshop most schools become affected. Such schools will encounter a problem when it comes to the implementation*

This might mean that late invitations yield poor attendance at workshops. The advice is that districts should invite teachers to the workshops timeously to prevent them from arriving late at the meetings or failint to appear at all as this would deny them information to implement PD. The finding contradicted with Rasebotsa (2017:73) who complained that emails and SMSs were sometimes sent after hours to invite teachers to the workshops and this made teachers arrive late at the workshop and to lose valuable information. According to the scholar, teachers were supposed to be invited to the workshops on time so that they could organise themselves and to curb arriving late at the workshops.

❖ *Limited time to conduct PD programmes*

Limited time to conduct PD programmes is another challenge encountered by CAs when conducting PD in the district. Thus, one of the CAs mentioned that in the past they had been given the whole day to train teachers but now teachers were no longer allowed to come early, and they trained them from twelve o'clock to half past two. The CA lamented that in summer, twelve o'clock was already too hot and some teachers slept while they were busy running the workshops. According to the CA, this made them select certain items to train teachers since

they did not have sufficient time to train them. The CA also mentioned that even if the workshops were shortened, some teachers came to the workshop late, and as time went on they would look at their watches indicating that they were no longer concentrating. Another CA indicated there was nothing that teachers came to gain unless was being put up in accommodation organised by the department. The teachers went to sleep there and CAs had no time to teach them.

Curriculum Advisor 1:

> *One other challenge is the limited time that we have to conduct PD. In the past, we were given the whole day to train teachers. Currently teachers are no longer allowed to come early hence we train them from twelve o'clock to half past two.*

Curriculum Advisor 2:

> *Time factor is one of the challenges. Teachers can only attend workshops after 12 o'clock. No workshops can be attended in the early hours. In summer 12 o'clock is already hot and this makes teachers to sleep since they first go to work before they come to school.*

The finding suggests that teachers' PD, especially DBE-initiated workshops, no longer served the purpose of expanding teachers' knowledge due to the limited time allocated for this purpose. This might mean that CAs, through the DBE, should organise sleepover workshops where teachers will be expected to attend and sta over at the venue. This would reduce late coming and limited time for the workshops. Darling-Hammond et al. (2017:15) support the finding stating that PD cannot be achieved in a single or short workshop if changes were expected from teachers; instead, more time should be provided to assist them.

- *Lack of transport*

Lack of transport for some teachers was a challenge encountered by CAs when conducting PD in the district. According to one of the CAs, teachers who lacked transport arrived late at the workshops because their schools are far from the circuit. Again, in workshops where they expected 20 teachers, only five of them would arrive on time and the rest joined after the

workshop hd started. The CA argued that teachers arrived late because they had been waiting for a taxi that to take them to the workshop venue. The challenge emanated from the fact that taxis only moved when they were full.

Curriculum Advisor 2:

> *Some teachers have a problem of transport because their schools are far from the circuit. They first wait for a long time on the taxi rank before they could get a taxi coming to the workshop. This makes them to arrive late. You could find that in the workshop that we expected 20 people only five arrive in time and the rest join when then workshop is busy. These people have been standing on the taxi rank since from 9 o'clock and the taxi moves when it full.*

It seems that a lack of transport for teachers had a negative impact on the success of PD. My recommendation is schools within a circuit should organise transportation for teachers to minimise poor attendance in workshops. The finding is supported by Mpahla and Okeke (2015a:17) who seemed to be worried about workshops that were conducted for a short time due to the late coming of both facilitators and teachers.

5.5.3 Theme 3: How Mathematics Teachers are Inspired to Engage in Professional Development

5.5.3.1 Teachers

The theme on how mathematics teachers are inspired to engage in PD gave rise to suggestions for strategies that can be used to inspire teachers and how principals can inspire teachers. The following paragraphs provide a detailed discussion of the sub-themes.

- *Strategies that can be used to inspire teachers to participate in PD.*

The strategies that can be used to inspire teachers to participate in PD were offering bursaries; interacting with studying teachers; giving awards to the best teachers and improving teachers' salaries.

❖ *Offering bursaries*

Offering bursaries to teachers was one of the strategies that could be used to inspire teachers to participate in PD. According to one of the teachers, the DBE and private companies should offer bursaries to teachers in order to encourage them to further their studies. The teacher indicated that they wanted to study but were discouraged by a lack of money. When they wanted to study, they were hindered by a lack of money for registration, travelling, and tuition fees. Another teacher indicated that bursaries could also assist teachers to attend workshop sessions and pay for accommodation.

Teacher 1*:*

> *Lack of bursaries contribute for us not to enrol for studies. Studying is very expensive because it does not in registration but one has to travel to workshops and paying accommodation; buying laptops and books as well as food when attending workshops. When we are offered bursaries to pay our fees and attend workshops can encourage us to participate in PD.*

Teacher 4:

> *We fail to improve our qualifications due to lack of funds" while Teacher 5, says, offering of scholarships and bursaries by DBE and companies can inspire us to participate in PD. When we think of enrolling courses, we think twice because it is the activity that involves money that we do not have. Studying requires monies for registration, travelling as well as tuition fee.*

The finding suggests that teachers wanted to participate in PD; however, their main challenge was the lack of money. It may also suggest that providing bursaries and scholarship would play a positive role in motivating teachers to further their studies. The finding is supported by DBE (2016a: 37) which indicated that prospective teachers who intend to do MST subjects were offered a bursary called "Funza Lushaka" which paid all the funds that students needed to encourage them to study for a qualification for teaching mathematics.

❖ *Interacting with studying teachers*

Interacting with studying teachers is another strategy that can be used to inspire teachers to participate in PD. According to one of the participants, teachers who were currently studying and those who had completed their studies could influence each other by sharing ideas on how they could succeed in their studies. It appeared that interaction with colleagues who were currently studying was a way of inspiring teachers to participate in self-study and motivated them to improve their qualifications.

Teacher 2:

> *If one wants to study should choose friends who have interest in studying. They should interact act with them in order to get motivated, guidance and support during study. Such people can influence, direct us to choose the suitable institution and courses. They can also give us tips how to read and approach study challenges..*

This suggests that teachers who aspired to study should interact with teachers who were currently studying and those who had already completed their studies because they had suitable knowledge to guide and support others when they encountered challenges. The finding is reinforced by Shabani (2016:6) in stating that less knowledgeable individuals should interact with highly knowledgeable persons in order to be developed.

❖ *Giving awards to the best teachers*

Giving awards to the best teachers is another strategy that could be used to inspire teachers to participate in PD. According to one of the teachers, awards were a source of inspiration because they had the potential to encourage teachers to work hard in their profession. The finding might suggest that if teachers believed that their hard work would receive recognition, they might improve their performance. This improvement might also work towards improving learner performance, which was the ultimate goal.

Teacher 2:

> *Giving awards to the teachers who are committed to their school work should be considered because it can motivate teachers to go extra mile. It is very discouraging to work very hard but only to find that people pretend to be not seeing your effort. When you stop working they become quick to speak hence the schools and DBE should offer awards to teachers who bring changes in schools. Giving awards to the best teachers can encourage us to perform exceptionally well in our teaching subjects and PD programmes. It can also encourage most teachers to seek information in their own and get assistance from other people in order to advance their profession.*

The idea is that if awards can be offered to the best teachers, most teachers would do their best to manage their workload and deliver their subject matters properly in order to get awards. This could also help teachers to master their teaching subjects. According to Manqele (2017:192), monetary recognition for excellent work should be implemented in rural schools in order to encourage teachers to perform to their best ability.

❖ *Improving teachers' salaries*

Improving teachers' salaries by DBE is another strategy that could be used to inspire teachers to participate in PD. According to one of the teachers, it is discouraging when teachers use their own money and time to study, but after completing they did not receive any recognition in terms of a salary increment. Another teacher indicated that most teachers spent large sums of money on studying but once completed, they were not rewarded and this discouraged them.

Teacher 3*:*

> *The DBE must take extra mile to increase the salaries for the teachers who further their studies more especially in mathematics. As teachers we feel discouraged to use our own monies when studying but when we complete our studies not given reasonable salary increment.*

Teacher 5:

> *If the DBE can consider increasing our notches after the completion of studies can encourage teachers to study. It is pointless to use your own money and time to study with a purpose of helping learners but only to find that the DBE does not increase our salaries when we have completed our studies.*

This suggests that there is a correlation between studying to improve one's qualifications and the expectation of receiving an increase after completion of the qualification. It might mean that teachers are inspired by the prospect of earning high salaries after the study, which often turns to disappointment, since the DBE no longer recognises the acquisition of qualifications by means of salary increments. Manqele (2017:191) argues that the lack of improvement in teachers' salaries discourages them from furthering their qualifications and hinders them from acquiring skills and knowledge.

5.5.3.2 Principals

The theme on how mathematics teachers are inspired to engage in PD revealed strategies that principals can use in inspiring teachers to participate in PD. The following paragraphs discuss the sub-theme in detail.

- *How principals inspire mathematics teachers to participate in PD*

The study revealed that principals inspire mathematics teachers to participate in PD by explaining the benefits of PD; persuading teachers to participate in competitions; leading by example; motivating teachers to develop their interest in mathematics, and encouraging teachers to improve their qualifications.

❖ *Communicating the benefits of PD*

Communicating the benefits of PD to teachers is a strategy that principals use in inspiring teachers to participate in PD. One of the principals mentioned that he always talked to teachers about the benefits they would achieve when participating in PD. According to the principal, some of the benefits include gaining knowledge of the subject they taught, improving their

subject presentation, skills and learner assessment. The principal also communicated with teachers that participating in PD had the benefit of improving one's salary such with the IQMS or QMS.

Principal 1:

> *Talking to the teachers about the benefits of PD is necessary because it stimulates them to participate in PD. I always talk to the teachers about the benefits they will get when participating in PD. The benefits include aspects such as gaining knowledge of the subjects they teach, improving their teaching subject and skills, as well as assessing learners. At the end, all teachers whom I talked to them about the benefits of PD developed the desire to participate in PD programmes.*

It appears that communicating the benefits of PD could help to motivate teachers to engage in PD. The prospect of gaining knowledge and skill through participating in PD is a strong inspiration for teachers to participate in PD. This is in line with Shikalepo's (2018:248) finding that indicates that teachers are motivated when they get job opportunities and work in a favourable working environment..

❖ *Persuading teachers to participate in preparing learners for competitions*

Persuading teachers to prepare learners to participate in competitions is another strategy that principals use to inspire teachers to participate in PD. One of the principals articulated that learners can be registered for mathematics competitions such as those run by AMESA. According to the principal, when learners participate in competitions, their teachers learn skills and knowledge from other teachers. Another principal mentioned that teachers must be encouraged to participate in mathematics projects such as Maths 24 (a mathematics teaching tool proven to successfully engage students in Grades 1–9 from diverse economic and social backgrounds (Suntex International, 2022). It seems that teachers are inspired by their participation in competitions.

Principal 2:

> *I think teachers need to be persuaded in participating and registering their learners in competitions in order to help them grow. When their learners participate in competitions it is like they are competing themselves because when their learners fail they will introspect themselves. They will improve on the gaps that their learners failed.*

Principal 4:

> *I inspire mathematics teachers by ensuring their learners participate in mathematics competitions such as AMESA. When their learners participate in such mathematics competitions, they also get opportunity to learn new things and improve their skills.*

The assumption is that when teachers prepare their learners to participate in competitions, they have the opportunity to interact with their counterparts and could discuss how PD can yield benefits to teachers. Another principal highlighted that teachers should take learners to the competitions so that they could meet with other teachers whose learners were participating. It can be concluded that when mathematics teachers take their learners to competitions, they would be able to identify their gaps, which, at the end, would improve their teaching.

❖ *Leading by example*

Leading by example is another strategy that principals used to inspire teachers to participate in PD. One of the principal indicated that she was a mathematics teacher by profession and led her teachers by example. The principal indicated that she taught mathematics in Grades 10, 11 and 12, and if there was a need she also taught Grade 8 and 9 students. According to the principal, she shared the subject with other teachers and she took topics that they felt were difficult for them. The principal taught while the teachers observed and learned. She had an honours degree in mathematics and her teachers were studying mathematics because she was their role model. Teachers enjoyed teaching mathematics like the principal did and they were proud of being productive mathematics teachers.

Principal 3*:*

> *Luckily I am a mathematics teacher by profession. I lead by example. I teach mathematics in grade 10, 11, and 12. I also teach grade 8 and 9 when there is a need and I share these subjects with other teachers. I usually take the topics that teachers feel they are difficult to teach. I take teachers who have challenges to the class and teach while they are observing and learning. I have honours degree in Mathematics and all teachers are currently studying because they want to be like me.*

The indication is that principals who are in the forefront when it comes to school activities have the ability to teach the subjects well and inspire teachers who have challenges to work like them.

❖ *Encouraging teachers to improve their qualifications*

Encouraging teachers to improve their qualifications is another strategy that principals used to inspire teachers to participate in PD. One of the principals mentioned that he sat down with two of his teachers who had secondary teachers' diploma qualifications and had specialised in mathematics. The principal indicated to them that they could not rely on the qualifications that they had acquired years ago without improving them despite believing that they were still relevant. He told them that the fact that they were using old methods to teach and assess learners meant that they should improve their qualifications. It seems that being honest with teachers and explaining the impact on quality education caused by lack of studying is essential in improving performance. If teachers heeded the call and engaged in further study, they would eventually achieve improved performance, which would lead to better academic performance in learners. The teachers could enrol for the Advanced Certificate in Education and later go on to get an honours degree in mathematics.

