A Participatory Action Research approach to the professional development of veteran primary school mathematics teachers

By

Caroline Nelisiwe Mahlangu

Submitted in partial fulfilment of the requirements for the degree

MAGISTER EDUCATIONIS

Department of Humanities

Faculty of Education

at the

UNIVERSITY OF PRETORIA

Name of supervisor: Prof Pieter Du Toit

July 2020

DECLARATION

I, Caroline Nelisiwe Mahlangu, student number 11362996, hereby declare that this dissertation – "*A Participatory Action Research approach to the professional development of veteran primary school mathematics teachers",* which is submitted in accordance with the requirements for the degree in curriculum development and instructional design at the University of Pretoria – is my original work and has not been previously submitted by me or any other student for a degree to any other tertiary institution. All sources employed or quoted in this dissertation are acknowledged with a precise list of references.

C.N MAHLANGU

Researcher

ABSTRACT

Research has shown that South African mathematics performance is extremely poor compared to other countries that participated in the Trends in Mathematics and Science Study in 2015 and 2016, respectively. Most of the competing countries were developing and were disadvantaged by their socio-economic status compared to the more economically vibrant South Africa. However, South Africa came last in the mathematics and science standardised tests commonly referred to as the Annual National Assessment and National Benchmark Test. The poor performance of the country's learners in mathematics is exacerbated by the inability of veteran mathematics teachers to adopt technological teaching methods and innovations during teaching and learning.

The Mathletics programme is a modern teaching tool that links every aspect of mathematics teaching and learning and gives individual learners the ability to successfully engage in mathematics learning activities. The learner gains mental mathematics skills to solve mathematical problems and is then able to apply the acquired mathematical skills to solve similar mathematical problems in any given situation. This study aimed to investigate and develop the professional status of veteran primary school mathematics teachers through participatory action research to improve their understanding of the application of Mathletics during teaching and learning.

The data for my study was collected via audiotape, semi-structured interviews, and participant observations. The participants were veteran mathematics primary school teachers between the ages of 40 and 59 from the Gauteng Department of Education, Tshwane South District Circuit 2. The interviews and observations were conducted at times and venues preferred by the participants at their respective schools.

The main research finding of the study shows that the majority of the participating veteran primary school teachers are not fully prepared in terms of skills, resources and methods to effectively respond to the recent technological teaching and learning transformations. As a recommendation, this study needs further research to benefit more schools and more teachers, so that participatory action research (PAR) can be a method for continuing professional development (CPD).

Key Terms: Participatory action research, Community of learning practice, Mathletics, veteran teachers, continuing professional development, action learning, peer mentoring, twenty-first century education.

ACKNOWLEDGEMENTS

In writing this dissertation, I received the support of many people from 2017 to 2018.

- My deep appreciation and thanks go to the One who gave me divine strength from the beginning of this journey to the end, the mighty God, Lord of lords, the first born of all creation – Jesus himself.
- Secondly, I thank my supervisor, who is now my father and my mentor, Professor Pieter Du Toit. I was fortunate to establish a warm and personally satisfying relationship with my supervisor; he challenged and supported the ideas I shared with him in a constructive and parental approach. I learned much from him. Above all, I learned that hard work, dedication, commitment and consistency are the rudimentary requirements for success in life.
- Thirdly, my special thanks go to my best friend, Dr. A.G. Adewusi, who gave me endless support both academically and spiritually. Through this gentleman, my personal relationship with God has developed deeper.
- Last but not least, my acknowledgement goes to the current HoD of the faculty of Humanities Department, Professor Johan Wassermann, for his leadership from the commencement to the end of my M.Ed. programme and for encouraging me to work speedily despite my health challenges. Thank you.
- Importantly, I appreciate Dr. Michelle Finestone and Dr. Alta Engelbrecht for academic guidance, and emotional and moral support.

DEDICATION

I dedicate this research to my late parents, my loving husband, F.F. Lafe, my in-laws, our beautiful girls, my siblings, my best friend and a brother, Dr. A.G. Adewusi. I further dedicate this work to all the novice researchers out there who are willing to grow in the journey of academia, I humbly say to them:

Let us make education a societal priority

ETHICAL CLEARANCE CERTIFICATE

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

RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE	CLEARANCE NUMBER: **HU 18/04/01**
DEGREE AND PROJECT	Whole Brain® participatory action research to enhance professional development of academic staff in higher education
INVESTIGATOR	Ms Caroline Mahlangu
DEPARTMENT	Humanities
APPROVAL TO COMMENCE STUDY	10 July 2018
DATE OF CLEARANCE CERTIFICATE	26 August 2019

CHAIRPERSON OF ETHICS COMMITTEE: Prof Liesel Ebersöhn

CC Ms Bronwynne Swarts
Prof Pieter Du Toit

This Ethics Clearance Certificate should be read in conjunction with the Integrated Declaration Form (D08) which specifies details regarding:

- Compliance with approved research protocol,
- No significant changes,
- Informed consent/assent,
- Adverse experience or undue risk,
- Registered title, and
- Data storage requirements.

EDITING CERTIFICATE

HESCOM
COMMUNICATION SERVICES

Translating.Writing.Editing

Hester van der Walt
HesCom Communication Services
Member: Professional Editors' Group
+27 84 477 2000

hester@hescom.co.za
633 Daphne Ave
Mountain View
0082

LANGUAGE EDITING STATEMENT

2020-04-16

A Participatory Action Research approach to the professional development of veteran primary school mathematics teachers
by Caroline Nelisiwe Mahlangu

- Has been edited for language correctness and spelling.
- Has been edited for consistency (repetition, long sentences, logical flow)
- Has been checked for completeness of list of references and cited authors.

No changes have been made to the document's substance and structure (nature of academic content and argument in the discipline, chapter and section structure and headings, order and balance of content, referencing style and quality).

HESTER VAN DER WALT

HESCOM
COMMUNICATION SERVICES

LIST OF ABBREVIATIONS AND ACRONYMS

ANA	Annual National Assessment
AP	Assessment Plan
CAPS	Curriculum and Assessment Policy Statement
CK	Content Knowledge
CLP	Community of Learning Practice
CPD	Continuing Professional Development
DBE	Department of Basic Education
ELRC	Education Labour Relations Council
FET	Further Education and Training
FP	Foundation Phase
GPLMS	Gauteng Provincial Literacy and Mathematics Strategy
IDSO	Institutional development and support official
IEA	Association for the Evaluation of Educational Achievement
IP	Intermediate Phase
LSE	Learner Support Educators
LTSM	Learning and Teaching Support Materials
NAEP	National Assessment of Educational Progress
NBT	National Benchmark Test
NPA	National Protocol for Assessment Grade R-12
NPPPPR	National Policy Pertaining to the Programme and Promotion Requirements Grade R-12
OECD	Organisation for Economic Co-operation and Development
PAR	Participatory Action Research
PCK	Pedagogical Content knowledge
PD	Professional Development
PISA	Programme for International Student Assessment
PK	Pedagogical knowledge
PLC	Professional Learning Community
SACE	South African Council for Educators
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
SASA	South African Schools Act No. 84 of 1996

SBST	School-Based Support Team
SIAS	Screening Identification Assessment and Support
SIP	School Improvement Plan
SMT	School Management Team
SNA	Support Needs Assessment
SP	Senior Phase
TIMSS	Trends in International Mathematics and Science Study
ZPD	Zone of Proximal Development

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1 INTRODUCTION AND ORIENTATION TO THE STUDY

1.1 INTRODUCTION

Technology is just a tool. In terms of getting the kids working together and motivating them, the teacher is the most important – Bill Gates.

Out of the extensive corpus of studies such as that of Henriksen, Mishra and Fisser (2016) and Ertmer and Ottenbreit-Leftwich (2010) on technology integration in teaching and learning, few have focused on developing teachers to effectively respond to and stay abreast of the contemporary learning and teaching of twenty-first century education teaching methods and the use of technological teaching resources. Utilising various resources and programmes to improve learner participation and performance in mathematics as a subject is still a challenge for teachers (Hilton, 2018). A large body of literature shows that the current education system is transforming due to the rapid changes impacting social and cultural areas of our lives; these changes are further accelerated by technology (Voogt, Erstad, Dede & Mishra, 2013; Collins & Halverson, 2018).

Worrying recent research shows that all these changes in twenty-first century education pose new and profound challenges to teachers because they are responsible for the what, how, why, where and when of the everyday curriculum and these teachers are inadequately prepared to implement all these changes during teaching (Day & Gu, 2009). Furthermore, one report after another shows that teachers are not well prepared for the rapid technological and curriculum changes taking place in the education sector (Spaull, 2013), especially South African veteran teachers who are working in township public primary schools (Venkat & Spaull, 2015). International and national literature has shown that mathematics performance is too poor when compared to the performance in other subjects. This is due to the myth posed by learners, teachers, parents, and the community at large that mathematics is a difficult subject (Bietenbeck, Piopiunik & Wiederhold, 2018). However, the focus of this study is on the context of the Gauteng Tshwane South District in South Africa. Recent

reviews agree that South African mathematics performance is extremely poor when compared to other countries, due to teachers' poor grasp of the pedagogical content of mathematics (McCarthy & Oliphant, 2013). Such reviews pertain to the countries that participated in the Trends in International Mathematics and Science Study (TIMSS) in 2015 and 2016, some of which are developing countries.

According to Kriek and Grayson (2009), the poor learner performance in mathematics is deeply rooted in the pedagogical content readiness of teachers; this poor performance is accelerated by rapid educational technology innovations regarding teaching and learning methods that are taking place (Dale, 2016). All these technological innovations in education, such as the Mathletics programme, put pressure on veteran teachers (Ryan & Bagley, 2015). Mathletics is a computer-based mathematics programme that delivers the curriculum to the learners, teachers, parents, guardians and education stakeholders by enabling the learning and teaching of mathematics to take place beyond the classroom (Malone & O'Shea, 2014). Mathematics teachers have pointed out that they have limited time for professional development; as a result, they fail to adapt to contemporary technological programmes such as Mathletics and recent teaching resources and methods (Meletiou-Mavrotheris & Mavrotheris, 2012). Research conducted by Shaffer and Thomas-Brown (2015) and Voogt, Erstad et al. (2013) indicates that veteran mathematics teachers are not adequately prepared to integrate Mathletics into their teaching and learning.