Principal 5:

> *Of course we do have teachers who are stagnant in their profession and not interested in taking the route of PD. I sat down with two teachers who had secondary teachers diploma qualifications specialised in mathematics. I said to them, you cannot come with qualifications that you acquired them fifteen years ago without improving them*

and still believe that you are relevant. That provoked the teachers to enrol for Advanced Certificate and later went for honours degree in Mathematics. Should I have not talked to them, these teachers even today would be still having the same qualifications.

The finding is in line with SACE (2017:24) which indicated that teacher' unions such as South African Democratic Teachers Unions should be commended for the initiatives taken to develop their members and update them on policies that affected their careers. This suggests that teachers need to be motivated to engage in PD and to see the bigger picture. They must be aware that improving their qualifications could improve their career paths and their performance in the profession.

5.5.3.3 Curriculum advisors

The theme on how teachers are inspired to participate in PD revealed that CAs employed various strategies to inspire teachers to participate in PD. The following paragraphs provide a detailed discussion.

- *How CAs encourage teachers to participate in their PD programmes*

It was found that CAs used various ways to encourage teachers' participation in PD programmes. Some of the ways involved encouraging teachers to share their best practices; encouraging teachers to participate in assessment; conducting circuit meetings, and conducting workshops in an organised way.

❖ *Encouraging teachers to share their best practices*

Encouraging teachers to share their best practices was revealed as a strategy that CAs used in inspiring teachers to participate in PD. According to one of the CAs, teachers were given an opportunity to discuss and share how they did things at their respective schools. The CA indicated that in Grade 8 and 9 they used what is called 1+9. In that 1+9, there is a day which was dedicated to discuss lessons that were to be presented during the following two weeks. Teachers and CAs met on Fridays to discuss how lessons should be presented. If CAs were allocated to go and support teachers in a particular circuit, they selected various schools and

teachers to present identified topics or lessons. Teachers were given such responsibilities in order to participate in PD.

Curriculum Advisor 1*:*

> *We encourage teachers to share their best practices. They are given opportunity to discuss and share how they are doing things in their respective schools. We meet on Fridays and discuss on how the lessons should be presented*

This suggests that when teachers from different schools came together to share their best practices, it helped them to acquire various skills and knowledge that were essential in teaching the subject effectively. The finding is supported by Abdella (2015:225) who indicated that teachers of the same subject came together to share ideas and support each other with regard to teaching the subject.

Encouraging teachers to participate in assessment

Encouraging teachers to participate in assessment was found to be another strategy that CAs used to encourage them to participate in PD programmes. According to one of the CAs, they trained teachers to do various forms of assessments that must be done as per the CAPs document. They trained them by allocating the cluster to set a formal assessment task and submit it to them for moderation. The CA argued that they used to do everything for the teachers but now they wanted teachers to do this on their own in order to acquire the skills. He commented that after teachers had set a formal assessment task, the CAs moderated it and made corrections. Thereafter, it was shared with the schools.

Curriculum Advisor 1:

> *We also encourage our teachers to participate in assessment by allocating them the forms of assessment that must be done as per CAPS document. We allocate the cluster to set a formal assessment task and submit to us for moderation. That is part of PD. We used to do everything for them but now we want them to acquire this skill.*

The assumption is that when teachers are given time to set formal assessment tasks in their cluster meetings, this helps them to master how to do it individually. If individual teachers got stuck on the way, they could seek help from other colleagues since they worked as a team.

❖ *Encouraging teachers to attend circuit meetings*

Encouraging teachers to attend circuit meetings was found as another strategy that CAs used to encourage teachers to participate in their PD programmes. One of the CAs indicated that at the beginning of every quarter, teachers check the performance of the learners per school with an intention to improve them. They also do item analysis in order to check the areas that are problematic to the learners. This helps them to discuss the areas that are problematic before they go back to their respective schools. According to the CA, this type of practice is encouraged although some teachers are lazy to do it.

Curriculum advisor 1*:*

> *teachers should be encouraged to conduct circuit meeting quarterly. As a Mathematics CAs, we always encourage mathematics teachers to conduct circuit meetings where they come together to share information. At the beginning of every quarter, they check the performance of learners and do item analysis in order to get their challenges. This helps them to address the challenges of learners before they go back to their schools. We encourage it as CAs.*

The idea is that when mathematics teachers do item analysis at the beginning of each quarter they get chance to detect topics that are problematic to learners and at the end they teach them thoroughly.

❖ *Conducting workshops in an organised way*

Conducting workshops in an organised was another strategy that CAs used to inspire teachers to participate in PD. One of the CAs articulated that when they invited teachers to workshops, they were expected to stick to time by arriving early at the workshop venue. The presenters were also expected to be short and to the point.. The CA also indicated that when they presented

their programmes to teachers, they ensured that teachers gained more information and most of their problems were solved.

Curriculum Advisor 2*:*

> *The only way we can encourage teachers to attend PD programmes is to be organised when presenting our workshops. As a CA, I must stick to time and keep the presentation short but to the point. We must not embarrass teachers when they make silly mistakes but must get a better way to correct them with respect. We must also give them chance to contribute.*

This could suggest that conducting organised and time-conscious workshops plays a sterling role in motivating teachers to attend such workshops which are part of their PD. It could also mean that when the workshops are straightforward, teachers would not lose interest and would gain more from their attendance. The finding is supported by Smith (2015:145) who indicated that mathematics teachers should be engaged in PD that contributes to their personal growth and personal learning on classroom practices. The researcher's view is that when CAs arrive on time and keep the workshops short and to the point, teachers would be encouraged to arrive early at the workshops knowing that if they arrived late they would find the workshop was over. Furthermore, if CAs presented their workshops professionally, teachers would be attracted to attend them with the understanding they would be informed on things that challenge them.

5.5.4 Theme 4: How the Professional Development of Teachers Contribute to the Improvement of Learners Achievement in Mathematics

5.5.4.1 Principals

- *The value added by PD to the performance of learners*

This study revealed that there were various benefits that PD contributed to the performance of learners. The benefits include improving learners' performance; learners acquiring different methods of learning; and learners being motivated to learn.

❖ *Improving learners' performance*

Improving learners' performance is one of the benefits of PD. According to some principals, PD contributed tremendously to the performance of learners. The principals indicated that when teachers engaged in PD, they obviously gained knowledge and were able to teach the subject better and with added confidence and motivation. The principals also mentioned that when teachers had a better understanding of the subject, they were able to present it in a manner that was understandable. Learners gained a good understanding and would therefore improve their performance. Another principal indicated that PD of teachers also helped learners how to count and solve problems in mathematics.

Principal 1*:*

> *I think PD is able to add value tremendously on the performance of learners in mathematics. When teachers engage in PD, they acquire knowledge and at the end they teach the subject with added confidence and motivation. When teachers have good understanding of the subject, learners will gain good understanding and will therefore improve their performance.*

Principal 2:

> *When teachers are developed, the school performs well. Learners know how to count and solve mathematical problems.*

The finding suggests that when teachers participated in PD, they gained more knowledge on their teaching subjects. Ultimately they increased in confidence and motivation while delivering the lessons and this improved the performance of learners. The finding concurs with Darling-Hammond et al. (2017:7) who indicated that collaboration had a positive effect on transforming teachers' teaching and improving learners' learning.

❖ *Learners acquiring different methods of learning*

Learners' acquiring different methods of learning is another benefit of PD. According to one of the principals, PD helps teachers to get different methods of solving problems resulting in

their learners acquiring different ways of solving mathematical problems. Another principal indicated that when teachers were adequately developed, they could instil team spirit in learners. According to the principal, learners learned to work and solve problems together including the challenges they face in life. Furthermore, few principals indicated that PD taught teachers effective strategies of assessing learners. As a result, learners became used to various types of questions and their performance improved.

Principal 2:

> *PD helps teachers to get different methods of solving mathematical problems resulting in their learners acquiring different ways of solving mathematical problems. It also helps them to gain knowledge to teach the subject with understanding, added confidence and motivation. When teachers have good understanding of the subject it helps learners to understand the subject better and ultimately their performance improve tremendously.*

Principal 5*:*

> *Teacher development provides teachers with strategies of how to assess learners better. Learners who are taught by teachers who know their subject better know how to count and write.*

It can be concluded that when learners are assessed by using different types of questions, they acquire better skills and knowledge of the subject content. It can also be deduced that teachers who were adequately developed had better techniques to teach their learners with understanding.

- *Learners getting motivated to learn*

Learners' getting motivated to learn was found to be another value added by PD to the performance of learners. According to some principals, teachers who underwent PD were motivated and had a high interest in teaching their learners. As a result, their learners became motivated to learn and were interested in their subjects. The learners strived to be like their teachers and to please them. They also felt that mathematics was an easy and interesting

subject. The teachers helped them to practise mathematics daily and because of their constant practice, they passed the subject. Another principal indicated that teachers must demonstrate proficiency in teaching mathematics. This would make learners want to be like them. The principal indicated that when she was a learner, she copied her teacher's style of communication because she was very interested in the way she was communicating.

Principal 6:

> *It is important that learners be motivated learn in order to encourage them learning. Learners who are who are well motivated are not told to write and read their books but they work in their own. This only occurs when teachers undergo PD which teaches them to master their subject and this also makes their learners to understand and love the subject,*

Principal 3*:*

> *Teachers who undergo PD demonstrate to the learners that mathematics is a very important subject. This would make learners to be like their teachers. Learners who are being taught by teachers who are motivated and interested, they become motivated and interested to.*

The assumption is that when teachers are motivated and confident when teaching their learners, their learners also become motivated to learn, and as a result, they started understanding and liking the subject, felt free to interact with the teacher and started working in their own. Kempen and Steyn (2016:43) who mentioned that the implementation of collaboration enhanced the level of motivation, commitment, confidence, and innovativeness of teachers strengthened the finding.

5.5.4.2 Curriculum advisors

- *How PD of teachers contributes to the performance of learners in mathematics*

The study revealed that PD of teachers contributes to the performance of learners. The contributions include significantly improving the performance of learners, and gaining of confidence by learners.

❖ *Improving the performance of learners*

Improving the performance of learners was one of the contributions made by the PD of teachers. One of the CAs mentioned that after learners had written tests or exams, the CAs did item analysis to check the performance of learners and determine problematic areas. After that, they developed materials to address those items. They then discussed the identified misconceptions with teachers so that they could present the topic better in the future.

Curriculum advisor 1*:*

> *In everything that we do our aim is to improve the performance of learners especially in mathematics. After learners have written a tests or examinations, we do item analysis to check the performance of learners and problematic areas. After that, we develop materials to address those problems. We also discuss the misconceptions with teachers so that they can know how to present correctly in future.*

This finding may suggest that when item analysis is done, areas where learners encounter challenges are found. After that teachers embark on PD and, thus, gain knowledge and skills, which equip them to deliver their lessons effectively. This would ultimately result in the improvement of learners' performance. The finding is in agreement with Johnson (2017:31) who indicated that after learners had written ANA tests, their results were analysed to identify the weaknesses and strengths.

❖

❖ *Gaining confidence by learners*

Improved confidence in learners is another value added by the PD of teachers. According to one of the CAs, learners knew when their teachers were sure or unsure about their teaching. In addition, the CA mentioned that teachers needed to be confident and stand firm on what they were teaching and this confidence should be demonstrated to the learners. According to the CA, confidence goes hand-in-hand with improved performance. When teachers are confident and enjoyed what they were doing, their results would be good. The CA argued that if learners perceived that teachers were sure about their teaching, they would do the work required but if it was the opposite, they would do the same.

Curriculum Advisor 1*:*

> *I will start with learners. Learners gain confidence when teachers are confident. They know us very well. If the teacher does not know his staff, they know that he or she is not sure. If a teacher is not confident, even learners will not be interested to what the teacher is doing. Learners will not the teacher's classwork and homework.*

Another CA indicated that teachers need to arouse the interest of learners so that they would become interested or confident in the subject. Once teachers build confidence in the learners, their attitude would change. They would become more positive towards the subject and would understand the subject better. Consequently, they would start enjoying the subject, practising and solving mathematical problems in the absence of their teachers despite the challenges they might encounter.

Curriculum Advisor 2*:*

> *We encourage teachers to arouse the interest of learners so that they become interested in mathematics. At the end, learners develop positive attitude towards the subject and teachers. Once teachers build their confidence their attitude will change. They will become more and more positive towards the subject and the teacher.*

The finding suggests that by engaging in PD, teachers gained confidence, which could be transferred to the learners. Learners would gain confidence in mathematics through their

observation of teachers who exuded confidence while teaching. This new confidence in terms of the findings might translate to improved learner performance. The finding supports Manqele (2017: 180) who indicated that teachers who had limited subject knowledge not only diminished their confidence but they also were not able to motivate learners. This suggests that teachers should always be confident when teaching their learners in order to help them believe that they were taught correctly.

5.5.5 Theme 5: Teachers' Capabilities Acquired during their Participation in Professional Development in Mathematics

5.5.5.1 Principals

The theme on teachers' capabilities acquired during their participation in PD in mathematics revealed various interesting points. The principals revealed that when teachers participated in PD they found ways to develop in the profession. These ways are indicated and discussed in the following paragraphs.

❖ *Gaining knowledge in their teaching subjects*

Gaining knowledge in their teaching subjects was revealed as one of the teachers' capabilities acquired during their participation in PD in mathematics. Some principals mentioned that they assisted teachers to achieve good understanding of what they were expected to teach in terms of the content. According to them, teachers achieved a good understanding of dealing with the actual presentation of lessons and learners' assessment.

Principal 1:

> *When teachers participate in PD, they acquire skills and knowledge to teach subjects. They understand the subjects that they teach better. They know various aspects of their profession such as setting question papers; planning the lesson and assessing their learners well. Strategies that I employ include: IQMS, QMS, staff meetings, subject meetings.*

Principal 3:

> *There is no way a teacher who participate in PD cannot gaining something. Some of the things that teachers gain when participating in PD are using pace setters, setting formal tasks and interpreting policy documents appropriately. These help them to master their subjects and to be confidence when teaching their lessons.*

This means that when teachers participated in PD activities, they gained new knowledge, which translated to higher levels of motivation and confidence. Svendsen (2016:325) who mentioned that PD programmes conducted in workplaces increase confidence and motivation of the teachers as they had time to reflect on their subjects reinforces the finding. This indicates that when teachers were engaged in PD programmes they had the opportunity to improve their knowledge and skills on aspects such as lesson preparation, setting tests and interpreting policy documents.

- *Getting promoted to higher positions*

Being eligible for promotion to a higher position was found to be another capability acquired during teachers' participation in PD in mathematics. Some principals mentioned that teachers who participated in PD stood a better chance of being promoted to higher position such as HoDs, deputy principals, principals, and CA*s*.

Principal 5*:*

> *As a principal, I usually tell my staff to participate in school activities because at the end they would get a reward of some kind. I tell them that when they improve their qualifications stand a better to be promoted to higher positions such as HoDs, deputy principals, principals, CAs and circuit managers. Besides, being promoted they can become assets to the community since knowledgeable people are needed all over.*

This suggests that teachers who participated in PD ultimately stood a better chance to be promoted to higher positions due to the knowledge and abilities that they acquired from the PD programmes. SACE (2017:240) indicated that the PD programmes that were offered to teachers

provided them with knowledge and skills required in the work situation, which supports the finding.

❖ *Improving teaching practice*

Improving teaching practice was revealed to be another ability acquired during teachers' participation in PD in mathematics. According to one of the principals, if teachers were well-developed, they would become knowledgeable in the subject. They also acquired various skills such as lesson presentation and new teaching practices. They could then tranfer acquired knowledge to their learners who would then improve their academic performance.

Principal 5*:*

> *Remember that when we do teacher development to the teachers, our focus is on the learners. When teachers are adequately developed they acquire knowledge to perform school activities including teaching skills, and lesson presentations. At the end, they translate the information to the learners and this helps them to realise improved performance.*

It seems that when teachers participated in PD, their newly found knowledge assisted them in improving the way they taught, which consequently led to improved learner performance. The finding is in line with Kirkgöz (2016:176) who indicated that PD had the potential to improve teachers' cognitive level and to unlock their understanding to solve problems in the practice of teaching.

5.5.5.2 Curriculum advisors

It was found that there were various types of skills that teachers acquire when participating in PD programmes. Some of these skills include acquiring methods of teaching mathematics; improving content knowledge; acquiring abilities to present topics; acquiring skills to operate computers effectively, and improving listening skills.

❖ *Acquire methods of teaching mathematics*

Acquiring methods of teaching mathematics was found to be one of the teachers' capabilities acquired during their participation in PD in mathematics. One of the CAs indicated that they tried their level best to assist teachers in learning new methods of teaching mathematics. The CA mentioned that he had piloted the programme called Teaching Mathematics with Understanding in five schools in Klein Letaba circuit. The programme focuses on training mathematics teachers on various teaching methods. It unpacks the way teachers can convey lessons to the learners in a comprehensible way. The CA stressed that when teachers taught concepts, they should move from the concrete and visual leel and to the abstract level.

Curriculum Advisor 1:

> *Teachers get methods of teaching mathematics when they attend PD. It is one thing to have knowledge of the subject and it also another thing to have ability to deliver the subject.*

Curriculum Advisor 2:

> *As CAs, we try our best to help teachers acquiring teaching methods in mathematics. Currently we are piloting five schools in Klein Letaba circuit in the programme called Teaching Mathematics with Understanding. In this programme we are interesting in teaching mathematics teachers teaching methods. This programme unpacks the concepts in a way teachers can unpack them to the learners in comprehensive way. This programme stresses that when teachers teach 3D objects should bring them to the class so that learners can know aspects such faces and vertexes.*

In line with the finding, OECD (2015:158) encourages teachers to believe in the programme in order to realise its effectiveness. The indication is that teachers had subject knowledge but lacked methodology to deliver the subject matter and they needed to engage in PD in order to improve their teaching methods. The understanding is that if teachers were committed to learning various methods of teaching mathematics, this would assist them to improve the

performance of learners in the subject. Learners' negative attitudes towards mathematics because teachers fail to teach them adequately may change for the better.

❖ *Improving content knowledge*

Improving content knowledge was found to be another teachers' capability acquired during their participation in PD in mathematics. One of the CAs explained that teachers came to the workshops with little knowledge but when they returned to their respective schools they had more knowledge. The CA indicated that teachers improved their content knowledge because they were exposed to various methods of teaching. In the workshops, they also learned how to assess formal tasks such as projects, assignments, investigations and tests. When teachers did investigations, they needed to make sure that they reached a conclusion, meaning that it should end instead of being an endless process.

Curriculum Advisor 1*:*

> *When teachers come the workshops come with little knowledge but when they go back to their schools go with more knowledge than what they came with. When we engage teachers in PD programmes, their content knowledge improve tremendously.*

Curriculum Advisor 2:

> *One other thing is the development of fair and reliable assessment tasks. In the workshops we develop teachers on how to assess tasks such as projects, assignments, investigations, and tests.*

My interpretation is that when teachers attended workshops and other PD activities, they had the opportunity to improve their content knowledge of the subject. This improvement could assist teachers to deliver effective lessons and conduct quality assessment of learners. My understanding is that if this occurred, there was bound to lead to improved learner performance. The finding complements Abdella (2015:223) who found that teachers who worked together in a lesson study felt more professional than before they participated in the study.

❖ *Acquiring skills to operate computers*

Acquiring skills to operate computers was found to be another capability that teachers acquired when participating in PD. According to one of the CAs, teachers improved their computers skills because they forbade them to use handwritten question papers.

This indicates that all teachers needed to type their question papers to be in line with other teachers and to comply with the mandate of the CAs. Ayielko, Gokbel and Nelson (2017:83) indicated that ICT programmes were provided to support teachers to use them for teaching and learning. The scholars also mentioned that most mathematics teachers used computers for teaching mathematics in various ways. The suggestion is that when CAs mandated teachers to type question papers, they were helping them to acquire and master computer skills which made question papers neat and legible.

Curriculum Advisor 2:

> *PD of teachers develop teachers in a number of things. Among other things, they are developed in computer skills. To encourage teachers using computer skills, as CAs we do not accept handwritten question papers. We expect everyone to type his or her question papers. They learn how to use the characters of the computers and spacing of words.*

❖ *Improving listening skills*

Improving listening skills was found to be an additional teachers' capability acquired when participating in PD in mathematics. According to one of the CAs, when teachers attend workshops where the presenter exhibit a good grasp of the subject matter, they are bound to listen. He also indicated that teachers learn how to solve the problems logically following the steps. The CAs required teachers to impart the reasoning skills to the learners so that they could solve mathematical problems following the steps. During workshops, the CAs also taught them classroom management skills so that when they were in the classroom, they could manage their learners well.

The finding suggests that, during PD, teachers were expected to pay attention to the content of the presentation so that they would be able to translate their learning to the classroom

environment. Wen and Wu (2017:82) who found that beginning teachers required intensive support from experienced teachers in the areas such as classroom management and learning assessment support the finding.

5.5.6 Theme 6: The Strategies that can be used to Curb Problems in Professional Development Implementation

- *Strategies that can be used to curb problems in PD implementation.*

The study revealed that principals use various strategies to curb problems in PD implementation. The strategies comprise focusing PD on low-performing teachers; ongoing support of teachers; employing young teachers and improving teachers' salaries

❖ *Professional development focusing on low-performing teachers*

Professional development focusing on low-performing teachers is one of the strategies that can be used in curbing problems in PD. One of the principals indicated that PD should be focused specifically on low-performing teachers in order to encourage them to participate in PD. According to the principal, teachers who perform well should be enlisted to assist and coach teachers who underperformed.

Principal 1:

> *The first strategy is focusing on low-performing teachers. Teachers who perform well should be enlisted to assist and coach teachers who under perform. At the end teachers who underperform would get knowledge and skills from teachers who are knowledgeable.*

My take here is that enlisting the services of high-performing teachers to assist those who were under-performing could be beneficial. My understanding is that low-performing teachers would learn more by observing others in action. Manqele (2017:182) who found that most teachers possessed content knowledge but lacked teaching skills supports this finding.

❖ *Ongoing support of teachers*

Ongoing support of teachers was found to be another strategy that can be used to curb problems in PD implementation. According to some principals, teachers should be supported continuously through class observations, school-based workshops, provision of resources, constant monitoring, and feedback. Another principal indicated that at school level, there should be HoDs who had qualifications in mathematics. The principal also indicated that at district level, the department needed CAs who were ready to support and monitor teachers in schools and give them constructive feedback.

Principal 1:

> *Teachers should be provided with ongoing support. They should be supported continuously through class observations, school-based workshops, provision of resources, constant monitoring and support.*

Principal 5*:*

> *We need to have adequate monitoring and support by both the school and district level. At school level we need to have HoDs having proper qualifications in mathematics. At district level we need curriculum advisors who are ready to support and monitor teachers in schools and give them constructive feedback.*

The understanding is that for teachers to stay focused and continue to perform well, they need constant support from both principals and CA's. The finding is in line with Ndebele et al. (2016a:326) who indicated that after teachers had attended workshops, CAs could visit the schools to provide on-site support by conducting class visits, moderating learners' books, and checking their files.

❖ *Employing young teachers*

Employing young teachers was revealed as another strategy that can be used to curb problems in PD implementation. According to one of the principals, young and energetic teachers who were still waiting to enter their careers should be employed in order to solve the problem of

lack of energy during teaching and learning. If such teachers were available, the school should be willing to mentor and give them the necessary support so that they could maximise the permance in such programmes as the Maths Olympiad and ANA.

Principal 2:

> *I believe young teachers should be employed. Young and energetic teachers who are still willing to adventure their career can assist to curb problems in PD implementation. Being young they could be trained in various school activities such as the usage of ICT and sports since most senior teachers seem to be struggling in performing them.*

The finding might suggest that young and energetic teachers could assist in solving the prevalence of poor performance in schools. My understanding is that the system needs new blood to reinforce the culture of teaching and learning. However, experience also counts a lot towards the success of schools. Due to this, there should be a mix between the new and the old guards, so that the new will gain experience from the old. The OECD (2018:23) which revealed that PD programmes were in place to mentor and guide young students to become student-teachers and to support teaching and learning reinforces the finding.

5.5.7 Theme 7: Recommendations on how Mathematics Teachers can Improve in Mathematics

5.5.7.1 Teachers

The theme, recommendations on how mathematics teachers can improve in mathematics has revealed various aspects collected from the interviews on teachers. The sub-theme emerged from the teachers included teachers' recommendations on how they engage in PD in mathematics.

- *Teachers' recommendations on how they engage in PD in mathematics*

The participants recommended various ways that can be used to develop them in mathematics. The strategies included registering studies with institutions of higher education; and attending workshops.

❖ *Registering with institutions of higher education*

Registering with institutions of higher education was revealed as one of teachers' recommendations on how they can engage in PD in mathematics. Most of the teachers indicated that they should remain lifelong learners because the level of education keeps on changing, hence they need to be suitably qualified. They indicated that they could enrol in subject specialisations in courses such as advanced certificate education, honours, and master's degree. The finding suggests that teachers must register themselves for various courses in order to be in par with the standard of education around the globe since it keeps on evolving due to the needs of the society. The finding is in line with Adler (2017:2) who indicates that mathematics teachers should engage in PD courses that aim to improve their mathematics pedagogic and content knowledge

Teacher 1:

> *Since we are living in a changing world teachers should remain lifelong learners. We can enrol in subject specialisation such as Advanced Certificate Education and Master's degrees. This would equip us with knowledge and skills needed in our teaching profession.*

Teacher 2:

> *Our fellow teachers should make sure that they enrol with institutions of higher education in order to improve their qualifications. This would help them to be equipped in a numerous activities that exist in teaching profession since most of the things have changed.*

❖ *Attending workshops*

Attending workshops was also found to be another teachers' recommendation on how they engage in PD in mathematics. Most teachers indicated that they would be willing to attend workshops in order to acquire more skills and knowledge in the subject. Another teacher indicated that they did attend conferences that were planned to develop teachers in mathematics. It seems that teachers regarded attending workshops as part of their PD.