Literature by Strang (2017) demonstrates that Mathletics presents a tremendous challenge for teachers during teaching and learning; thus, they do not cover the stipulated curriculum due to limited acquisition in this area (Li, Worch, Zhou & Aguiton, 2015). As a result, learners fail to understand and acquire basic mental mathematical skills, knowledge and concepts (Cross, 2009). Teachers' ability to effectively integrate technology resources and programmes into their classroom during teaching and learning is the most essential skill that teachers need to acquire in the twenty-first century (Siddiq, Scherer & Tondeur, 2016). This skill will allow teachers to respond effectively to various learners' needs in accordance with their mathematical learning ability (Muir, 2014).

I am a beginner Mathematics and Natural Sciences Senior Phase (SP) teacher and a newly elected professional learning community (PLC) leader for Natural Sciences and Mathematics in the Tshwane South District (D4) Circuit 2. I have worked in three different schools so far (2015-2019) and during this time, I have observed that the majority of the veteran mathematics teachers encountered challenges in the application and understanding of educational technology programmes that are being introduced in workshops, specifically the Mathletics programme. Veteran teachers are also referred to as experienced teachers or teachers who have been actively teaching in the teaching profession for 15 years or more without any break in their service or any resignation (Carrillo & Flores, 2018). As a PLC leader, I mentor teachers in terms of their teaching methods, share with them and advise them about teaching and learning resources, work on the challenging topics in the curriculum together and assess their portfolios or preparation files. A portfolio or preparation file is a collection of the documents that serve as a guideline for teaching and learning; this includes the records of the teacher, learners and parents. In South Africa, the content of the teacher portfolio – also called the teacher preparation portfolio – is similar. It is guided by the Curriculum and Assessment Policy Statement (CAPS) and the portfolio includes the teacher's personal timetable, school timetable, Annual Teaching Plan (ATP), lesson plans, learning and teaching resources, assessment plans, formal assessment tasks, rubrics, diagnostic analysis of the results of learner performances, and pre-moderation and post-moderation tools that assess the quality and weighting of the content in relation to the stipulated curriculum. The portfolio also encompasses intervention and support for the learners who are academically struggling, and enrichment activities for learners who are performing well. It includes reports of the class visits for teachers by the heads of their departments (HoDs) or their immediate seniors to check their progress and provide necessary support, CAPS, National Protocol for Assessment (NPA), and the National Policy Pertaining to the Programme and Promotion Requirements Grade R-12 (NPPPPR). Added to this are minutes of meetings such as staff, departmental, phase or parents' meetings; workshop reports, district memos and circulars, assessments tasks, learner books, and examinations to see if the standard is aligned with the ATP. Afterwards, the researcher reports to subject advisors. It was noticed that numerous teachers, especially the veteran teachers, encounter challenges in implementing the programmes and tools that they received from the workshops and they hesitate to seek assistance. This was especially the case for the

more experienced teachers – referred to as veteran teachers in this study – who have been in the teaching profession for at least 15 years without any break in service or resignation (Day & Gu, 2009) and who do not feel comfortable about reaching out for assistance. In drawing on the experiences of these veteran mathematics teachers, the researcher intended to assist them and remind them that their presence matters in this profession.

Various reports show that the most trending technological programme in mathematics that is currently used nationwide is Mathletics (Muir, 2014; Nansen, Chakraborty, Gibbs, Vetere & MacDougall, 2012). Mathletics has tremendous benefits for both teachers and learners. However, the literature shows that the inadequacy of veteran mathematics teachers in using Mathletics is a major concern (Nansen et al., 2012). It is well known that mathematics is a crucial subject; this is evident in its empirical utilisation, as every individual applies mathematics to solve everyday life challenges. Mathematics is like the oxygen around us; it is there, but in some places is not noticeable and is only felt like the wind. Mathematics is one of the most essential and treasured core skills that is needed for everyday survival (Lee & Morgan, 2012). Today's world is filled with technological transformation; thus, there is a need for mathematics teachers to effectively upskill their pedagogical content knowledge (Budd, 2015).

The study conducted by the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) showed that the South African primary education system, especially in mathematics and reading, is not good when compared to 14 other counties. These included Botswana, Kenya, Mauritius, Mozambique, Namibia, Seychelles, Tanzania, and Uganda (Milner et al., 2008). The various contextual factors of each country and school determine the learners' performance, ability to read with comprehension and complete basic mathematical tasks appropriate for their age level. These contextual factors include the socio-economic, political and cultural setting of each country or school.

Most South African schools have an accepted level of traditional teaching and learning infrastructure, although the country is still behind with technological teaching and learning resources. It is evident that our government, especially in Gauteng, is pushing

towards paperless classrooms to meet the Fourth Industrial Revolution of integrating technology during teaching and learning. However, most veteran teachers are left behind due to their lack of skills in using technological programmes and gadgets. This calls for urgent, successful, effective, hands-on, self-directed participatory action research (PAR).

According to Burghes (2011), mathematics is used everywhere; for example, it is used in banks, by constructors, doctors, meteorologists, education specialists, engineers, psychologists, musicians, journalists, athletes and IT specialists. Primary mathematical knowledge is important for survival in the twenty-first century. Even if an individual does not wish to pursue mathematics as a career, the fact is that human nature is inseparable from mathematics; therefore, primary school mathematics should prepare learners to positively and actively partake in the ongoing economic prosperity of our country. This is only possible if learners acquire computation skills with an adequate theoretical and practical understanding of the subject matter; the integration of Mathletics will help them in this regard (Muir,2014).

This study aimed to investigate and develop the professional status of veteran primary school mathematics teachers by helping them acquire the relevant and contemporary skills required for the use of Mathletics during teaching and learning through a PAR approach. Veteran mathematics teachers are those who have been teaching mathematics for a long time. However, scholars find it difficult to define veteran teachers; they posit that a veteran teacher is someone who has been teaching for at 15 years or more (Orlando, 2014). These veteran teachers are also referred to as experienced teachers (Day & Gu, 2009). With my limited lived experience as a young teacher and a lead teacher in Gauteng Tshwane South District (D4) for Mathematics and Natural Sciences, I do not share the same sentiments as these scholars. I strongly hypothesise that a veteran teacher is a teacher who has been actively engaged in the educational context and who acquired knowledge, skills and values and openly shared the ups and downs of personal experience in the teaching profession to develop the teachers with whom he shares the PLC, regardless of the number of years worked. I also observed that some teachers have been in the teaching field for quite some time. However, they did not produce any helpful results; in that case, I do not think such a teacher deserves to be called a veteran. The word “veteran teacher” must be directly

proportional to the positive contributions that are brought to the development of the profession, teachers, schools, learners and the educational community at large, and not only reflect number of years.

The reason why veteran teachers find it difficult to adapt to the twenty-first century teaching system is that they were drilled more in terms of traditional methods of teaching. Moreover, they were trained to teach with poor technological resources and would only direct learners to learn through memorisation and recitation methods (Meletiou-Mavrotheris & Mavrotheris, 2012).

Literature asserts that educational technology was not thoroughly introduced in teacher education colleges during the pre-service training of the majority of veteran teachers during their teaching practice (Carrillo & Flores, 2017). As a result, this caused the veteran teachers to spend more time trying to adapt, with limited success and many difficulties (Orlando, 2014). In the twenty-first century, it is believed that modern teaching strategies should be based on the constructivist approach (Von Glasersfeld, 2006) with the ability to effectively utilise various technological tools that will enhance learners' instructional understanding; this falls under the connectivist approach (Muir, 2014).

The constructivist approach provides clear strategies to enable learners to make meaning out of the school curriculum by relating it to real-life contexts and linking prior knowledge to the new knowledge acquired. Hence, the curriculum must be realistic and relevant to the lives of these learners (Schweisfurth, 2011). Scholars, including Du Toit (2013), contend that when learners' ideas are implemented during the learning process, they gain more understanding. This will maximise learner participation during teaching and learning. However, various scholars believe that the most favoured teaching approach is connectivist in nature, which deals more with technological and online teaching and learning resources (Klinger, 2011). Moreover, scholars contend that constructivism is no longer flexible for the teaching of mathematics in this technological era. I hypothesise that constructivism blended with connectivism can improve the quality of education.

Based on the constructivist approach, the teacher should be an effective facilitator and assessor of learning, with the ability to integrate different teaching methods and pedagogies to empower learners to become actively engaged, reflect during the learning process and be willing to learn more by asking questions with the urge to gain a better understanding and be curious (Du Toit, 2013; Day & Gu, 2009). Learners in this era are different from learners of the past in terms of their social and cultural context; thus, their way of learning is quite different from that of the previous generation (Slabbert, De Kock & Hattingh, 2009). This implies that education needs to transform and meet the learning needs of these learners in such a way that it will prepare them for the future workplace (Du Toit, 2012). However, this cannot be accomplished if teachers are not taken into consideration during the design of the curriculum and other policies related to teaching, learning and the well-being of the learners. Because teachers are in direct contact with learners, they know the strengths, weaknesses, opportunities and threats to the learners. Various researchers, including Condie and Livingston (2007) and Du Toit (2014), assert that the professional development of teachers should take place to ensure that teachers are re-skilled and developed to acquire modern teaching and learning methods, pedagogies for them to offer quality teaching.

The study conducted by Zain, Rasidi and Abidin (2012) shows that teaching and learning is now learner centred (Du Toit, 2012). This implies that learners must be able to link their personal experiences with the competencies they master during teaching and learning. This enables them to construct meaning from what they learn and also to see the relevance of what is being learnt in school and make connections to their everyday lived experiences as entailed in the theory of constructivism (Bada & Olusegun, 2015). This will maximise the participation of learners “and improve their understanding of the content and enable them to think critically and apply the mastered skills in real-life situations that require higher-order thinking skills, critical analysis and creativity” (Dole, Bloom & Kowalske, 2016).

By implication, it is important for veteran mathematics teachers to partake in professional development in Mathletics and other technological online learning platforms. This will enable them to acquire a better understanding of how to effectively integrate Mathletics into teaching and learning to ensure that learners acquire basic

mathematical skills, competencies, values, problem-solving skills and knowledge at primary school level which will assist them to effectively solve the complex and routine challenges that require mathematical knowledge (Bate, 2010). Scholars such as Smit and Du Toit (2016) contend that professional development increases lecturers' content ability and maximises their pedagogical knowledge, their competencies and skills in the institutions of higher education. I therefore hypothesise that professional development will afford equivalent results if applied in the primary school context; thus, veteran teachers can adapt contemporary classroom teaching and learning methods if they can engage in professional learning communities (PLC) with newly qualified teachers, while continuing to improve their professional status.