Teacher:

> *As teachers we should attend workshops in order to improve our qualifications. We should be willing to learn in order to grasp more knowledge.*

Teacher 5:

> *We can also attend workshops and conferences that are planned to develop us in mathematics.*

The finding is line with Thanheiser et al. (2017:482) who stated that PD programmes that last for a long time allow the trainee to learn classroom activities and to ask questions where they experience challenges. The understanding is that if teachers attended workshops, they would be equipped in the abilities that they lacked.

5.5.7.2 Principals

The sub-themes that emerged from the principals included recommendations of how mathematics teachers can improve their subject

- *Recommendations of how mathematics teachers can improve the teaching of their subje*ct

The principals provided a numbers of recommendations that can improve their teaching of the subject, which are indicated and discussed in the following paragraphs.

❖ *Conducting subject meetings*

Conducting subject meeting was found to be one of the recommendations on how mathematics teachers can improve their subject. According to one of the principals, subject meetings that teachers have to attend should be called by the HoDs heading the subject. The principal indicated that the meetings should focus on discussing the challenges that mathematics teachers encounter when teaching mathematics.

Principal 1:

> *I would recommend frequent subject meetings initiated by myself and mathematical DH. Those meetings should focus on discussing the challenges that mathematics teachers encounter when teaching mathematics. Teachers should also share light on the activities that are done in the subject including pace setters, subject policy and assessment of the subject.*

The assumption is that discussing these problems would assist in discovering solutions that would lead to improvements in teaching the subject. It seems that principals valued subject meetings. According to Moekwa (2020:133), when teachers attended learning committees, they acquired information regarding the subject and they were also empowered in integrating teaching techniques.

❖ *Furthering their studies with registered institutions of higher education*

Furthering their studies with registered institutions of higher education appeared to be another recommendation of how mathematics teachers could improve the their teaching of the subject. According to one of the principals, mathematics teachers should enrol for courses that specialise in mathematics that can help them master content knowledge. Another principal indicated that the more teachers became knowledgeable in the subject, the more they would become confident and interested in teaching the subject. According to the principal, learners trusted teachers who were knowledgeable because they knew that they would find solutions to the mathematical problems in the class. They would tend to like the subject and practise mathematical problems daily; treating mathematics as a game of numbers and they would be

more likely to pass the subject. Another principal stipulated that teachers should be motivated to specialise in mathematics but when they furthered their studies they tended to focus on other subject instead of mathematics.

Principal 1:

> *I would also recommend that mathematics teachers further their studies in mathematics in order to become lifelong learners. When they enrol for courses that specialises in mathematics can assist in improving their mathematical content knowledge. This will make their learners having trust in them because learners trust teachers who are knowledgeable and capable to answer their problems.*

Principal 3:

> *Mathematics teachers must be motivated to specialise in mathematics other than others subjects in order to develop interest in the subject. Currently, young generation are reluctant to specialise in mathematics hence they need motivation. It is worrying that the country that the country keeps on outsourcing mathematics teachers from the other countries.*

Principal 6:

> *It is the responsibility of the principals to ensure that teachers are motivated. Currently, young generation do not want to specialise in mathematics when going to higher institutions, instead they prefer specialising with other than mathematics.*

It seems that furthering one's studies built confidence when it came to teaching the subject. This improved confidence could be transferred to learners through their observation of teachers' confidence, and might consequently translate to improved performance. Azano and Stewart (2015:583) support the finding indicating that teachers who participated in PD xperienced personal transformation and growth in their careers.

❖ *Attending workshops*

Attending workshops was found to be another strategy for how mathematics teachers can improve their teaching of the subject. Some principals mentioned that teachers should attend in-service training workshops organised by the DBE and be engaged in various topics. They indicated that if teachers attended workshops, they would be motivated to strive to make their teaching of mathematics content effective. They also mentioned that workshops taught teachers to use simple language that was acceptable and understood by learners.

Principal 4:

> *If teachers attend in-service training workshops organised by the district they get clarification on how to teach various topics.*

Principal 5:

> *At provincial or district level they need to take these teachers to workshops that can add value to the performance of learners.*

The researcher's view is that when teachers attended workshops, this would help them to use the correct language suitable for the learners. Furthermore, when teachers attended in-service training workshops organised by the DBE, they would be exposed to various methods of teaching the subject. Ultimately, learners would understand the subject better.

5.5.7.3 Curriculum advisors

The sub-theme that emerged from the interviews with the CAs included their recommendations on further developing teachers in mathematics.

- *CAs' recommendations on further developing teachers in mathematics.*

It was established that CAs recommended various ways that teachers could use to be developed in mathematics. These recommendations are stated and discussed in the paragraphs below.

❖ *Training teachers in suitable venues*

Training teachers in suitable venues was revealed as one of the CAs' recommendations on further developing teachers in mathematics. One of the CAs indicated that if there was extensive information that needed to be conveyed, teachers could not do this hastily. They selected a few teachers and invited them to attend residential courses. They would be put up in a hotel or lodge where they would stay for at least five days. Teachers' development focused on topics that were difficult to teach.

Curriculum advisor 1*:*

> *If there is huge information that needs to be trained teachers we do not perform training quickly in order to develop them well. Few schools are selected and invited to the suitable venue such as lodges or hotels. We usually train them the whole week and the focus is on the identified difficult topics.*

The idea was that this would help teachers to understand curriculum content well since the CAs would have enough time to interact with them. According to Baloyi (2015:106), teachers should participate in workshops in order to be developed in both pedagogical content knowledge and subject content knowledge.

❖ *Increasing time for PD programmes*

Increasing time for PD programmes was revealed to be another recommendation by CAs on developing teachers in mathematics. According to one of the CAs, time for conducting PD programmes for teachers needed to be increased because they did not want to spend time after hours at the workshops and wanted them to be over quickly.

Curriculum advisor1:

> *Time for teacher PD needs to be increased. Our workshops start in the afternoon at 12 o'clock and knock off at 2 o'clock. Our worry is that some teachers arrive late due to transport problems and when other teachers knock off, they also want to knock off*

and they have not fully work shopped. If our workshops would start in the morning all teachers can attend and benefit.

The finding might suggest that the DBE should arrange workshops early during the day, and the workshops should not stretch for very long period to reduce the tendency by some teachers to dodge the workshops. Cordingley et al. (2015:4) who indicated that PD programmes should last for a long time in order to allow teachers to understand the programme better support the finding.

❖ *Teachers' becoming lifelong learners*

Teachers' becoming lifelong learners was found to be another recommendation on further developing teachers in mathematics. According to one of the CAs, mathematics teachers should not spend more than three days without studying or reading up on the content of their subjects. They should read books written by different authors in order to study how they approached different problems. The other CA mentioned that teachers can attend conferences such as those organised by AMESA where there were different presenters presenting topics using different approaches.

Curriculum Advisor 1:

Another thing, a teacher should remain the student of himself or herself. This means the teacher should not spend more than three days without studying or reading the content of his / her own subject. He / she must read books written by different authors in order to learn how they approach different problems.

Curriculum Advisor 2:

We advise mathematics teachers to attend peer conferences. When there are conferences talking about mathematics it is good for them to attend because they can be exposed to many things. We have conferences such as AMESA where there are different presenters presenting different topics using different approaches. When

teachers attend such conferences it will assist them to know more than one way of teaching a topic.

This might suggest that lifelong learning or further study can equip teachers with new knowledge and skills and can afford them the opportunity to stay abreast of global education trends.

❖ *Collaborating with other teachers*

Collaborating with other teachers was an additional recommendation on further developing teachers in mathematics. One of the CAs indicated that when a teacher volunteered to share how they taught learners, it was like sharing a story. The teacher would know the story from the beginning to the end. In turn, other teachers could help the teacher to understand how things are done.

Curriculum Advisor 2*:*

The teacher must share good practices with other teachers. When a teacher volunteer sharing how he / she teach learners it is like sharing the same story. The teacher will attend up knowing they story from the beginning to the end. In turn, other teachers can help the teacher how things are done.

The researcher's take is that sharing best practices amongst teachers can assist them to gain new knowledge in relation to how they teach and assess. It may also assist them to pinpoint areas that need correcting, or challenges that require solutions as they listen and observe others share their practices. In line with the finding, Dollar and Mede (2019:209) indicated that reflective activities could be used by student-teachers and teachers to improve their teaching practice as well as to identify their weaknesses and strengths.

5.6 SUMMARY OF THE FINDINGS

The findings in this study were classified under seven themes. The first theme focused on how mathematics teachers can improve their qualifications through PD. All the participants agreed that mathematics teachers need to be engaged in PD programmes. According to Moekwa

(2020:130), when teachers participate in PD programmes they have an opportunity to improve their knowledge, skills, values and attitudes in terms of their profession. The study revealed that teachers are developed in different ways such as registering themselves with accredited institutions; reading subject related information; and attending workshops and subject meetings. It was found that CAs also contribute to the PD of teachers. Stephen (2018:227) mentions that some of the responsibilities of CAs are to give support to teachers and to ensure that curriculum delivery is adequately carried out in schools. Thus, the study revealed that CAs invite teachers to workshops in order to guide them on how to teach mathematics as a subject; develop materials for teachers to use during teaching and learning and conduct school visits to assist teachers in schools.

Theme 2 dealt with the challenges that can hinder PD of teachers when participating and implementing the learning gained in thei classrooms. Stephen (2018:227) shows that most teachers lack commitment and accountability towards their profession. In relation to this, it was found that most mathematics teachers lack interest to participate in PD; are unwilling to further their studies and display a lack of teamwork, all of which have a negative impact on implementing PD. Again, Shikalepo (2018:253) emphasises that rural schools should be provided with adequate resource materials in order to deliver appropriate learning and teaching. However, it was found that most schools lack resources such as classrooms and resource materials which pose a challenge to teachers in teaching some topics. It was also indicated that in the district there is a shortage of Mathematics CAs (Stephen, 2018:229) which suggests that teachers do not get adequate support from them.

Theme 3 dealt with how teachers are inspired to participate in PD. According to Bantwini (2019: 226), teachers should be given support to help them overcome contextual problems and to master their teaching strategies. Thus, the study revealed various ways that can be used to encourage teachers participating in PD. Some of the ways included principals communicating the benefits of PD; leading by example; conducting PD that addresses their specific needs and offered incentives. Teachers are also motivated to participate in PD by being CAs conducting workshops professionally. According to Stephen (2018: 232), CAs should make sure that they collaborate with teachers to avoid causing unnecessary friction between them by ensuring that they address their challenges correctly. The findings revealed that teachers are encouraged to participate in PD through sharing their best practices; participating in assessment, and conducting workshops in an organised way.

Theme 4 focused on how PD programmes of teachers contribute to the performance of learners in schools. The findings were that when teachers participate in various PD, their learners adopt different approaches to learning; they get motivated to learn; gain confidence in their teachers; develop a positive attitude towards mathematics and improve their performance in the subject. This finding is supported by Moekwa (2020:133) who indicates that when teachers attend learning committee activities they ultimately acquire educational information and new teaching approaches which improve the performance of learners.

Theme 5 discussed the teachers' capabilities acquired during the participation in PD programmes. According to Dayal and Cowie (2019:115), when teachers attend workshops they learn many things that are important to their career. The scholars indicate teachersa are developed in aspects such as assessing portfolios in mathematics; assessing students' learning; assessing learners in various ways and setting higher-order questions that promote learning mathematics in context. This study found that when teachers participate in PD, they learn several methods of teaching mathematics; improve content knowledge; and acquire skills to operate computers and manage the classroom.

Theme 6 delved into strategies that can be used to curb problems in PD implementation. Moekwa (2020:132) indicates that schools should be encouraged to interact with other schools to share and facilitate challenges that they encounter in terms of teaching subjects. This study revealed that a number of strategies can be used to curb challenges when implementing PD programmes. Some of them were that teachers should be supported continuously; the DBE should ensure that it employs young teachers and that they improve teachers' salaries.

The last theme was about recommendations on how mathematics teachers can improve in the subject. Some of these strategies were registering studies with institutions of higher education; collaborating with other teachers; using resource materials; and attending workshops. According to Manqele (2017:181), workshops were insufficient if they fail to solve teachers' contextual problems. Thus the scholar suggests that workshops should be on-going process.

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

CHAPTER 6
SUMMARY OF THE FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

6.1 INTRODUCTION

The aim of this study was to explore the role of PD in assisting teachers to improve mathematics achievements in rural schools of Mopani District. In order to obtain thick information about the study, the researcher interviewed mathematics teachers and school principals from the selected rural public schools in the Mopani District. The researcher also interviewed CAs who are responsible for mathematics in the district. This chapter focuses on aspects such as a summary of the findings of the study, the contribution of the study and the recommendations. However, the researcher first presents a summary of the chapters before presenting the other aspects.

6.2 SUMMARY OF THE CHAPTERS

Chapter 1 discussed the introduction and background of how PD of teachers in mathematics is conducted around the globe, in South Africa, and in the Mopani District. It also discussed the significance of the study which was supported by relevant literature regarding PD in mathematics. In addition, it discussed the statement of the problem; the main research question; the sub-questions which directed the study and the aim and objectives of the study. The chapter also contained a preliminary literature review which briefly explained the strategies that drive PD and the benefits of such development. It further discussed the theoretical framework using Guskey‘s (2002) theory of teacher change as the basis of the study, which supports PD in schools. Research design and methods were also discussed which included the research paradigm, population and sampling and trustworthiness. The study also discussed the delimitations and limitations of the study. Finally, the chapter clarified the concepts that had a bearing on the study.

Chapter 2 discussed different types of PD existing in selected developed and developing countries, South Africa, Limpopo Province and Mopani District in order to understand how teachers are developed both in general and in mathematics. The study also discussed the similarities and differences found in the literature review. Furthermore, the study discussed

how mathematics teachers are developed in the subject. Lastly, the benefits and challenges that hinder the participation and implementation of PD were discussed.

Chapter 3 discussed various theories and models that support PD of teachers in schools. The theories include Vygotsky's social cultural theory, and Guskey's theory of teacher change. Each theory plays its own role in the PD of teachers in schools. Vygotsky's social cultural theory indicates that human learning does not depend on single aspects, but that social interactions increase the learning process; while Guskey's theory of teacher change aims at developing teachers' new knowledge proficiently and promoting quality learning and teaching. The chapter also contains a section that explains how theories contribute to PD of mathematics teachers in the past and at present. Lastly, it discusses how ongoing support and feedback should be provided to teachers during their PD programmes.

Chapter 4 focused on the methodology used in the study. It also explained how the data collection process was conducted while investigating the implications of PD in rural schools in the Mopani District. Furthermore, it used an interpretive research paradigm, which comprised of ontology, epistemology and methodology. A qualitative research approach was used to explore how mathematics teachers are developed in schools. The study also used a case study research design. The other aspects included in the chapter were the data collection instruments, namely, individual, in-depth semi-structured interviews and the data collection process, which indicated how the researcher prepared for the interviews and interacted with the participants. The chapter also described sampling strategies of snowball and purposive sampling to select suitable participants from the rural schools in the Mopani District; the trustworthiness of the study; and ethical considerations.

Chapter 5 dealt with research findings and data analysis. It also discussed biographical information of the participants. Furthermore, it presented the research questions and themes in a tabular form. There were seven emerged themes. These themes include how teachers improve their qualifications in terms of PD in mathematics; challenges encountered by teachers when participating in PD, and how mathematics are inspired to engage in PD. Other themes are how PD of teachers contributes to the performance of learners; teachers capabilities' acquired during their participation in PD programmes; strategies that can be used to curb problems in PD in mathematics; and how teachers should engage in PD in mathematics. Findings were discussed under each theme.

6.3 SUMMARY OF RESEARCH FINDINGS

The main findings are that teachers can improve their qualifications either by registering for courses with institutions of higher learnings, attending workshops at district level and participating in school-based programmes. The challenges encountered are a lack of resources, inviting teachers to workshops when they are already tired, difficult working conditions, and lack of interest by some teachers. The sources of inspiration for mathematics teachers to engage in PD are offers of bursaries by the DBE and private companies, sharing of best practices by teachers, participating in assessments such as Maths Olympiad and ANA and attending circuit meetings. Contributions made by teachers' PD to the improvement of learners' achievement in mathematics is that learners show improved academic performance, acquire different modes of learning and develop the motivation to learn.

Problems with PD are best dealt with through focusing on low-performing teachers, providing ongoing support to teachers, employing young teachers and improving teachers' salaries. Teachers' capabilities acquired through their participation in PD are that teachers gain an understanding of using pace setters, preparing lesson plans, setting formal tasks and interpreting policy documents. The following paragraphs present a summary of the themes and sub-themes.

6.3.1 Teachers' Professional Development and Enhancement of Knowledge in Teaching Mathematics

The study revealed that mathematics teachers can improve their qualifications through enrolling their studies with accredited institutions of higher education such as universities and colleges. They enrol for short courses and long courses that offer certificates, diplomas and degrees in order to acquire more skills and knowledge in the subject. Some teachers improve their qualifications in mathematics but others further their qualifications in other subjects because they believe that mathematics is very difficult. The study also found that teachers could be developed through school-based workshops and workshops organised at circuit and district level. It was found that when teachers attend workshops they improve on aspects such as subject content, classroom practices, lesson planning, lesson presentation and assessment techniques. According to the teachers, when there are workshops, principals should inform them in time so that they can be prepared and avoid arriving late at the workshops.

The study also revealed that teacher development is the core responsibility of the CAs. When there are changes that replace the old curriculum, CAs call teachers to workshops and train them. When information needs to be shared quickly, they invite teachers to subject meetings for two to three hours. Curriculum advisors also train teachers on how to implement CAPS in schools; for example, they trained teachers on how to use ATPs during the period of COVID-19 since some of the content was reduced. Furthermore, CAs develop materials for teachers. After developing these materials, they train teachers on how to use them and encourage them to read them. They also distribute materials to schools. In addition, they train HoDs to train their own teachers since it is not possible for all teachers to attend workshops. Teachers are sometimes engaged in group discussions and later requested to give feedback. The CAs sometimes create a platform for the teachers to share information in order to learn from one another. They guide teachers on how to use the correct methods of teaching learners and to approach questions in mathematics in order to teach their learners in schools. After teachers have submitted their files for moderation, they check their challenges and discuss them later during the workshops. Curriculum advisors also guide teachers on how to transfer marks correctly and set balanced question papers that correlate with Bloom's taxonomy. They also develop teachers through MASTEC programme that focuses on MST for three weeks in residential areas and, at the end of the programme, they are awarded certificates.

The study also revealed that teachers are developed in schools. At school level, teachers attend subject meetings in which they share issues regarding the subject. These meetings are facilitated by immediate seniors or subject heads who later give feedback to the principal. The school principals invite CAs to the schools to assist teachers on issues that challenge them. They also invite motivational speakers to motivate teachers to participate in PD programmes. Furthermore, the school principals conduct teacher development analysis in order to develop teachers according to their personal needs which are identified by checking teachers' qualifications and learners' work and by conducting class visits. After identifying their individual needs, they encourage them to study and provide them with valuable information that can help them to participate in PD. They also conduct staff meetings in which they give departmental feedback to teachers. Teachers are also developed through the IQMS and QMS where their weaknesses are identified in order to help them solve their challenges. The principals also develop teachers through delegating them to perform various school responsibilities in order to equip them with knowledge and skills.

6.3.2 Challenges Hindering PD of Mathematics Teachers in Rural Public Schools

This study revealed various challenges that hinder PD of mathematics teachers in rural public schools. The first challenge is a lack of resources. Mathematics teachers lack teaching aids such as fraction walls, counters, and building blocks when teaching geometry. The lack of resources forces teachers to teach learners in abstract form instead of using concrete objects. Teachers are also not given money to attend workshops and this discourages them from attending workshops since they have to use their own monies. It was also found that some teachers struggle to implement PD programmes. Some of the reasons include failure to attend workshops due to late release of invitations by district officials, lack of understanding of the PD programmes when the CAs are presenting and lack of necessary qualifications to teach mathematics because some teachers do not have mathematics as a teaching subject.

Another challenge was inviting teachers to workshops in the afternoon when they are already tired because they first have to go to work since DBE policies mandate that districts start workshops after 12 o'clock in the afternoon so as not to interrupt teaching time. It was found that when teachers arrive at the workshops they fall asleep when CAs are busy developing them, especially during summer because it is very hot. It was also found that some teachers arrive late at the workshops due to the shortage of transport. Curriculum advisors need to shorten some topics due to time constraints of training teachers, and they skip others. Ultimately the implementation of PD programmes is negatively affected.

The study also revealed that teachers work programmes contain too much information and teachers are expected to teach it within a short time. This forces teachers to skip some topics and they also do not complete them.

Another challenge was a shortage of CAs in mathematics. It was found that the Mopani District has only two mathematics CAs who are responsible for developing teachers and supporting them. Their scope of work also include conducting evaluations, workshops, continuous assessments and monitoring examinations and these activities seem to be overwhelming when it comes to implementing PD programmes.

Another challenge was difficult working conditions. It was found that learners come to school with cell phones and when teachers are busy teaching, they play music, watch pornography,

make a noise and bully one another. Teachers spend most of their teaching time calling them to order instead of teaching. In addition, classrooms are overcrowded with learners and this hinders teachers from teaching, supporting learners and monitoring school work due to lack of space. Furthermore, they are given more paperwork and other responsibilities such as supervising learners during breaks; participating in various sporting activities and committees; coaching learners and controlling class attendance which prevent teachers from working effectively.

It was also found that some teachers lack interest in improving their qualifications. Some of the reasons are that they use time and money when studying but after the completion of the study they do not get salary increases; they are nearing retirement age; and they struggle to use technology when studying. Most teachers also indicated that they were challenged by a lack of support from the DBE by CAs and at school level. They reported that it was rare for the CAs to come and support them in schools and, furthermore, their immediate supervisors did not support them adequately.

6.3.3 Sources of Inspiration for Mathematics Teachers to Engage in Professional Development

The study found various ways that can be used to inspire mathematics teachers to engage in PD. The first strategy is that DBE and private companies can offer bursaries to mathematics teachers in order to encourage them to study further since most of them fail to engage in PD due to lack of finances. Another strategy is to interact with other teachers who are studying and those who have completed their studies. The study found that experienced and qualified teachers can provide valuable information that would assist others to succeed in their studies. Some other strategies that can inspire teachers include giving awards to the best teachers; improving teachers' salaries and employing additional mathematics CAs. It was also revealed that teachers can be inspired by asking them provoking mathematical questions during workshops. According to the participants, this encourages teachers to ask for information from other teachers and read mathematics-related books in order to find answers. The other strategies include communicating the benefits of PD such as getting promotion posts and salary improvements that result from participating in the QMS; persuading teachers to participate in competitions such AMESA; leading by example; instilling interest in mathematics and encouraging them to improve their qualifications.

The study also revealed that teachers are encouraged to share their best practices; participate in assessment and attend workshops organised by the circuit. The study shows that teachers should be given an opportunity to discuss and share how they do things in their schools and to set a question paper in a group. The CAs should show teachers how things are done correctly. Lastly, teachers can be inspired to participate in PD when CAs conduct workshops in an organised way. It was found that if CAs start their workshops on time and keep the presentations short and to the point, teachers would be motivated to attend their workshops.

6.3.4 Contributions made by Teachers' Professional Development to the Improvement of Learners Achievement in Mathematics

The theme how PD of teachers contributes to the performance of learners comprises of two sub-themes. These two sub-themes include the value added by PD to the performance of learners and how PD of teachers contributes to the performance of learners. In terms of the value added by PD to the performance of learners it was found that PD of teachers helps in improving learners' performance; learners acquire different methods of learning and they get motivated to learn.

The study found that if teachers participate in PD, their learners improve their performance tremendously. This is because teachers teach learners with confidence and understanding. Consequently, learners gain good understanding of the subject. Professional development of teachers was also found to provide teachers with different methods of solving mathematical problems. In turn, teachers who participate in PD programmes have the advantage of providing opportunities for learners to work on their own and solve educational problems together, including the challenges that they face in life. The study also revealed that teachers who participate in PD become motivated to learn and interested in teaching their learners, and as a result their learners become motivated to learn and interested in their subject. Teachers who participate in PD also become confident when teaching their learners and they impart this cofidence to their learners. According to the study, learners do the work of teachers who are motivated or confident when teaching them and forsake the work for teachers who are not sure about their work.

6.3.5 Teachers' Capabilities Acquired During Their Participation in Professional Development in Mathematics

The findings regarding teachers' capabilities during their participation in PD in mathematics revealed that they gain knowledge in the subjects they teach. This knowledge assists teachers in gaining an understanding of how to use pace setters, prepare their lessons, set formal tasks, and interpret policy documents. They also acquire content knowledge as well as the correct method for teaching mathematics. The study also found that PD helps teachers to develop a spirit of ownership to the point that they become experts in their chosen areas. If teachers participate in PD, they become supportive when it comes to running the school. They do not leave the burden to the principal alone; instead, they work as a team to improve school issues. The study also revealed that when teachers participate in PD they have a better chance of being promoted to higher positions such as HoDs, deputy principals, principals and CAs. Professional development also helps teachers to improve their teaching practice. When teachers are well-developed, they raise the performance of the learners.

Other capabilities that teachers gain include acquiring skills to use computers and assess formal tasks. Teachers acquire computer skills when they set questions since they are not permitted by the CAs to use handwritten question papers. Formal assessment tasks skills are acquired in the workshops when they are developed to set projects, assignments, investigations, and tests. The study also found that teachers acquire listening skills during workshops. When CAs present their information well, teachers are bound to listen. Another capability that teachers acquire during PD includes classroom management skills. This skill helps teachers to manage learners well which is needed for effective teaching and learning.