The communities of learning practice allow for peer mentoring between newly appointed teachers and veteran teachers to be proactive in the development of their professional skills (Darling-Hammond, Wei, Andree, Richardson & Orphanos, 2009).

1.2 BACKGROUND TO THE STUDY

Independent research supported by Modisaotsile (2012) on mathematics learning and teaching in South Africa shows that the poor performance in this country is extremely high, compared to other African countries (Carnoy, Chisholm & Baloyi, 2008). The international study conducted by the Human Sciences Research Council (HSRC) and the International Association for the Evaluation of Educational Achievement (IEA) on the Trends in International Mathematics and Science Study (TIMMS) raises an urgent need to diagnose the mathematical challenges faced in education in this country to correct and remediate the current disheartening mathematics performance (Venkat & Spaull, 2015).

1.3 PROBLEM STATEMENT

Very few articles about the use of Mathletics during teaching and learning have been published due to teachers "limited acquisition in this area" (Muir, 2014). The inadequacy of veteran primary school teachers in applying Mathletics has been a major concern (McKeown, 2015). According to Nansen et al. (2012), the inability of

teachers to use Mathletics has contributed to the poor learner performance in mathematics. It is thus essential for mathematics teachers to actively engage in professional development (PD) to reskill themselves to meet contemporary education standards .Improving mathematics performance in South Africa has been a focus for educational leaders, researchers, scholars, curriculum developers, teachers and other educational stakeholders (Spaull & Kotze, 2015). The poor performance in mathematics is linked to teachers' professional readiness (Tshabalala & Ncube, 2016). Most South African mathematics teachers do not make the teaching of mathematics practical, engaging or exciting. Learners are denied the opportunity to actively engage in lessons during teaching and learning due to the limited acquisition of teachers in mathematics. Teachers are still integrating the traditional teaching methods during teaching and learning, thus preventing learners asking questions, because they do not want their lack of knowledge to be exposed (Adler, 2017).

According to Tshabalala and Ncube (2016), most teachers lack pedagogical content knowledge. When teachers have to deal with topics that they do not understand and related principles they cannot apply, as is expected of learners, often these teachers absent themselves from school and when they come back, they move forward without completing the curriculum. Hence, learners miss out on the most important basic mathematical content and related competencies and they intentionally skip that particular content; teachers are aware that their limited understanding of a certain topic directly affects the learner performance (Zakharov, Tsheko & Carnoy, 2016). Some teachers simply skip the topics that they do not understand without seeking help from their fellow teachers because of the fear of being judged. International studies show that countries like China, Japan, Taiwan, Thailand and Singapore scored high in the international comparative Programme for International Student Assessment (PISA) and TIMSS studies because their Communities of Learning Practice (CLP) are functional (Mullis, Martin, Foy & Arora, 2012). This was shown to be because learners and teachers actively engaged in technologically integrated practical activities where they learnt, taught and shared information (Voogt, Erstad et al., 2013). The 2015 TIMSS report results are further represented in Table 1.1 on the next page.

Table 1: 2015 TIMSS performance (Reddy et al., 2016)

Summary of South African Performance on 2015 TIMSS			
International Benchmark	**Grade 5**	**Grade 9**	
	Mathematics	**Mathematics**	**Science**
Advanced (>625)	1%	1%	1%
High (550-625)	4%	3%	4%
Intermediate (475-550)	12%	10%	9%
Low(400-475)	22%	21%	18%
Potentials (325-400)	28%	35%	28%
Not Achieved (<325)	33%	31%	40%

Scholars, including Kafyulilo, Fisser and Voogt (2016), posit that teachers should indulge in continuing professional development (CPD), attend seminars and workshops, and engage in the cluster meetings to improve their teaching practice with currently acquired technological teaching tools and competencies. In the twenty-first century, teachers are expected to use multiple teaching resources and methods; it is thus important to empower mathematics teachers to have sound knowledge and understanding of Mathletics and the application of related principles for them to effectively integrate it and be able to facilitate the process by encouraging learners to actively engage and contribute meaningfully (Shin, Sutherland, Norris & Soloway, 2012).

Henriksen et al. (2016) find that for teaching and learning to meet the required twenty-first century standard, teachers should acquire adequate pedagogical content knowledge through ongoing professional development. Scholars such as Darling-Hammond et al. (2009) contend that for teachers to be effective, they should be willing to improve their professional standards, as well as those of the teachers with whom they share a scholastic environment. This was expounded by Du Toit (2013) in his literature articulating about the PD of lecturers in the institutions of higher learning – he is one of the best educational specialists, a scholar and a lecturer for PD based at University of Pretoria, South Africa.

1.4 RATIONALE FOR THE STUDY

With the increased use of technology in education nationwide, it is evident that schools all over the country are utilising technology for teaching and learning purposes (Wachira & Keengwe, 2011). For teachers to contribute to current and future society, they should adhere to digital literacy and be able to effectively use technology during teaching and learning (Henriksen et al., 2016). They must also be willing to be active agents of change by improving the quality of teaching and learning (Voogt, Erstad et al., 2013). Building on this, it is important to empower teachers to gain an understanding of how to effectively use technology during teaching and learning in ways that will enable learners to construct meaningful and connected knowledge that can be applied in a real-life context (Ertmer & Ottenbreit-Leftwich, 2010). One has to bear in mind that primary education is the foundation that prepares learners for the future. As a result, this foundation must be strong because this plays a role in learners' future career choices. For those who do not go to higher institutions of learning, it prepares them for their future employment (Haylock & Manning, 2014).

The desire to conduct this study started in 2015 when I attended a 5-day mathematics workshop offered by Mr Suleiman Motala, the mathematics intermediate phase (IP) facilitator in Tshwane South District (D4); this took place at Burgher Right Primary School in Pretoria West during the winter holidays in my first year of teaching. I was so touched to see what was happening in the workshop. A mathematics software package called Mathletics was introduced to all primary mathematics teachers from Grade R to Grade 9. Due to limited accommodation, only two teachers were selected to represent each school. Of the 80 participants, most were veteran teachers and HoDs in their schools. I noticed this information in the workshop attendance registers that we signed.

Mathletics is an online mathematics learning space for Grade R to Grade 9 and is aligned with the South African mathematics curriculum called CAPS (Curriculum and Assessment Policy Statement), a new South African national curriculum policy for Grade R-12 for all the subjects that are taught in schools. This was introduced in January 2012 (SA.DBE, 2012). CAPS guides teachers on what to teach, how to teach,

how long the lesson should take, which learning and teaching resources must be used, the time allocation for teachers, how to set formal assessment tasks, and how and why to moderate the formal assessment tasks. It outlines the types of assessment that teachers can implement in the classroom (CAPS, 2012). This curriculum policy is used with the NPA and the NPPPPR Grade R-12 document (National Policy Pertaining to the Programme and Promotion requirements) in terms of section 6A of the South African Schools Act (SASA). (1996) (Government Gazette No 17678). The NPA Grade R-12 document outlines the school assessment records, basic requirement for learner profile, teacher files, report cards, record sheets and school schedules; the NPPPPR document deals with the progression requirements for learners.

Table 1: Adapted from (CAPS; 2012) learners' performance standard

RATING CODE	DESCRIPTION OF COMPETENCE	PERCENTAGE
7	Outstanding Achievement	80-100
6	Meritorious Achievement	70-79
5	Substantial Achievement	60-69
4	Adequate Achievement	50-59
3	Moderate Achievement	40-49
2	Elementary Achievement	30-39
1	Not Achieved	0-29

To access Mathletics, each learner must have a username and password (Pilgrim, Bledso & Reily, 2012). It enables parents, guardians and other education stakeholders – such as facilitators or subject advisors – to view their children's progress without having any face-to-face contact with the teacher. If parents can use their cell phones, that implies that they can use the Mathletics programme. It is self-explanatory like any other technological programme – as long they can download Facebook and WhatsApp, they can also use Mathletics. Teachers give learners formal and informal tasks to be executed online (Nansen et al., 2012). According to the CAPS Grade R-12 document, informal tasks or formative assessments include everyday class work and homework activities. They are not used for promotional bases. Formal activities include tests, examinations, investigations, projects and practical tasks, which must

go through the process of pre-moderation to check the fairness, validity and quality of the assessment before they can be administered to learners. Again, after it has been administered by learners it must go through the process of post-moderation to check if the teacher marked and entered the marks fairly (CAPS, 2012). Formal assessment tasks or summative assessments are used for promotional purposes, as stipulated in Chapter 4 of the CAPS document and NPA document.

During the workshop, the facilitator assisted the teachers to create their usernames and passwords. The facilitator was very fast and most of the veteran teachers seemed to be confused and could not understand what was happening, because they were not familiar with using technology. Most of the questions came from beginner teachers who were already knowledgeable about education technology. Before the end of the workshop, the attendance drastically dropped and only beginner teachers were present and actively engaged. What puzzled me the most was that the facilitator was not even worried about the attendance; he simply carried on with the training. Due to this experience, I developed the urge to research the PD of South African veteran primary school mathematics teachers.

Teaching and learning have become learner centred (Du Toit, 2012) with the influx of educational technology (Orlando, 2014). However, veteran teachers find it difficult to use Mathletics due to their limited acquisition of technological skills (Orlando, 2014). Teachers need to be reskilled to acquire contemporary pedagogical twenty-first century competencies to offer quality teaching (Desimone, 2009).

According to research that was conducted by the South African Council for Educators (SACE) in 2007, there was a need for expert teaching in subjects such as mathematics, accounting and Physical Sciences. The same report also highlighted the need for teachers to upgrade their qualifications as part of the notion of being a lifelong learner in the twenty-first century (Modisaotsile, 2012).

1.5 PURPOSE OF THE STUDY

The study conducted by Tsai and Chai (2012) shows that veteran teachers struggle to cope due to the rapid technological advancement taking place in the education sector. This is especially the case for mathematics teachers facing challenges with Mathletics (Muir, 2014; Van Driel & Berry, 2012; Steyn, 2008; Plair, 2008). Studies increasingly indicate how to use different technological resources and teaching and learning methods in specific circumstances and for certain purposes, but teachers need guidance and support to engage in such developments (Voogt, Erstad et al., 2013). Thus, I saw a need to engage in PAR and empower veteran primary school mathematics teachers to use Mathletics. This was motivated by the importance of teachers "sufficiently educating learners and preparing them for future careers in the Fourth Industrial Revolution and workplace environments".