6.3.6 Strategies that can be used to Curb Problems in Professional Development Implementation

The study identified various strategies that can be used to curb problems in PD implementation. The strategies include PD focusing on low-performing teachers; ongoing support of teachers; employing young teachers and improving teachers' salaries. The study revealed that PD should focus on low-performing teachers in order to encourage participation in school issues. Teachers who perform well should be selected to assist and coach teachers who under-perform. In terms of ongoing support of teachers, it was found that teachers need continuous support through

classroom observations, school-based workshops, provision of resources, constant monitoring and feedback. At school level, mathematics teachers need to be supported by HoDs who are qualified to teach mathematics, while at district level CAs should come to schools and give support to the teachers. The study also revealed that young teachers should be employed to curb problems in implementation of PD. In terms of this strategy, young and energetic teachers still regard the teaching career as an adventure should be employed in order to solve PD implementation. When such teachers are available, they should be given thorough support so that they can maximise their PD. Another strategy that can be used to curb problems in PD implementation is improving teachers' salaries. The findings revealed that teachers are demotivated due to low salaries that they get. To solve this problem, it was suggested that the DBE should apply notch increases for the teachers who complete their studies. Again, the DBE should acknowledge teachers' years of experience in order to increase teachers' salaries.

6.4 THE STUDY'S CONTRIBUTION TO THE KNOWLEDGE

The study led to the development of a model for implementing PD in school-based teachers. This is a new model specifically developed by the researcher for a programme that can be used by DBE and schools in developing school-based teachers. The model is referred to as the **Professional Development Model for School-Based Teachers** and it can be used at various levels in schools. The model may also be adopted for use by other teachers based outside the school environment such as circuits and district offices and may include people from other sectors. The implementation of this new model can add value to teacher performance in all areas including the teaching of mathematics, which seems to be a challenge in most schools. The model addresses types or levels of PD. The first type focuses on the PD initiated at DBE level. This is where the DBE through its CAs conducts PD programmes that aim at imparting knowledge and skills to teachers. Teachers are not responsible for running these programmes since they are planned at a higher level. The second type of PD focuses on the PD that is initiated at the school level. Here, the responsibility rests with the school, especially the principal and HoDs who take the initiative to impart knowledge and skills to teachers, especially when they have identified a need or a gap in knowledge. The third type focuses on the PD that is initiated at the personal level. At the personal level, teachers take their own initiative and embark on lifelong learning by registering with institutions of higher learning and by reading to enrich themselves with new knowledge and skills. Figure 6.1 depicts the professional development model as devised by the researcher.

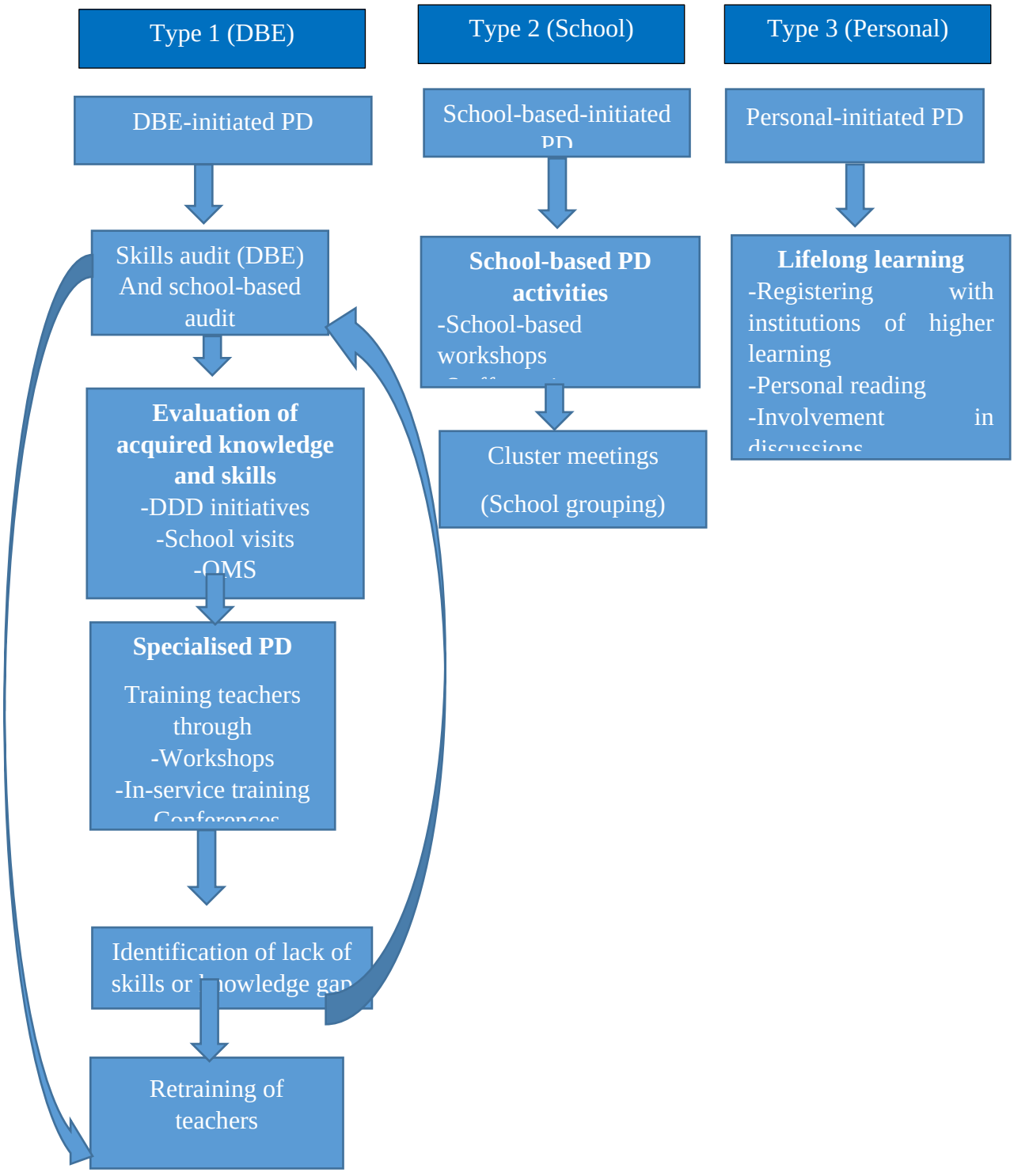

Figure 6.1: Professional development model for school-based teachers

(Author: Researcher)

6.4.1 Type 1: Department of Basic Education Initiated Professional Development.

The DBE-initiated PD is the first type of the professional development model for school-based teachers. In this phase, the DBE should conduct a skills audit through CAs. The DBE can access teachers' files and check the level of their qualifications. If the DBE finds a lack of skills and knowledge gaps in specific areas, it should conduct training of teachers. The training of teachers should focus on the identified challenges. It should be done through various activities including workshops, in-service training, conferences and seminars. For the effectiveness of these training programmes, the DBE should conduct them at suitable times and venues. The DBE should appoint qualified and knowledgeable facilitators who have the capacity to impart knowledge and skills by training teachers on any chosen subject.

After training, the DBE should conduct an evaluation of acquired skills and knowledge on trained school-based teachers. This exercise should be done through CAs. The CAs can perform school visits to check if teachers have implemented the programmes. The skills can also be evaluated through the QMS at school level. In the QMS, School Development Support Teams can assist in monitoring teachers' knowledge and skills through class observation to check if they have applied the acquired skills. The implementation of the skills can also be checked through whole school evaluation. If it is found that a large number of teachers still lack skills or knowledge on specific areas, DBE should repeat the process.

6.4.2 Type 2: School-based Professional Development

The second type of the professional development model for school-based teachers is school-based PD. In terms of the model, school-based PD should be conducted at school level through the collaboration of school SMTs and DBE through its CAs. The school should invite CAs to workshop teachers within the school environment. The focus will be on schools that exhibit a lack of skills and knowledge and general poor learner performance. The school-based workshops can also be organised by SMTs who will take the responsibility to train their own staff on specific areas that need attention. The SMTs can invite the teachers in the staff meetings to workshop them on the implementation of specific programmes such as the implementation of new curriculum. During staff meetings, they can also report information acquired from the DBE-initiated meetings. In addition, teachers can also be developed through subject committee meetings in which immediate supervisors for specific subjects will lead their

subject meetings. In these subject meetings, teachers can share challenges that they encounter in the subject such as learners' assessment, content knowledge, and teaching methods. The teachers involved can also share possible solutions for identified challenges. The immediate seniors can report the progress of the subject meetings to the school principal on a monthly basis for any support if needed.

Teachers can also be developed through cluster meetings. The schools within a particular area can collaborate and organise themselves as a cluster or group to share information on a particular subject. In a situation where clusters fail to find solutions to their common challenges, they can invite facilitators or experts to address them on the subject.

6.4.3 Type 3: Personal Professional Development

The third type of the professional development model for school-based teachers is personal PD. In this phase, teachers take the initiative to acquire knowledge and skills that would improve their level of teaching. Through taking their own initiative, teachers enrol for studies with institutions of higher learning that include colleges and universities, and eventually become lifelong learners. Teachers receive encouragement from various sources such as their colleagues, family members, and personal friends to embark on lifelong learning. In addition to becoming lifelong learners, teachers also embark on informal discussions in relations to education. These discussions serve to equip teachers through broadening their knowledge in terms of education development locally and internationally.

6.5 CONCLUSIONS

The study revealed that mathematics teachers improve their qualifications by enrolling with institutions of higher learning such as universities and colleges. When enrolling in these institutions, mathematics teachers engage in studying short and long courses such as certificates, diplomas, degrees, and honours degrees.

The study also found a myriad of challenges that hinder the PD of mathematics teachers, especially in rural public schools. These challenges include, among others, a lack of resources, unavailability of transport money to attend workshops, difficult working conditions, workshops starting late in the day resulting in teacher tiredness and lack of focus, and a lack of support

from the DBE. These challenges serve to hinder the PD of mathematics teachers, which consequently negatively affects learner performance in the mathematics subject.

In addition, the study found factors that serve as inspiration for mathematics teachers to engage in PD. These inspirational factors include the prospect of receiving bursaries either from the DBE or private companies and the prospect of engaging in positive interactions amongst teachers involved in studying and with teachers who have succeeded and have passed their studies. In addition, mathematics teachers are also said to be inspired by the prospect of receiving awards; improvement in their salaries; and the DBE appointing additional CAs for mathematics.

The study also found that PD of teachers contributes to the performance of learners. It found that learners acquire different methods of learning and are motivated to learn. In addition, PD helps teachers to teach with confidence and this motivates learners to learn with understanding.

Furthermore, the study found that when teachers participate in PD in mathematics they acquire a number of capabilities. These capabilities include knowing how to use pace setters and computers; preparing lesson plans; and setting formal tests. In addition, they also improve their content knowledge and classroom management skills.

The study also revealed the strategies that can be used to curb problems in PD implementation. These strategies include implementing PD focusing in low performing teachers; ongoing support of teachers by schools through HoDs and DBE through CAs; employing young teachers; and improving teachers' salaries to motivate them to participate in PD.

6.6 RECOMMENDATIONS

An exploration on of "Teachers' improvement of mathematics achievements in rural schools of Mopani District – implications for PD" has generated the following recommendations to remedy the challenges.

6.6.1 Recommendations in Respect of Challenges That Teachers Experience When Participating in PD in Mathematics

- Attending workshops late in the day was found to be a challenge that teachers experience when participating in PD in mathematics. It is, thus, recommended that the DBE, through its curriculum section, should convene and conduct workshops early in the day when teachers are still fresh.
- A shortage of mathematics CAs was also revealed as a challenge that teachers experience when participating in PD in mathematics. It is recommended that the DBE should create additional CA positions in order to appoint more mathematics CAs to augment the shortage of CAs in the department.
- Non-improvement of qualified teachers' salaries was found to be another challenge that teachers experience when participating in PD in mathematics. It is recommended that the DBE should prioritise improving the salaries of teachers who pursue additional qualifications as a way of motivating teachers to continue participating in PD programmes.
- Teachers being overburdened with responsibilities was also revealed as another challenge that teachers experience when participating in PD in mathematics. It is, thus, recommended that the DBE should reduce the amount of paperwork that teachers are expected to deal with. The reduction in paperwork would create more time for teachers to focus on PD and teaching and learning.

6.6.2 Recommendations in Respect of Challenges Encountered by Teachers When Implementing PD in Schools

- Overcrowding of learners in classes was found to be a challenge encountered by teachers when implementing PD in schools. It is, thus, recommended that the DBE should provide schools with additional classrooms to counteract the issue of overcrowding. In addition, the DBE should appoint additional teachers to take charge of the extra classes in schools.
- As the study revealed a lack of resources as a challenge encountered by teachers when implementing PD in mathematics, it is recommended that the DBE should provide schools with the required resources for the effective running of schools. These

resources might include adequate money in terms of Norms and Standards for School Funding that schools could use to provide much needed resources that would assist in achieve successful PD in schools.

- A lack of team work was also found to be a challenge encountered by teachers when implementing PD in mathematics. It is recommended that the DBE and schools, through their SMTs, should organise team-building activities that would strengthen team work in schools. These team-building activities could include weekends away and subject committee meetings.

6.6.3 Recommendations in Respect of the Challenges Encountered by CAs When Conducting PD in the District

The constant annual allocation of new subjects to teachers was found to be a challenge encountered by CAs when conducting PD in the district. It is, thus, recommended that schools, through their SMTs, should ensure subject allocation based on teachers' qualifications. This would mean that teachers teach subjects for which they are qualified.

6.7 FUTURE RESEARCH

This study was investigating teachers' improvement of mathematics achievements in rural schools of the Mopani District and it did not extend to the other areas of the country. Thus, the researcher recommends that additional studies focusing on PD of teachers in rural schools should be conducted on the topics suggested below in order to improve the profession of teachers in the country.

- A study to explore how the South African Council of Educators engage teachers in PD.
- A study to explore the experiences of principals in conducting PD of teachers in schools.
- A study to explore the perception of teachers on the value of participating in PD programmes.
- A study to explore how CAs conduct PD of teachers at the DBE level.
- A study to explore how mathematics teachers can be motivated to participate in PD.

- A study to explore the challenges that hinder teachers from participating in PD.

6.8 CONCLUDING REMARKS

Purposive sampling was used to select the participants who could provide rich information in their natural settings. The information provided cannot be generalised since it was only collected from the participants of Mopani districts. However, the study found that if teachers participate in PD programmes this would improve their profession and they would acquire capabilities that are necessary for their profession and to improve the performance of learners. The study also revealed the strategies that can be used to inspire teachers to engage in PD. In addition, it also discussed the challenges that could hinder PD and strategies that could be used to resolve them. The recommendations were developed based on the challenges revealed in order to assist the DBE to improve teaching profession.

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APPENDICES

APPENDIX A: PROOF OF REGISTRATION

UNISA university of south africa

1011

SAMBO S I MR
P O BOX 5436
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0826

STUDENT NUMBER : 44015593

ENQUIRIES TEL : 0861670411
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2022-05-03

Dear Student

I hereby confirm that you have been registered for the current academic year as follows:

Proposed Qualification: PHD (EDUCATION) (90019)

CODE	PAPER	S	NAME OF STUDY UNIT	NQF crdts	LANG.	PROVISIONAL EXAMINATION EXAM.DATE	CENTRE(PLACE)
Study units registered without formal exams:							
TFPCU01			PhD - Education (Curriculum Studies)	**	E		
@ TFPCU01			PhD - Education (Curriculum Studies)	**	E		

@ Exam transferred from previous academic year

You are referred to the "MyRegistration" brochure regarding fees that are forfeited on cancellation of any study units.

Your attention is drawn to University rules and regulations (www.unisa.ac.za/register).
Please note the new requirements for reregistration and the number of credits per year which state that students registered for the first time from 2013, must complete 36 NQF credits in the first year of study, and thereafter must complete 48 NQF credits per year.
Students registered for the MBA, MBL and DBL degrees must visit the SBL's ESOnLine for study material and other important information.
Readmission rules for Honours: Note that in terms of the Unisa Admission Policy academic activity must be demonstrated to the satisfaction of the University during each year of study. If you fail to meet this requirement in the first year of study, you will be admitted to another year of study. After a second year of not demonstrating academic activity to the satisfaction of the University, you will not be re-admitted, except with the express approval of the Executive Dean of the College in which you are registered. Note too, that this study programme must be completed within three years. Non-compliance will result in your academic exclusion, and you will therefore not be allowed to re-register for a qualification at the same level on the National Qualifications Framework in the same College for a period of five years after such exclusion, after which you will have to re-apply for admission to any such qualification.
Readmission rules for M&D: Note that in terms of the Unisa Admission Policy, a candidate must complete a Master's qualification within three years. Under exceptional circumstances and on recommendation of the Executive Dean, a candidate may be allowed an extra (fourth) year to complete the qualification. For a Doctoral degree, a candidate must complete the study programme within six years. Under exceptional circumstances, and on recommendation by the Executive Dean, a candidate may be allowed an extra (seventh) year to complete the qualification.

BALANCE ON STUDY ACCOUNT: 0.00

Yours faithfully,

Prof M S Mothata
Registrar

0108 O 00 0

UNIVERSITEIT VAN SUID-AFRIKA PRETORIA UNIVERSITY OF SOUTH AFRICA

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

APPENDIX B: UNISA ETHICS CLEARANCE CERTIFICATE

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2018/11/14

Ref: **2018/11/14/44015593/60/MC**
Name: Mr SI Sambo
Student: 44015593

Dear Mr Sambo

Decision: Ethics Approval from 2018/11/14 to 2023/11/14

Researcher(s): Name: Mr SI Sambo
E-mail address: 44015593@mylife.unisa.ac.za
Telephone: +27 83 275 4604

Supervisor(s): Name: Prof TI Mogashoa
E-mail address: mogasti@unisa.ac.za
Telephone: +27 76 372 5084

Title of research:

The role of professional development of teachers in improving mathematics in rural schools in the Mopani district

Qualification: PhD in Curriculum and Instructional Studies

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2018/11/14 to 2023/11/14.

*The **low risk** application was reviewed by the Ethics Review Committee on 2018/11/14 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing.
5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
7. No field work activities may continue after the expiry date **2023/11/14**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number **2018/11/14/44015593/60/MC** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Kind regards,

Prof AT Motlhabane
CHAIRPERSON: CEDU RERC
motlhat@unisa.ac.za

Prof V McKay
EXECUTIVE DEAN
Mckayvi@unisa.ac.za

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

APPENDIX C: LETTER TO LIMPOPO DEPARTMENT OF EDUCATION REQUESTING PERMISSION TO CONDUCT RESEARCH

Enq: Sambo SI, 072 807 3695/ 083 275 4604 P.O.BOX 5436

Email address: samboisaac01@gmail.com GIYANI 0826

22 October 2018

The Director: Planning and Research

Limpopo Department of Education

Private Bag x 9489

Polokwane

0700

Dear Sir/Madam

APPLICATION TO CONDUCT RESEARCH IN LIMPOPO: MOPANI DISTRICT

I, Sambo Sosa Isaac, intend undertaking research under the supervision of Prof T I Mogashoa, an associate professor in the Department of Curriculum and Instructional Studies, for a PH D degree at the University of South Africa. I, hereby, request permission to conduct research interviews with the principals, teachers and curriculum advisors attached to rural schools in the Mopani district.

My research topic is: The Role of Professional Development for Teachers in Improving Mathematics in Rural Schools in the Mopani District. The aim of the study is to explore the role of professional development for teachers in improving Mathematics in the rural schools in the Mopani district.

The outcome of the study will help teachers in rural schools implement educational programmes effectively. The study will also assist educational authorities to be more aware of the importance of involving rural schools in the planning of professional development programmes and in policy-making. This study will have no risks for the participants. There will be no imbursement or incentives for participation in the research. Feedback procedures will include providing copies of the research report to the schools that participated in the study and discussing the findings and recommendations with the participants. I will also send a copy of the report to the Department of Education through the University of South Africa.

The dates and times for interviews that will take place at the schools will be mutually agreed upon with the participants. I will endeavour to ensure that the research does not interfere with participants teaching time and obligations

. Yours faithfully

_____

S I Sambo

APPENDIX D: PERMISSION FROM THE LIMPOPO DEPARTMENT OF BASIC EDUCATION

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

CONFIDENTIAL

Ref: 2/2/2 Enq: Mabogo MG Tel No: 015 290 9365 E-mail:MabogoMG@edu.limpopo.gov.za

Sambo SI
PO Box 5463
Giyani
0826

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

1. The above bears reference.

2. The Department wishes to inform you that your request to conduct research has been approved. Topic of the research proposal: **"THE ROLE OF PROFESSIONAL DEVELOPMENT OF TEACHERS IN IMPROVING MATHEMATICS "**

3. The following conditions should be considered:

3.1 The research should not have any financial implications for Limpopo Department of Education.

3.2 Arrangements should be made with the Circuit Office and the School concerned.

3.3 The conduct of research should not in anyhow disrupt the academic programs at the schools.

3.4 The research should not be conducted during the time of Examinations especially the fourth term.

3.5 During the study, applicable research ethics should be adhered to; in particular the principle of voluntary participation (the people involved should be respected).

3.6 Upon completion of research study, the researcher shall share the final product of the research with the Department.

Cnr. 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X9489, POLOKWANE, 0700
Tel: 015 290 7600, Fax: 015 297 6920/4220/4494

4 Furthermore, you are expected to produce this letter at Schools/ Offices where you intend conducting your research as an evidence that you are permitted to conduct the research.

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

Best wishes.

25/06/2020

Mrs Dederen KO
Acting Head of Department

Date

APPENDIX E: PERMISSION LETTER TO CONDUCT RESEARCH IN MOPANI DISTRICT

Enq: Sambo SI, 072 807 3695/ 08327 54604

Email address: samboisaac01@gmail.com

P.O.BOX 5436

Giyani

0826

12 January 2020

The Senior District Manager

Department of Education

Mopani District

Private Bag x 578

Giyani

0826

Dear Sir/Madam

APPLICATION TO CONDUCT RESEARCH IN MOPANI DISTRICT RURAL SCHOOLS

I Sambo Sosa Isaac, intend undertaking research under the supervision of Prof T I Mogashoa, an associate professor in the Department of Curriculum and Instructional Studies, for a PHD degree at the University of South Africa. I, hereby, request permission to conduct research interviews with the principals, HODs, teachers, curriculum advisors and circuit managers attached to the selected schools in the Mopani District.

My research topic is: The Role of Professional Development for Teachers in Improving Mathematics in Rural Schools in the Mopani District. The aim of the study is to explore the role of the professional development of teachers in improving Mathematics teaching and learning in the rural schools in the Mopani District.

The outcome of the study will help teachers in rural schools implement educational programmes effectively. The study will also assist educational authorities to be more aware of

the importance of involving rural schools in the planning of professional development programmes and in policy-making. This study has no risks for, and does not offer incentives to, the participants. Feedback procedures will include providing copies of the research report to the schools and the circuit offices that participated in the study as well as discussing the report's findings and recommendations with the participants. I will also provide the copy of the report to the Mopani District and the Limpopo Department of Education.

The dates and times for the interviews at the schools will be mutually agreed upon with the participants. I will endeavour to ensure that the research process does not interfere with the schools' teaching time and obligations.

I trust that my request will receive your favourable consideration.

Yours faithfully

Sambo SI _____

APPENDIX F:PERMISSION FROM THE MOPANI DISTRICT

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

MOPANI

EAST DISTRICT

CONFIDENTIAL

Ref : 2/2/2 **ENQ: Ngobeni D Email: davidngobeni9@gmail.com** Date: 08.03. .2020

TO : SAMBO S.I

PERMISSION TO CONDUCT RESEARCH: THE ROLE OF PROFESSIONAL DEVELOPMENT OF TEACHERS IN IMPROVING MATHEMATICS IN RURAL SCHOOLS IN MOPANI DISTRICT

1. The above matter refers.
2. The Department wishes to inform you that your request to conduct research on the above mentioned Topic has been approved.
3. The following conditions should be considered:

3.1. Arrangement should be made with selected schools.

3.2. The research should not be conducted during Examinations especially the 4th term.

3.3. During research, applicable research ethics should be adhered to, in particular the principle of voluntary participation (the people involved should be respected).

3.4. Upon completion of the research study, the researcher shall share the final product of the research with the Department.

3.5. The research should not have any financial implications to the Department of Education Limpopo Province.

4. Furthermore, you are expected to produce this letter to schools and offices where you intend to conduct your research since it will serve as proof that you have been granted permission to conduct the research.

5. The Department appreciates the contribution that you wish to make and wishes you success in your research.

08. 03. .2020

……

pp ***DISTRICT DIRECTOR***

APPENDIX G: PARTICIPANT INFORMATION SHEET FOR A TEACHER

Date: _____

Title: **The Role of Professional Development for Teachers in Improving Mathematics in Rural Schools in the Mopani District**.

My name is Sosa Isaac Sambo. I intend undertaking research under the supervision of Prof T I Mogashoa, an associate professor in the Department of Curriculum and Instructional Studies, for a PH D degree at the University of South Africa.

I would like to invite you to participate in the study which is entitled: **The Role of Professional Development for Teachers in Improving Mathematics in Rural Schools in the Mopani district.** This study aims to collect important information that could assist all stakeholders concerned to understand the role of professional development for teachers in improving Mathematics in rural schools. You are invited because you are a Mathematics expert who has experience in teaching Mathematics and of being involved in professional development programmes for the subject. I obtained your contact details from your school principal.

The study involves face-to-face semi-structured interviews which will be audio-taped with your consent. The interview sessions will each take 20 to 30 minutes.

Participating in this study is voluntary and you are under no obligation to consent to participate. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are assured of complete anonymity, privacy and confidentiality of information that you give during the study. Your name will be allocated a code number or pseudonym and you will be referred in this way in the data, any publications or any other research reporting methods, such as in conference proceedings. You are free to withdraw at any time if you feel you would like to do so and you will not be bound to provide a reason. There are no potential benefits for participants except that by participating in the study the findings from the information you provide will assist to improve the performance of learners in Mathematics in your district. The purpose of the study is to understand the role of professional development for teachers in improving the teaching and learning of Mathematics in rural public schools.

There will be no negative consequences for you if you take part in the research project; no potential levels of inconvenience and/or discomfort for the participants; or foreseeable risks of harm or side-effects to potential participants.