A worrying finding from recent research conducted by Muir, Livy, Herbert and Callingham (2018a) shows that teachers who do not engage in ongoing professional development negatively affect learner achievement due to their limited acquisition in the recent teaching methods and resources. As a result, they fail to apply Mathletics and other online learning programmes – this puts learners at risk because they are the ones who suffer the consequences of the current teaching practices, and this will reflect in their future workplace. This is because Mathletics is directly proportional to what learners will be doing at their place of work in the future, especially those who will be in the Mathematics, Sciences and Technology stream path (Berry, 2016). Thus, it is important to close the gap between how learners live and learn by ensuring that teachers undergo PD to reskill and upgrade their teaching practices and methods to meet contemporary education standards. It is evident that the current standards of education require learners who can think outside the box and solve real-life challenges independently using technological resources, while collaborating and effectively communicating with their peers to solve such challenges (Van Driel & Berry, 2012; Orlando, 2014).

Therefore, I intended to find effective methods through PAR that would empower veteran teachers to develop skills and competencies in using Mathletics. Teachers

can contribute to one another's PD through peer mentoring within their community of practice in their school zones (Stronge, 2018). Teachers who do not understand Mathletics can work closely with those who did master this programme, so that they can improve their teaching practice by learning from colleagues (Orland-Barak & Hasin, 2010). For peer mentoring to succeed, a facilitator or an expert teacher must be available to monitor and guide the progress, so that teachers with limited understanding can discuss the challenges that they face (Smit & Du Toit, 2016). In this case, I facilitated throughout the process and allowed teachers to collaborate and work together through teamwork. I put a teacher who understands Mathletics better in each team and they would empower teachers to master the use of Mathletics. I communicated with each group expert over three weeks between August and September 2018 to address challenges encountered by participants in the application of Mathletics. I arranged with my participants to contact me even after the process of data collection if they still needed any support regarding Mathletics, which they did.

Scholars such as Day and Gu (2009) posit that most veteran teachers who struggle to use Mathletics may jeopardise learners' performance in Mathematics. Learners with no competence regarding the use of Mathletics may exhibit poor performance in both formal and informal tasks. As outlined earlier, formal tasks are used for promotional bases and informal tasks are administered in everyday teaching and learning; they are not used for promotional bases, but are preparing learners for formal assessment tasks since these tasks are accessed through an understanding of Mathletics (Nansen et al., 2012).

The introduction of technological programmes such as Mathletics in mathematics will not yield a positive output if teachers have limited understanding in implementing these programmes during teaching and learning (Pan & Franklin, 2011). I hypothesised that the PD of teachers through peer mentoring and PAR would empower teachers to improve their teaching practice because they would learn by reflecting on their experiences (Smit & Du Toit, 2016; Zuber-Skerritt, 2015; McNiff & Whitehead, 2006). During the process of peer mentoring, the veteran primary school teachers were required to link their prior content knowledge to the new content knowledge. It was hypothesised that this could assist them to understand and better prepare for today's generation of learners (Hughes, 2005).

Most aspects of education at present are becoming technologically orientated right from the preparation of lessons, the presentation thereof and the recording the learners' achievement scores, and communication with the department, district, parents, learners, colleagues, and community at large. This requires good technological skills (Desimone, 2009). The majority of veteran teachers have limited technological know-how (Orlando, 2014; Day & Gu, 2009; Plair, 2008).

1.6 RESEARCH QUESTIONS

Primary research question

- Which method of continuing professional development should be used by veteran primary school mathematics teachers to improve their use of Mathletics?

Secondary research questions

- Which professional initiatives help veteran mathematics teachers to improve their teaching practice in the twenty-first century?
- What can be done to ensure successful PD for veteran mathematics primary school teachers?
- How can the Mathletics programme be applied in the professional development processes of veteran primary school mathematics teachers in South Africa?

1.7 WORKING ASSUMPTIONS

I hypothesised that through PAR, where all participants actively engage in the research process, the effective PD of veteran primary school mathematics teachers could be achieved. Scholars, including Smit and Du Toit (2016) and Orland-Barak and Hasin (2010), support the idea that if teachers work together through peer mentoring and PAR, veteran and beginner teachers can improve their PD among themselves as they share more practical, relevant and applicable teaching methods with peers. Such strategies encompass inclusivity, accommodation of all learners during teaching and learning, classroom management skills, successful curriculum differentiation, shared teaching resources, exchanging of lesson plans and the pedagogy of using Mathletics.

PAR enables teachers and other professionals to critically reflect on their work and collaboratively find ways to improve their performance, job satisfaction, work environment and understanding of work-related dynamics (Zuber-Skerritt, 2015). Teachers respond better to other teachers who share situations similar to theirs because they all know what it is like in the classroom – especially regarding what can go wrong, and how learners respond to their school environments (Orland-Barak & Hasin, 2010). Skilful teachers who can facilitate the learning of groups of academically diverse learners with the latest technological resources and programmes are in demand (Stronge, 2018). The literature shows that learners who are taught by newly appointed teachers achieve better results, as opposed to learners who are taught by veteran teachers, especially in Mathematics, Physical Sciences, Life Sciences, Technology and Natural Sciences (Tezci, 2011). These newly appointed teachers have acquired ample competence in using educational technology at their respective institutions of higher learning.

1.8 CONCEPT CLARIFICATION

This study is based on key concepts outlined in Table 3.

Table 2: Key concepts in the study

1.7.1 Professional Development (PD)	This is the experience that one attains from work every day, whether formal or informal, and all other related activities and interactions that take place amongst colleagues, the learners and community members (Desimone, 2009)
1.7.2 Continuing Professional Development (CPD)	CPD is a process by which professionals update their professional knowledge and develop professional competencies throughout their working life to respond to changing work environment and maximising their potential (Attwell & Hughes, 2010).
1.7.3 Veteran teachers	Experienced teachers who have worked in a teaching profession for a long time,

	approximately between 15 to 20 years, without any break of service or resignation (Orlando, 2014; Day & Gu, 2009).
1.7.4 Twenty-first century education	This is a modern educational transformation where learners are required to combine new competencies with prior competencies to construct new knowledge structures and meaning using a technological medium that responds to the current Fourth Industrial Revolution (Tapscott & Williams, 2010).
1.7.5 Constructivism	This is a teaching philosophy based on the concept that learning is the result of previous experience being applied to the currently acquired experience to maximise comprehension. Again, it further emphasises that previous experience is a great building block for present and future experience. Learners construct their own understanding by reflecting on their personal lived experiences and linking new knowledge, skills, values and competencies with what they already know (Dowling, 1995).
1.7.6 Social constructivism	This is a theory of knowledge that maintains that the knowledge and understanding of the world are developed by an individual's knowledge and social experiences. Such meaning-making social experiences are socially and culturally constructed by a group of people and their environment (Amineh & Asl, 2015).
1.7.7 Action learning	This is a social process where a group of people learn with and from each other. They can come up with a solution to the presented

	challenge or a problem. Action learning involves acting to the presented local, real-life challenge and reflecting upon the output results of the action taken and is a continuous process (Revans, 1982).
1.7.8 Peer mentoring	This relates to highly knowledgeable teachers in certain competencies such as subject content or computer skills, helping and guiding other teachers to acquire needed skills and competencies by guiding, facilitating and mentoring them (Colvin & Ashman, 2010; Smit & Du Toit, 2016).
1.7.9 Mathletics	Mathletics is an online mathematical educational programme that was developed in Australia. Mathletics ensures that mathematical subject learning takes place anywhere, anytime, inside and outside the classroom, with any technological gadgets; it also ensures that mathematics as a subject becomes fun, learner-centred and enjoyable (Nansen et al., 2012).
1.7.10 Participatory Action Research (PAR)	PAR emphasises the participation and action taking of all the participants involved in the research. It is a research study that is done collectively with the participants, not for participants, and it focuses on local challenges. Hence, it promotes local solutions of the local participants, throughout the research process reflection is fundamental (McNiff & Whitehead, 2006; Zuber-Skerritt, 2015; Du Toit, 2012).
1.7.11 Lifelong learning	All learning activity is undertaken throughout a person's life, whether formal or informal, to

	improve the competencies within a personal, civic, social and/or employment-related perspective (Fletcher, Zuber-Skerritt, Bartlett, Albertyn & Kearney, 2010).
1.7.12 Web 2.0	Web 2.0 is social networking software which promotes the development of online communities and allows people to work collaboratively. Users can generate and publish their content rather than just being consumers by being able to edit their contributions to what is presented on the social network (Attwell & Hughes, 2010).
1.7.13 Community of Learning Practice (CLP)	This is a group of people who share the same concerns and work together by sharing ideas, teaching methodologies, teaching tools and many more to improve their teaching practice; namely, teachers who share the same subject, phase or department (Wenger, 2000).

1.9 ROLE OF THE RESEARCHER

Du Toit (2013) explains: “The teacher is responsible for his own PD and the professional development of the teachers with whom he shares the PLC inside and outside the scholastic environment”. This statement describes my rationale for my scholastic journey. I worked with the participants from Gauteng primary schools who had been teaching mathematics for more than 15 years and yet were struggling to integrate Mathletics into teaching and learning.

I sat with the participants and we collectively put in place a plan of action to find out the root cause of their limited usage of Mathletics. We also planned how we could remedy the situation, suggesting remedial strategies that they should implement in their respective practices. This formed part of Cycle 1 of the PAR projects. Using different stages, the plan was executed and monitored. Different data collection

methods were used, and the teachers raised the challenges that they encountered during the implementation of the programme (Smit & Du Toit, 2016).

As I engaged with participants during the interview sessions, I was able to gain an in-depth understanding of how these veteran teachers perceived the introduction of Mathletics and their reaction to applying the new teaching method. Through such interaction in the classroom, it was envisaged that both the participating teachers and I would benefit immensely, since our professional learning was reciprocal. This process of professional reciprocal learning is considered a socio-constructivist approach (Du Toit, 2013) to new meaning-making. In this study, both the participants and I learnt greatly from this exercise. I hypothesise that my association with veteran mathematics teachers through the application of the professional development assisted both the participants and me to become pedagogically enriched. This was the case as we worked to identify new knowledge systems to promote the acquisition of new pedagogical understanding in the integration of technology in teaching and learning.