All information collected during the study will be treated as confidential. Participant identities and records will be kept confidential. Participants will remain anonymous; their names and addresses will be removed and the interview data will be coded. What I hear and see during the course of the study will not be discussed with anyone. Coding will be used during the gathering of data and the processing of interview notes and the transcripts.

The records that identify you will be available only to people working on the study, unless you give permission for other people to see the records. A report of the study may be submitted for publication, but participants' names will not be identifiable because they will remain anonymous.

Hard copies of your responses to the interview questions will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet in his office for future research or academic purposes and all related electronic information will be stored on a password protected computer. Any future use of the stored data will be subject to further Research Ethics Committee review and approval, if applicable. Hard copies will be shredded and electronic copies will be permanently deleted from the hard drive of the computer by using a relevant software programme.

No payment or reward, financial or otherwise, for participating in the study will be offered. Participants will not incur any costs in the study. The researcher has applied for written approval from the Research Ethics Review Committee of the University of South Africa (UNISA) to conduct this study. A copy of the written application letter may be obtained from the researcher.

Should you have any concerns about the way in which the research has been conducted, you may contact my supervisor, Prof. T I Mogashoa, on 082 681 7934 or by email at mogasti@unisa.ac.za or my co-supervisor, Prof. G P Baloyi, on 072 201 9276 or by email at baloygp@unisa.ac.za.

Thank you for taking the time to read this information sheet and for participating in this study.

Yours faithfully

_____

S I Sambo

APPENDIX H: PARTICIPANT INFORMATION SHEET FOR THE PRINCIPAL

Date: _____

Title: **The Role of Professional Development for Teachers in Improving Mathematics in Rural Schools in the Mopani District**.

My name is Sosa Isaac Sambo. I intend undertaking research under the supervision of Prof. T I Mogashoa, an associate professor in the Department of Curriculum and Instructional Studies, for a PH D degree at the University of South Africa. I have received no funding for conducting the research project.

I would like to invite you to participate in the study which is entitled: **The Role of Professional Development for Teachers in Improving Mathematics in Rural Schools in the Mopani district.** This study aims to collect important information that could assist all stakeholders concerned to understand the role of professional development for teachers in improving Mathematics in rural schools. You are invited because you have many years' experience as a school manager who is responsible for the curriculum management of the school; your school has a large enrolment; and you are exposed to the various professional development programmes that take place at your school.

The study involves face-to-face semi-structured interviews which will be audio-taped with your consent. The interview sessions will each take 20 to 30 minutes.

Participating in this study is voluntary and you are under no obligation to consent to participate. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are assured of complete anonymity, privacy and confidentiality of information that you give during the study. Your name will be allocated a code number or pseudonym and you will be referred in this way in the data, any publications or any other research reporting methods, such as in conference proceedings. You are free to withdraw at any time if you feel you would like to do so and you will not be bound to provide a reason. There are no potential benefits for participants except that by participating in the study the findings from the information you provide will assist to improve the Mathematics of learners in your district. The purpose of the study is to understand the role of professional

development for teachers in improving the teaching and learning of Mathematics in rural public schools.

There will be no negative consequences for you if you take part in the research project; no potential levels of inconvenience and/or discomfort for the participants; or foreseeable risks of harm or side-effects to potential participants.

All information collected during the study will be treated as confidential. Participant identities and records will be kept confidential. Participants will remain anonymous; their names and addresses will be removed and the interview data will be coded. What I hear and see during the course of the study will not be discussed with anyone. Coding will be used during the gathering of data and the processing of interview notes and the transcripts.

The records that identify you will be available only to people working on the study, unless you give permission for other people to see the records. A report of the study may be submitted for publication, but participants' names will not be identifiable because they will remain anonymous.

Hard copies of your responses to the interview questions will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet in his office for future research or academic purposes and all related electronic information will be stored on a password protected computer. Any future use of the stored data will be subject to further Research Ethics Committee review and approval, if applicable. Hard copies will be shredded and electronic copies will be permanently deleted from the hard drive of the computer by using a relevant software programme.

No payment or reward, financial or otherwise, for participating in the study will be offered. Participants will not incur any costs in the study. The researcher has applied for written approval from the Research Ethics Review Committee of the University of South Africa (UNISA) to conduct this study. A copy of the written application letter may be obtained from the researcher.

Should you have any concerns about the way in which the research has been conducted, you may contact my supervisor, Prof. T I Mogashoa, on 082 681 7934 or by email at

mogasti@unisa.ac.za or my co-supervisor, Prof. G P Baloyi, on 072 201 9276 or by email at baloygp@unisa.ac.za.

Thank you for taking the time to read this information sheet and for participating in this study.

Yours faithfully

_____

S I Sambo

APPENDIX I: PARTICIPANT INFORMATION SHEET FOR A CURICULUM ADVISOR.

Date: _____

Title: **The Role of Professional Development for Teachers in Improving Mathematics in Rural Schools in the Mopani District**.

My name is Sosa Isaac Sambo. I intend undertaking research under the supervision of Prof. T I Mogashoa, an associate professor in the Department of Curriculum and Instructional Studies, for a PH D degree at the University of South Africa. I have received no funding for conducting the research project.

I would like to invite you to participate in the study which is entitled: **The Role of Professional Development for Teachers in Improving Mathematics in Rural Schools in the Mopani district.** This study aims to collect important information that could assist all stakeholders concerned to understand the role of professional development for teachers in improving Mathematics in rural schools**.** You are invited because you monitor the curriculum; support teachers; and facilitate professional development programmes for Mathematics teachers in the Mopani district. I obtained your contacts from the office of the Chief Education Specialist for the Mopani district. The study involves face-to-face semi-structured interviews which will be audio-taped with your consent. The interview sessions will each take 20 to 30 minutes.

Participating in this study is voluntary and you are under no obligation to consent to participate. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are assured of complete anonymity, privacy and confidentiality of information that you give during the study. Your name will be allocated a code number or pseudonym and you will be referred in this way in the data, any publications or any other research reporting methods, such as in conference proceedings. You are free to withdraw at any time if you feel you would like to do so and you will not be bound to provide a reason. There are no potential benefits for participants except that by participating in the study the findings from the information you provide will assist to improve the Mathematics of learners in your district. The purpose of the study is to understand the role of professional

development for teachers in improving the teaching and learning of Mathematics in rural public schools.

There will be no negative consequences for you if you take part in the research project; no potential levels of inconvenience and/or discomfort for the participants; or foreseeable risks of harm or side-effects to potential participants.

All information collected during the study will be treated as confidential. Participant identities and records will be kept confidential. Participants will remain anonymous; their names and addresses will be removed and the interview data will be coded. What I hear and see during the course of the study will not be discussed with anyone. Coding will be used during the gathering of data and the processing of interview notes and the transcripts.

The records that identify you will be available only to people working on the study, unless you give permission for other people to see the records. A report of the study may be submitted for publication, but participants' names will not be identifiable because they will remain anonymous.

Hard copies of your responses to the interview questions will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet in his office for future research or academic purposes and all related electronic information will be stored on a password protected computer. Any future use of the stored data will be subject to further Research Ethics Committee review and approval, if applicable. Hard copies will be shredded and electronic copies will be permanently deleted from the hard drive of the computer by using a relevant software programme.

No payment or reward, financial or otherwise, for participating in the study will be offered. Participants will not incur any costs in the study. The researcher has applied for written approval from the Research Ethics Review Committee of the University of South Africa (UNISA) to conduct this study. A copy of the written application letter may be obtained from the researcher.

Should you have any concerns about the way in which the research has been conducted, you may contact my supervisor, Prof. T I Mogashoa, on 082 681 7934 or by email at

mogasti@unisa.ac.za or my co-supervisor, Prof. G P Baloyi, on 072 201 9276 or by email at baloygp@unisa.ac.za.

Thank you for taking the time to read this information sheet and for participating in this study.

Yours faithfully

_____

S I Sambo

APPENDIX J: INFORMED CONSENT FORM FOR PARTICIPANTS

Contact No.: 072 807 3695
Email address: samboisaac01@gmail.com

30 September 2018

I, ---------- (participant's name), confirm that the person asking for my consent to take part in this research has told me about the nature, procedures, potential benefits and any anticipated inconvenience for my participation.

I have read (or had explained to me) and understand the study as explained in the information sheet. I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty. I am aware that the findings of this study will be processed in a research report, journal publications and/or conference proceedings and that my participation will be kept confidential unless otherwise specified.

I agree to the audio recording of the interviews and I have received a signed copy of the informed consent agreement.

Participant's name and surname (please print) _____

_____ _____

Signature Date

Researcher name and surname: SAMBO SI

_____ _____

Researcher's Signature Date

APPENDIX K: INTERVIEW QUESTIONS

A. MATHEMATICS TEACHERS

1. What can you do to improve your qualifications in Mathematics?
2. To what extend do you recommend that teachers should attend PD in mathematics?
3. What do you think the principal can do to develop you in your profession?
4. What do you think the Department can do to develop you in your profession?
5. What strategies do you believe can assist you to develop yourself in your profession?
6. What challenges do you experience when participating PD in mathematics?
7. What challenges do you encounter when implementing PD in schools?
8. What do you think can be done to inspire you to participate more in your own professional development?

B. PRINCIPALS

1. What do you do as a principal to develop teachers in their profession?
2. What recommendations can you make to improve teachers in Mathematics?
3. How do you manage PD in your school?
2. How do the strategies you use to develop teachers help them in their profession?
3. What value do you think PD adds to the performance of learners in Mathematics?
4. How do you inspire Mathematics teachers to participate in PD?
5. What do you think the Department can do to encourage teachers to participate in PD?
6. What challenges do you encounter when it comes to the implementation of PD?
7. What do you believe should be done to curb problems in PD implementation?
8. Is there anything you would like to add?

C. CURRICULUM ADVISORS

1. What do you do as a curriculum advisor to develop teachers in Mathematics?
2. What advice do you give teachers before they implement PD?
3. What recommendations can you make to further develop teachers in Mathematics?
4. How do you interact with teachers during PD?
5. What strategies do you use to improve the qualifications of Mathematics teachers?

6. What abilities/skills do teachers acquire when they participate in PD programmes?
7. How do you encourage teachers to participate in your PD programmes?
8. What are the benefits of PD for teachers with regard to the performance of learners in Mathematics?
9. What challenges do teachers face when they implement PD in schools?
10. What challenges do you encounter as a curriculum advisor when conducting PD in the district?
11. Is there anything you would like to add?

APPENDIX L: BIOGRAPHICAL INFORMATION OF THE TEACHERS

1. When did you start teaching? _____
2. Age (How old are you?) _____
3. What are your specialist subjects? _____
4. When did you start teaching Mathematics? _____
5. What is your professional qualification? _____
6. Beside your professional qualification, have you been awarded any further qualification?

   _____
7. What additional qualifications were you awarded? _____
8. Do you enjoy teaching Mathematics and why?

   _____

APPENDIX M: TURNITIN REPORT

APPENDIX M: TURNITIN REPORT –SAMBO SI

TEACHERS IMPROVEMENT OF MATHEMATICS ACHIEVEMENTS IN RURAL SCHOOLS OF MOPANI DISTRICT-IMPLICATIONS FOR PROFESSIONAL DEVELOPMENT

Revised Thesis 3 for Sambo Sosa Isaac student No: 44015593

ORIGINALITY REPORT

10%	9%	2%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

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The first page of your submissions is displayed below.

Submission author: Sosa Isaac Sambo
Assignment title: Revision 3
Submission title: Revised Thesis 3
File name: FINAL_THESIS_SAMBO_SI_TURNITIN_23_NOVEMBER_2022.docx
File size: 415.83K
Page count: 220
Word count: 78,215
Character count: 435,209
Submission date: 23-Nov-2022 02:32PM (UTC+0200)
Submission ID: 1961998955

APPENDIX N: CONFIRMATION OF LANGUAGE EDITING

Blue Diamonds Professional Editing Services (Pty) Ltd
Polishing **your** brilliance
Email: jacquibaumgardt@gmail.com
Website: www.jaybe9.wixsite.com/bluediamondsediting

30 November 2022

Declaration of professional editing

Teachers improvement of mathematics achievements in rural schools of Mopani District –Implications for professional development
By
Sambo Sosa Isaac

I declare that I have edited and proofread this thesis. My involvement was restricted to language usage and spelling, completeness and consistency and referencing style. I did no structural re-writing of the content.

I am qualified to have done such editing, being in possession of a Bachelor's degree with a major in English, having taught English to matriculation, and having a Certificate in Copy Editing from the University of Cape Town. I have edited more than 400 Masters and Doctoral theses, as well as articles, books and reports.

As the copy editor, I am not responsible for detecting, or removing, passages in the document that closely resemble other texts and could thus be viewed as plagiarism. I am not accountable for any changes made to this document by the author or any other party subsequent to the date of this declaration.

Sincerely,

Dr J Baumgardt
UNISA: D. Ed. Education Management
University of Cape Town: Certificate in Copy Editing
University of Cape Town: Certificate in Corporate Coaching
Full member: Professional Editors Guild (BAU001)
Intermediate member: Chartered Institute of Editors and Proofreaders (CIEP 21858)