1.10 ETHICAL CONSIDERATIONS

I successfully defended my proposal on 27 October 2017 and thereafter applied for ethical clearance from the University of Pretoria. After being approved, I then sent a letter of permission to the Gauteng Department of Basic Education (DBE) to obtain permission to conduct my study in public primary schools. Having done this, I applied for permission at Tshwane South District Circuit 2(D4) for permission to collect data in schools located in Circuit 2. After obtaining permission, I then approached the school principals of the selected schools with a letter requesting permission to conduct this study. After obtaining the principal's approval, I sought permission from primary school mathematics teachers who had been teaching for more than 15 years to participate in this study. I made it clear to the participants that the rationale behind this study was to investigate and develop their professional status through PAR to improve their competence in the application of Mathletics during teaching and learning. After agreeing to participate, they were requested to engage in semi-structured interviews and participant observations. I visited them individually while they implemented the

Mathletics programme, which took from 30 to 45 minutes. However, my participants refused to be videotaped because they were concerned that they were not perfect. They said they would let me know when they were ready and asked me to respect the request. I observed them in their classrooms and recorded all the information in my journal. After data collection, Mr Longwitz and I conducted follow-up workshops and visited schools where they encountered challenges with Mathletics. Mr Longwitz is the 3P learning and Mathletics manager in Gauteng and offers Mathletics workshops all over Gauteng.

1.10.1 Voluntary participation and trust

I maintained the highest level of objectivity in discussions and analyses throughout the research. I secured the consensual agreement of the participants and did not force participants to be part of the research. The participants received letters of informed consent that stated their right to voluntary participation, indicating their role if they wished to participate in the study. I let them know that they were more than welcome to withdraw from the study at will and would suffer no consequences due to their withdrawal. The participants were constantly reminded throughout the study that their participation was voluntary and that they could withdraw at any time. The data were only collected from the participants who gave their consent. Those who did not give permission or consent were not included in the study.

The participants' identities were protected to the best of my ability, and all the data gathered was kept confidential. Their identity was not disclosed in the final reporting and dissemination phase of the study. Their participation in this project was completely voluntary and the information recorded during this study is kept in a locked file that will be accessed only by me or my supervisor.

1.10.2 Informed consent

Informed consent forms were obtained from the veteran primary school mathematics teachers in the form of letters. These letters explained the research and what was expected from them. Learners did not participate in this study and observation was

only done with the participating veteran primary school teachers. Full consent was obtained from the participants before the study. I explained what this study entailed, how this study would benefit them and me, and the community at large. In this regard, the participants needed to sign an acknowledgement that they agreed to take part in the research process without being forced in any way. The letters also included the researcher and supervisor's contact numbers and e-mail addresses for any questions or queries before the research.

1.10.3 Safety in participation

I ensured that the participants did not become subjected to harm in any way. Respect for the dignity of the participants was prioritised. Any type of communication about the research was done with honesty and transparency. I avoided any misleading information and deception representing the primary data findings in a biased way. The teachers may have feared the discovery of their teaching incompetence (Bryman & Bell, 2007). When I analysed the collected data, I ensured that I removed all identifying information, such as the school and teachers' names and qualifications. Instead, I used a numbering system to identify the teachers in the research.

1.10.4 Privacy, confidentiality and anonymity

The protection of the privacy of the research participants was ensured. An adequate level of confidentiality of the research data was ensured. The interviews were conducted in a private setting that was suitable and safe for all the participants and at the times that suited the participants, as suggested by Gajjar (2013). The data obtained from the research were used to compile this dissertation and will further be sourced for an article and journal paper.

1.11 LAYOUT OF THE STUDY

This study constitutes five chapters, which are laid out as follows:

Chapter 1

Chapter 1 introduces the study by providing the abstract, introduction, the background to the study, problem statement, the rationale for the study, the purpose of the study, research questions, working assumptions, concept clarification, the role of the researcher, ethical considerations and the conclusion for Chapter1.

Chapter 2

Chapter 2 provides a literature review that discusses the veteran primary school mathematics teachers who struggle to cope due to the rapid technological advancement taking place in the education sector. This is especially the case for mathematics teachers facing challenges in integrating the Mathletics programme into teaching and learning. This chapter further highlights what can be done in practical terms to mitigate the challenge faced by these veteran teachers.

Chapter 3

In Chapter 3, I discuss the research methodology, sampling procedure, data collection and documentation, outline of the data analysis and interpretation, possible contribution of the study to knowledge creation, possible limitations of the study, and possible delimitations, credibility, and trustworthiness of the study.

Chapter 4

This chapter presents the analysis and interpretation of the findings. The findings are presented as themes aligned with the research questions and the conceptual framework.

Chapter 5

This chapter outlines a summary of the findings, the conclusion and the recommendations put forward in this research. I also make suggestions for further research on the topic.

1.12 CONCLUSION FOR CHAPTER 1

From the previous literature, there appears to be a gap in the research on the application of Mathletics during teaching and learning by veteran primary school mathematics teachers in the African context (Odine, 2015). Mathematics is globally viewed as a difficult subject by both teachers and learners and this is also shown in the poor performance of learners (Reddy et al., 2016). The Mathletics programme has been used in approximately 190 countries, including Australia, New Zealand, the USA, Pakistan, Ireland, Canada, Britain, Saudi Arabia, Qatar, Oman, Bahrain and Brazil (Nansen et al., 2012).

It is evident that poor learner performance in mathematics is deeply rooted in the pedagogical content readiness of teachers (Tshabalala & Ncube, 2016). The poor performance in mathematics is exacerbated by the inability of veteran mathematics teachers to adopt new, or rather more improved technological teaching innovations in the form of Mathletics during teaching and learning (Tsai & Chai, 2012). Teacher and learner engagement in the classroom is included, which implies that veteran primary school mathematics teachers should partake in PD in Mathletics to acquire a better understanding of how to effectively integrate Mathletics during teaching and learning to ensure that learners acquire sound knowledge and improve their performance in mathematics (Shaffer & Thomas-Brown, 2015).

I hypothesise that further research will be required in this regard, which will benefit numerous scholars, schools and institutions nationwide. I also believe that this will serve as a catalyst to acquire solutions that ensure that mathematics teachers gain an understanding of the application of this programme. Finally, my wish is to see Mathletics used by all teachers nationwide to experience the benefits of this programme and improve their learners' instructional understanding of mathematics, regardless of their teaching experience, socio-economic status and their geographical location. Our learners and teachers should regain a love of mathematics.

CHAPTER 2 LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

"It is not the strongest of the species who survive, nor the most intelligent: rather it is those most responsive to change"

Charles Darwin

The gap in research regarding technological mathematics teaching and learning tools is widening (Bietenbeck et al., 2018). Therefore, more research is needed to help teachers understand who they are they teaching, how to teach them and how to prepare learners for life after Matric and for the future world. Therefore, teachers must understand and acquire an in-depth knowledge of mathematics as a subject and be able to effectively share the acquired knowledge with their learners during teaching and learning using various teaching practices and tools that are relevant in today's world. Teachers must be flexible enough to respond to changes taking place in education. The generation of learners we are currently teaching are technological gurus; therefore, it is critical that teachers upskill and learn how to utilise programmes such as Mathletics in their teaching to expand learner participation, interest and love for mathematics (Stephan,2017).Scholars have found that Mathletics can improve the performance and understanding of learners who are struggling in mathematics. Various authors, including Letwinsky and Berry (2017), emphasise that Mathletics has the potential to improve learners' independent learning by encouraging them to learn on their own or with their peers.

The rationale behind the PD of teachers is to enable teachers to respond effectively to the changes that are taking place in the education system (Bietenbeck et al., 2018). Moreover, the rationale is to empower teachers to continue upgrading their pedagogical content knowledge to meet the needs of twenty-first century learners and the contemporary standard and to keep abreast of new technology in education (Carrillo & Flores, 2018). Based on current literature, it is evident that educational technology has transformed the educational landscape (Ryan & Bagley, 2015).

Therefore, teachers must undergo hands-on development so that they can provide quality education (Letsatsi, 2010). Again, professionals are expected to keep abreast of contemporary pedagogical knowledge and skills through CPD to be productive in the workplace (Coles, 1996). Studies cited in the literature accentuate that PD is more effective and productive when teachers who share the same goal come together in their CLP and participate with others who share the same grade, subject or department (Desimone, Porter, Garet, Yoon & Birman, 2002).

Innovations in education are taking place more rapidly than before. This is due to the acceleration of educational technology to improve the quality and productivity of education. This produces learners who are ready to work hard and are capable; in turn, this promotes job satisfaction in the twenty-first century (Serdyukov, 2017). This implies that teachers should be prepared to handle these changes. The literature shows that this generation of learners is diving into technology, as they were born in a connected world of technology and they have acquired technological skills from birth. Thus, various scholars support the connectivist approach, which believes that since we are living in a globalised world with different traditions, socio-economic levels, and di religions and belief systems, it is important for all individuals to promote unity in all our differences. This can be achieved through the sharing of information via online platforms such as the World Wide Web. Education must not be limited by any boundaries or borders (Goldie, 2016); this simply implies that education must take place inside and outside the school premises and encompass not only school information, but social information that can lead to individualised learning or self-directed learning, which is also promoted by constructivist theory (Hwang, Lai & Wang, 2015). Education must be accessible to learners any time and everywhere through social networks, technologies and all the available Internet (Bell, 2011). Learners must take responsibility for their learning by being open-minded, critical and analytical thinkers. However, all this will only be successful if teachers fully embrace the technological transformation in the education sector. Learning and teaching are no longer fixed, but interactive; this implies that learners in South Africa can learn with their peers over the social networks worldwide, and teachers can do the same and share teaching methods, resources and programmes through social networks. This strategy is also interlinked with CLP for teachers, and a constructivist and connectivist learning and teaching approach (Stephan, 2017).

Using this literature review, I explored the challenge that veteran mathematics primary school teachers are facing in understanding and applying Mathletics skills and principles during teaching and learning to differentiate learning to maximise learner engagement (Orlando, 2014). They are also learning how this challenge can be mitigated using different approaches of professional development through PAR. The literature shows that South Africa's mathematics teachers in most grades are near the bottom in terms of world standards, as they produce the poorest results when compared to other countries worldwide (Burghes, 2011).

2.2 PRIMARY SCHOOL MATHEMATICS IN THE SOUTH AFRICAN CONTEXT

2.2.1 Laying a strong foundation at primary school level

Literature shows that it is essential for primary school mathematics teachers to lay a strong foundation to ensure that learners develop an innate love for mathematics at primary school level. Hilton (2018) contends that this might positively influence learner achievement and participation in mathematics. Moreover, educational technology is transforming at an alarming rate. Therefore, it is essential for teachers to possess the required knowledge, skills and the willingness to provide quality education that meets the needs of our technological learners (Henriksen et al., 2016). Twenty-first century teachers should be adequately trained in managing and catering for the needs of diverse learners through effective facilitating learning with the proper tools and media that can help learners become constructors of knowledge, not just learners who are inactive participants during teaching and learning (Eickelmann, Drossel, Wendt & Bos, 2012).

2.2.2 South African mathematics performance

To raise the quality of teaching and learning of mathematics as a subject in primary schools, the higher institutions of learning for teacher education should be enhanced, and PD for teachers must not be a "talk show". Rather, it must be pragmatic, relevant, valid and real by integrating twenty-first century skills required by the Fourth Industrial Revolution (Dale, 2016). Lifelong learning for teachers should be enforced and should

include attitudes, teaching style, motivation, skills, competencies, self-assessment, creativity, responsibility and also the capacity to innovate and engage in a CLP. This postulation equally resonates with what Wolvaardt and Du Toit (2012) suggest will be the best practice to improve our current situation in South African schools. Du Toit posits that CLP in schools should be effectively implemented and functional so that teachers can learn from one another in a scholastic way (Du Toit, 2018b). This can also assist beginner teachers to acquire important knowledge, skills and values of the school environment such as classroom management, lesson preparation, effective communication skills with colleagues, parents and learners. Veteran teachers can also benefit in terms of acquiring improved teaching approaches and implementation of technology during teaching and learning from the new teachers as expounded by Du Toit (2018b).

However, there seems to be no consensus on the definition of PD by academics. The common view of this construct is that PD encompasses growing professionally by being hands-on, gaining more understanding and being able to do well at work. This growth is depicted by the improved work practice and ethics of an individual (Bellibas & Gumus, 2016; Smit & Du Toit, 2016; Hammond & McLaughlin, 2011).

2.2.3 Ongoing professional development for mathematics teachers

Tam (2015) describes PD as the experience that an individual attains over some time – this includes personal professional knowledge and skills relating to work goals. Darling-Hammond and McLaughlin (2011) argue that effective PD is when a teacher finds him- or herself in a state where he or she is both a learner and a teacher and becomes actively dedicated in both instances.

Moreover, PD is cyclical and inquiry-based, and this allows teachers to share knowledge and skills amongst themselves and critically reflect on their teaching and professional learning processes. Effective professional development helps teachers to improve their thinking ability, teaching approaches and analytical decision-making. Again, knowledge and exposure of teachers determine their actions in the classroom. Thus, teachers need to stay abreast of new concepts, skills, tools and methods

through PD and by staying active, committed and engaged in the CLP that takes place in their schools, circuits and districts, both at provincial and national levels (Mishra & Mehta, 2017).

Vygotsky (1987) strongly believes that learners learn best through socially constructed reasoning, by taking their preconceived knowledge as a foundational base and reforming ideas based on their social experiences. This expands their conceptual understanding of mathematics. This implies that teachers should encourage learners to work together, scaffold mathematics lessons for their peers and be fully engaged in hands-on activities (Zain et al., 2012). This will require learners to apply their critical and problem-solving skills and should be fundamental in mathematics classrooms. In the process, academically weak learners will benefit from this collaboration with their peers and their achievement might improve. A case in point is that of a supervisor at the University of Pretoria. He allows his students to work in groups in his lectures and this approach has been working very well for him and his students (Du Toit, 2018a). I hypothesise that this strategy of collaborative working can yield the same results if it can be applied in the CLP, where teachers come together and share their good teaching practices. Mathematics is a language of its own (Spaull, Van der Berg, Wills, Gustafsson & Kotzé, 2016), which implies that teachers should play a role in ensuring that learners understand the basic concepts of this language for them to be fluent and able to solve real-life problems. Hence, teachers must be able to differentiate their teaching pedagogy, curriculum and their resources to make the learning of mathematics real, reliable and relevant to the everyday life of learners and to make it fun by adjusting class activities. Examples would be to include photographs in the formal and informal tasks and to put rich print on the classroom walls, and to use videos during teaching and learning to attract learners' attention by using real-life examples and objects that learners can touch and feel to boost their understanding (Adler, 2017). White Paper 6 is a policy which deals with inclusive education. This policy was introduced in 2001 and is based on the view that all children must acquire formal education, regardless of their learning abilities, physical abilities and any other contextual factors that might hinder the smooth learning process. To eliminate learning barriers, all children must receive full support from teachers, parents and their community. Teachers must accept and embrace the differences that learners have, increase the participation and engagement of all learners in the classroom, with no

learner being left behind. All learners must acquire a quality education (Walton & Rusznyak, 2017). White Paper 6 called for teachers to implement curriculum differentiation to meet the learning needs of all learners. In the simplest terms, curriculum differentiation is when a teacher restructures the lesson plans, assessments, teaching methods, classroom arrangements and class activities to leverage or meet the learning needs of all learners. According to White Paper 6, teachers must be flexible enough in ensuring that high achievers and low achievers benefit equally during teaching and learning, without compromising their cognitive levels as stipulated in Chapter 4 of CAPS. In 2014, the Screening Identification Assessment and Support (SIAS) policy was introduced by the Minister of Basic Education. The main aim of this policy was to assist teachers in identifying learners who need additional support, such as learners who encounter learning barriers and are often called slow learners. After identifying such learners, teachers must create interventions or remedial work to ensure that these learners acquire quality education as much as possible. During the process of identification, teachers must complete the Support Needs Assessment (SNA) Form 1 as evidence that they have supported those learners. SNA Form 2 is completed by the teacher and the school-based support team (SBST) to show that they did support such identified learners if the support provided did not yield any improvement to the learners' educational progress. SNA Form 3 is completed by the district support team officials or district-based support team (DBST).

2.3 WEB 2.0 TECHNOLOGY IN MATHEMATICS

2.3.1 Technology at the centre of it all

When the educational landscape is transforming at a rapid rate, driven by technology, the most important action one can take is to get in, start learning and continue learning. Based on international literature, it is evident that technology is here to stay. Therefore, for teachers to be effective in the twenty-first century, they must "learn to swim" in the so-called river of technology. The more you learn, the more knowledge and skills you acquire (Collins & Halverson, 2018). Numerous studies expound that Mathletics promotes and instils mathematical higher order thinking skill development and

problem-solving skills in a more engaged, visual and enjoyable way than the normal, traditional, monotonous approach (Muir, 2014; Hilton, 2018).

2.3.2 Mathletics as a trending programme in mathematics

Technology in education, such as the Mathletics programme, has changed teaching and learning in a momentous manner. Web 2.0 technology permits the user to be actively engaged in reproducing, editing, creating and sharing content in new multimodal ways that enable all users to share information reciprocally (Kafyulilo, Fisser & Voogt, 2016).

Mathematical knowledge liberates the mind to understand other subjects; for example, Accounting, Physical Sciences, Life Sciences, Chemistry, Economics, Business, and Geography (Ker, 2013). Scholars contend that an individual must have a sound knowledge of mathematics to be able to effectively use technological resources (Chai, Koh, Tsai & Tan, 2011). Mathematics is everywhere – the simple technological gadgets that we use every day such as money, watches, cell phones, printers, photocopiers, personal computers, calculators, the Internet – specifically, downloading from the Internet – require certain skills. Learners and teachers seek clarity from the Internet when faced with challenges in projects, assignments and in lesson plans for teachers (Muir, 2014). Studies reported in the literature show that our learners are already technological gurus and therefore teachers must upgrade their teaching practices to accommodate these new millennium learners (Berry, 2016).

2.3.3 Ending primary school mathematics misconceptions

Learners have a lot of misconceptions, which they acquire in their foundation phase (Grades R-3) and retain up to their further education and training phase (Grades 10-12). In South African schools, we are guided by SASA (1996). In terms of SASA, the FP is the starting point of school for learners aged 6 to 9 years. Learners must start Grade R when they are 6 years old; in Grade 1 they should be 7 years old, in Grade 2, 8 years and in Grade 3 they should be 9 years old. The FP is followed by the Intermediate Phase (IP), covering Grades 4 to 6, in which learners must be between

10 to 12 years of age. In the SP, Grades 7 to 9, learners must be between 13 and 15 years of age; in the Further Education and Training phase (FET), learners must be from 16 to 18 years of age (SASA, 1996). The FET phase normally prepares learners for higher education and training. When learners complete Grade 12 or matric, they may opt to study further at universities or colleges, while some look for employment. Prevailing misconceptions cause them to perform poorly in mathematics (Muir, 2014). Mathematics experts hypothesise that if mathematic learners get help from external sources such as the Internet or Mathletics, their understanding and participation will be maximised because they will be getting practical explanations, assimilations also visual aid from the Internet. This will also help learners to relate what they learn to the outside world (Lowrie & Jorgensen, 2012; Muir, 2014). Building on this, and based on the literature, it shows that technology helps learners to improve their computerisation and conceptual understanding (Roschelle et al., 2010). Again, it simplifies mathematics for both teachers and learners, while permitting multiple opportunities to meet the needs of diverse learners and providing a range of teaching strategies for teachers.

2.3.4 Interesting facts about Mathletics

Mathletics makes teaching and learning easy and fun while providing relevant, curriculum-based content for learners, teachers, and parents (Nansen et al., 2012). Berry (2016) maintains that the implementation of Mathletics will only be successful in the most privileged schools where both parents and teachers are educated enough in terms of the technological skills and knowledge and can financially afford to buy or install technological programmes and tools. Research shows that parental involvement in education plays a tremendous role in encouraging learners to take full responsibility for their studies. Learners who receive support at home are more encouraged and achieve better than the ones who do not receive any support (Khan, Ahmad, Hamdan & Mustaffa, 2014). Based on this research and, as a teacher, drawing on my limited experience through daily observation and interaction with community members, particularly parents, I also believe that parental involvement does not require any formal education as long as parents can offer a word of support or go all out to attend parents' meetings offered by the school or buy school materials

or stationery required by the children to show that they care for their children. That is more than enough. Again, these technological tools that we use do not require one to obtain a formal education; for example, no one went to school to learn how to use WhatsApp, Twitter, Instagram, Facebook or how to withdraw money from the ATM, but we are capable enough and have taught ourselves to use all those apps and gadgets. Therefore, I strongly believe parents can encourage their children to use Mathletics and they can also assist them. Mathletics is an online educational programme that was developed in Australia in 2005 by Andrew Smith (Nansen et al., 2012). Mathletics is now available in Europe, the USA, Asia, Canada, New Zealand, and Africa. Mathletics is owned by 3P Learning (Muir, 2014). 3P Learning is an interactive electronic learning resource for schools, learners and parents; it focuses on mathematics (Mathletics), the sciences (IntoScience) and English (Spellodrome). However, it is essential that teachers and learners not only focus on how to use Mathletics, but acquire mathematical knowledge and skills, which is why Mathletics is also used to increase users' understanding of mathematics.

Mathletics ensures that learning takes place anywhere, at any time and inside or outside the classroom (Nansen et al., 2012). Mathletics is learner-centred, as learners play online mathematics games that are aligned with the school curriculum. This increases their understanding, critical thinking skills, analytical skills, independence and performance in mathematics (Nansen et al., 2012). Mathletics delivers learning through hands-on games that are presented through audio and text, which are appealing to learners, teachers and parents. Mathletics is aligned with the South African CAPS Grade R-12, which guides teachers on what to teach, when to teach, how to teach, which skills and knowledge must be assessed, how to set a formal task and which tools must be used to teach a particular topic or content. It provides instant feedback, encourages learners to engage in self-paced and self-directed learning. It also responds positively to various learners' needs by guiding them through the completion of a task. Thus, learners become motivated to learn mathematics (Malone & O'Shea, 2014).

Mastering mathematics should be viewed as both a process of active individual construction and a gradual process of enculturation into the mathematical practices of wider society (Cobb, 1994). Learners should not be confined to learning mathematics

content in the classroom, but they should be able to link and extend what they learn in the classroom to real-life contexts. This will enable them to see the relevance of mathematics in their lives (Cobb, 1994).

Mathletics is designed to teach mathematics to primary school learners, enabling them to learn at their various levels of capacity and in their comfort zones or outside the school or classroom boundary, where they freely collaborate and work, not only with their immediate peers in the classroom, but peers across the world over social media (Smith, 2005). Mathletics eliminates teachers' paperwork, such as marking, the recording of marks, setting tests and examination papers and preparing lessons. Through the Mathletics programme, teachers are encouraged to focus on the teaching and learning process and the quality of teaching, not on the output process where they only encourage learners to get good marks, despite not understanding the content (Muir, 2014).

Teachers are given alternative pedagogical strategies for approaching each topic and how to simplify the content without compromising the quality and standard of the curriculum (Muir, Livy, Herbert & Callingham, 2018b). Teachers can view their learners' progress during school recess and help their learners instantly without any face-to-face interaction (Muir, 2014). However, scholars such as Malone and O'Shea (2014) contend that technological teaching and learning can work best if it is commingled with the traditional teaching approach where the use of technology is implemented and the teacher facilitates and monitors the learning process *in propria persona* or in person, where teachers meet with learners face-to-face. Moreover, in the South African context, the notion of Muir (2014) that learners must do their schoolwork over the school recess without the supervision of the teacher cannot be functional. The morale of our educational system is diminishing, the majority of our learners are being spoon-fed and they cannot think outside the box – they are too lazy! Moreover, more than half of South Africans are poor and most of the public schools do not have technological teaching resources and programmes. They even lack basic learning and teaching support materials (LTSM) such as textbooks, stationery, chairs, tables, computer centres, science laboratories chemicals for performing experiments and limited classrooms. Hence, we are faced with overcrowding and the teachers from those schools have limited knowledge and skills in utilising technological teaching

resources. They are even discouraged from participating in teachers' CPD programmes. Therefore, for Mathletics to be effectively implemented, teaching tools and programmes must be available and teachers must acquire the necessary skills and knowledge for them to be able to effectively guide, monitor and facilitate the process.

Through Mathletics, parents and guardians are involved in the learning process and can view the learners' progress and assist learners without having any face-to-face interaction with the teacher. They can only communicate on the online platforms such as emails. Parents who need clarity regarding Mathletics can make an appointment with the teacher. Today's learners are digital natives, as they are being brought up in an environment where technology is found in almost everything (Alghamdi & Holland, 2016). Thus, the curriculum needs to be restructured to ensure that technology is integrated into the everyday teaching and learning process. Various scholars, such as Berry (2016), strongly believe that Mathletics can only be effectively integrated into privileged schools that have rich technological learning and teaching resources, where parents are educated enough to utilise and afford the technological tools and programmes and where teachers are educated enough to integrate modern teaching methodologies, resources and programmes such as Mathletics.

Attwell and Hughes (2010) conducted research in Saudi Arabia with primary school learners aged 6 to 9 years. They observed that when learners used technological programmes for learning, such as Mathletics, they developed an intrinsic motivation to learn and become more engaged. Moreover, they tended to develop skills that are essential in the twenty-first century, such as critical thinking, teamwork, digital literacy and problem-solving. However, the use of Mathletics during teaching and learning cannot be fully implemented, particularly by veteran teachers, because of their technological inadequacy. It means that teachers must undergo hands-on and continuous training for them to have a sound knowledge of Mathletics (Zaheer, Breyer, Dumay & Enjeti, 2018) and be able to use it.

2.3.5 Mathletics users and non-Mathletics users

According to a study conducted by Malone and O'Shea (2014), learners who use Mathletics achieve more than their counterparts who do not use Mathletics in the same standardised tests, such as common examinations, tests and projects, including the Annual National Assessment (ANA) and National Benchmark Test (NBT). This is corroborated by Reddy et al. (2015). Learners who use Mathletics have been shown to think out of the box and are quite analytical, creative thinkers and problem solvers; they are able to embrace any given challenge with a solution-driven attitude, they also participate more in teamwork. According to Hilton (2018), learners prefer to use Mathletics because of its ability to provide instant feedback, allowing learners to track their progress, set their own learning goals and compare and share their learning with peers. Berry (2016) shows that Mathletics can only be successfully implemented in schools where learners are privileged enough to have educated parents and guardians who will assist them to complete their tasks. This is also the case with schools where teachers are exposed to technological resources and programmes and have the necessary knowledge and skills.

2.4 VETERAN TEACHERS IN THE TWENTY-FIRST CENTURY

2.4.1 The definition of veteran teachers

Researchers have battled to provide an acceptable definition of veteran teachers. However, scholars such as Orlando (2014) state that veteran teachers are those who have been in the teaching profession for a long time – approximately 15 years or longer. These teachers are also referred to as experienced teachers (Day & Gu, 2009).

2.4.2 Certitude about mathematics veteran teachers

The literature shows that most of these veteran teachers tend to lose inspiration and enthusiasm to maintain their professional status and development due to various factors – personal issues, including remuneration, and social and work-related factors such as their relationship with colleagues, parents and learners (Day & Gu, 2009; Orlando, 2014). All these factors can directly or indirectly affect teachers' performance

and passion as the years go by. This is shown in their classroom commitment, practice and in learner performance.

A recent study conducted by Hilton (2018) shows that the majority of veteran teachers are not fully prepared to effectively respond to recent transformations in the classroom. Therefore, this clearly shows that more research on the PD of veteran primary school mathematics teachers should be conducted and harnessed (Mohyuddin & Khalil, 2016). In the twenty-first century, education revolves around technology (Slabbert et al., 2009). Multiple studies have found that computer competence decreases with age and years of teaching experience; thus, most veteran teachers encounter challenges in integrating technological resources and programmes like Mathletics (Inan & Lowther, 2010).

2.4.3 Technology integration in classrooms and veteran teachers' determination to use it

The entry of educational technology into schools compels teachers to be proficient in its application (Klinger, 2011). However, Orlando (2014) stresses that most veteran teachers are not willing to use technology during teaching and learning; they choose to stick to the traditional method of teaching. Their detachment from technology creates tension between them and their learners. Moreover, the literature shows that twenty-first century learners are technology gurus; therefore, these learners actively participate when technology is used (Hoyles & Lagrange, 2010). In this era, teachers must bring real-life challenges related to mathematics into the classroom that will enable learners to link school knowledge with what they encounter in their everyday lives; this will make it easy for them to link the school curriculum with what is happening outside. By so doing, learners will be more interested to continue learning mathematics in later grades when they see the importance or relevance of mathematics in their lives.

Muir (2014) has found that if Mathletics is applied correctly, learners' performance and the content understanding will increase and their participation and engagement during teaching and learning will improve. According to Nansen et al. (2012), Mathletics vastly

improved the teaching methods of Australian teachers and learners were motivated and more engaged in learning. Learners were eager to learn and asked more questions, indicating that they were more interested in the subject. Nansen et al. (2012) substantiate that Mathletics provided an opportunity for learners to practice, repeat and reinforce basic mathematics skills. It also offered extra support outside the classroom with differentiated learning approaches that allow for quick and instant feedback without any contact with the teacher.

Milondzo and Gumbi (2011) posit that the theory and practice of curriculum must effectively equip teachers with the necessary competencies to mitigate the challenges associated with teaching and learning in twenty-first century classrooms. It is evident that the curriculum is constantly changing with the influx of educational technological appliances and teaching is becoming more learner centred (Du Toit, 2012). Curriculum differentiation takes place when the teacher adjusts the lesson plans, arrangement of learners in the classroom, use of various teaching resources and teaching methods to accommodate various learning needs of learners in the classroom (Konstantinou-Katzi, Tsolaki, Meletiou-Mavrotheris & Koutselini, 2013).

However, veteran teachers, especially those from the townships and rural areas, are less interested in keeping up with the fast changes in curriculum transformations of contemporary South African society (Esau, 2015). More emphasis should thus be placed on developing educational technology to improve the standards of learning, which could also encourage learners' participation and academic improvement.

As discussed throughout the literature, there appears to be a strong relationship between mathematics and technology in twenty-first century education. The use of educational technology is a relatively recent approach to teaching mathematics. It has been proven by various scholars that learners' anxiety regarding mathematics can be lessened when they use interactive online mathematics games such as Mathletics (Vorensky, 2018). Multiple reports show that learners are more interested in pursuing online resources. This is shown by their increased cooperation and motivation to submit tasks on time and by increased interest in sharing ideas with their peers through online learning platforms (Malone & O'Shea, 2014). However, recent literature shows

that most teachers are not well prepared for this new learner-centred technological teaching approach in terms of the Pedagogical Content Knowledge (Liu et al., 2018).

2.4.4 New teaching approaches in the mathematics classroom

MacManus (2018) contends that new approaches to teaching and learning are critical in this new era to suit the needs of the new generation of learners that we are currently teaching, as well as future generations. The teaching and learning process should therefore be constructivist-based and should cater for individual learning differences. It should further enable learners to be in control of their own learning, be inclusive yet effective and all the mediums should be integrated, especially technology. Furthermore, the main foci during teaching and learning should be on activating the higher order thinking skills and collaborative learning and problem-solving skills of learners (Lee, 2002). For mathematics teachers to stay relevant, they must be willing to engage in PD opportunities to acquire the necessary skills of utilising technology in the classroom. A perturbing finding from recent research by Orlando (2014) has shown that teachers' limited knowledge of implementing technology during the teaching and learning process emanates from their lack of participation in professional development programmes and failure to collaborate with other teachers in PLCs. This negatively affects learner achievement (Adler, 2017).

Various scholars, such as Day and Gu (2009), also contend that the reason why most veteran mathematics teachers have limited knowledge and skills in certain areas, like technology, is that they are generalist teachers. Generalist teachers must be everything to everyone – they must be scientists, mathematicians, historians and economists. This makes it difficult for generalist teachers to successfully master all the required skills and knowledge for all the subjects they teach. Primary school teachers are already under pressure by trying to master the pedagogical content of all the subjects they teach. Personally, as a primary school Natural Sciences and Mathematics teacher, a cluster leader, a mother to toddlers, a wife and a full-time master's student, I am only coping because of my supportive family. It is overwhelming and challenging. Some teachers do not receive adequate support at work or at home. These teachers do not have any interest in upskilling through lifelong learning.

In short, the primary school system must be like that of a secondary school where a teacher becomes a specialist and focuses on a particular subject like mathematics (Modisaotsile, 2012). Again, in South Africa, most of the teachers who are confident and knowledgeable about a specific subject tend to look for teaching opportunities in best performing secondary schools, while teachers in primary schools have limited knowledge and skills in the subjects that they teach – especially the veteran teachers who have been trained to teach all the subjects or learning areas (Jensen, Roberts-Hull, Magee & Ginnivan, 2016). Teachers who specialise will gain more interest in mastering one particular subject, unlike in a primary school where teachers are required to teach numerous subjects. This makes it hard for teachers to be focused because they are trying to learn many things at once. Overburdened teachers tend to not complete the curriculum as required by policy. This is not just a problem in South Africa; in Australia, various scholars have found that current primary teaching degrees do not give teachers adequate skills to teach all their subjects.

2.5 Pedagogical Content Knowledge required for primary school mathematics teachers

2.5.1 Modernised classrooms, learners, teachers and teaching approaches

Recently, we have seen a proliferation of the use of technology in education (Dunn, Gray, Moffett & Mitchell, 2018). The majority of mathematics teachers in America and Australia have also noticed the probable benefit of using Mathletics during teaching and learning to support learning at school and at home (Malone & O'Shea, 2014). It is also used as a fundamental that promotes teaching and learning outside the school walls. However, researchers such as Hwang et al. (2015) have highlighted the importance of having effective teaching pedagogies that will ensure that technology is effectively implemented in classrooms and brings forth the desired educational outcomes as intended by the DBE (Nansen et al., 2012). The relationship between teachers' pedagogical knowledge (PK), content knowledge (CK) and PCK is shown in Figure 1.

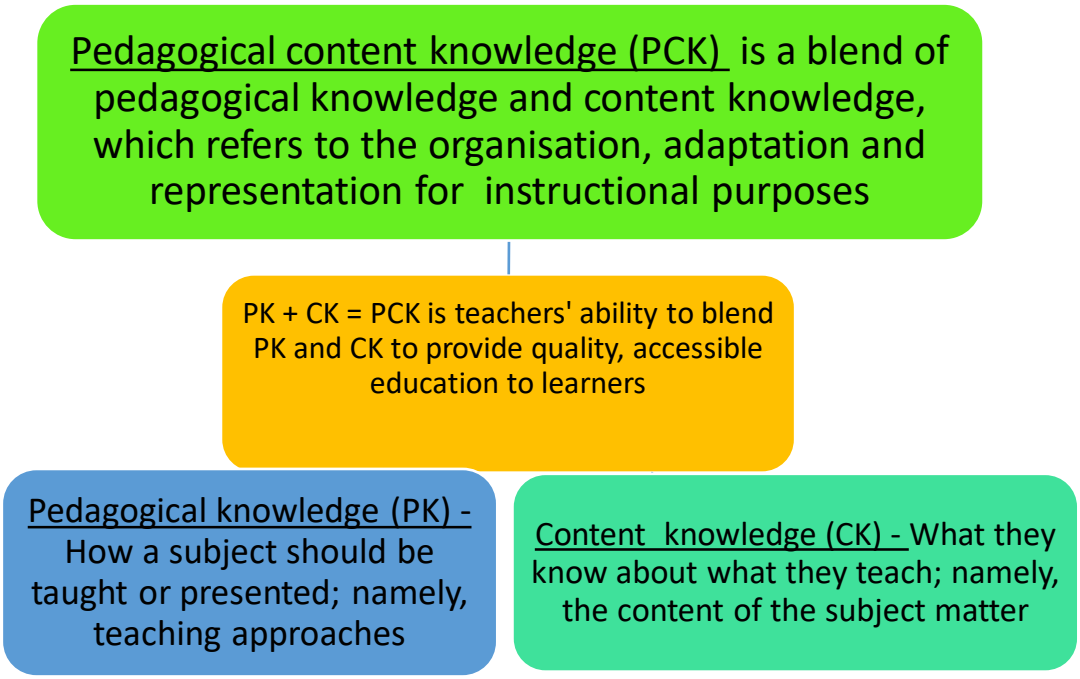


Figure 1: The relationship between PK, CK and PCK

A large body of research shows that educational technology is transforming at an alarming rate (Henriksen et al., 2016). Therefore, teachers need to possess the required knowledge, skills and willingness to provide quality education to technology-born learners – also known as technology gurus – who will inevitably be our future leaders (Hilton, 2018). Studies posit that in twenty-first century education, the main role of teachers is to facilitate, coach, support and guide the learning and teaching processes inside and outside the school walls (Du Toit, 2018b). This implies that teachers must acquire an in-depth understanding of all the CAPS-aligned subjects before they can attempt to integrate or implement them during learning processes; they must understand what they teach and how to teach. Teachers must go an extra mile, hence there is an increasing need for ongoing teacher PD. Teachers have to study further, be active in their PLCs, attend workshops and seminars, equip themselves with all educational policies and enrol for short courses in technology and mathematics subjects to upgrade their skills, because we can see that technology is here to stay.

2.5.2 Day-to-day teaching of mathematics in Gauteng primary schools

The day-to-day teaching and learning of mathematics in the South African province of Gauteng is guided by the Gauteng Provincial Literacy and Mathematics Strategy (GPLMS) and CAPS Grade R-12 (De Clercq, 2014). South Africa consists of nine provinces, one which is Gauteng. Gauteng contains the country's largest capital and is the centre of the country's economy, education, agriculture and health. Gauteng carries most of the internationally ranked universities, including the University of Pretoria and the University of the Witwatersrand. The word Gauteng comes from the Sotho word *gauta*, which means gold; Gauteng means "place of gold". This province's name depicts the engrossing history of how gold was discovered in 1886 in Johannesburg, whose name in the vernacular is Egoli, which also means "place of gold".

In Gauteng, teachers are given strict guidelines on what, how, when and where to do the readily available lesson plans prepared by the Gauteng Department of Education through the Gauteng Provincial Literacy and Mathematics Strategy (GPLMS)(Department of Basic Education, South Africa,2012). Teachers are voiceless and do not contribute to the process of making lesson plans. These lesson plans make curriculum differentiation difficult. Questions and answers are readily available, like a cooking recipe – teachers are being fed what to do and what not to do through the traditional teaching approach, which puts restrictions on their teaching practice. Teachers who do not comply with the step-by-step intervention presented in the GPLMS and CAPS Grade R-12 documents are criticised by subject advisors. In the South African context, subject advisors, who are also referred as facilitators, work closely with the teachers by providing support and guidance in terms of the Curriculum Management Framework. If teachers are encountering challenges with a certain topic or content area, it is the duty of the subject advisor to step in. Again, subject advisors are monitoring the progress of teachers to check whether they are teaching the right content that is aligned with the CAPS and the ATP requirements (Nkambule & Amsterdam, 2018). Subject advisors are experts in their subjects; hence, they are given the power to facilitate, support, guide and monitor other teachers, including post-level-one and post-level-two teachers. The rigidity of the GPLMS and CAPS

documents exacerbate the poor performance of learners in mathematics because teachers are not allowed to adjust the content.

As a mathematics teacher in Gauteng, I have noticed numerous errors in the GPLMS; however, teachers do not have the power to correct these errors. This implies that some of the teachers who have not seen these errors continue to present these misconceptions to their learners. The South African mathematics curriculum is constrained to the point where teachers and learners do not solve problems critically. The teaching of mathematics does not encourage flexibility and the full cooperation of learners. Authors such as Dunaway (2011) show that memorising and rote teaching is now shifting to a new, connected, problem-solving approach that is advanced by technology. This will engage learners in improving their understanding of mathematical concepts, guided by a constructivist and connectivist approach.

South African mathematics literature shows that most mathematics teachers have limited mathematical knowledge due to curriculum restrictions (Long & Dunne, 2014). Again, the majority of teachers who are qualified to teach mathematics lack the scaffolding of pedagogical teaching practice and cannot effectively connect the curriculum to learners' interest. The curriculum does not allow for problem-solving tasks, presents limited collaboration tasks and is dominated by traditional teaching approaches. There is thus a need for curriculum restructuring.

Voogt and Erstad et al. (2013) find that in the twenty-first century, technological transformations are affecting the way we live, work and learn. In today's world, certain competencies are needed for an individual to be productive and effectively contribute to the world economy (Klinger, 2011). However, the twenty-first century competencies such as effective communication, understanding and the ability to use technological resources, problem-solving, collaboration, lifelong learning and analytical skills are not well implemented in the education sector (Du Toit, Bothma & De Boer, 2015). Most teachers, especially veteran teachers, are inadequately prepared for most of the transformations that are taking place in the education system (Carrillo & Flores, 2018). Competencies needed in the modern world include digital literacy, productivity, adaptability, teamwork, literacy, numeracy, curiosity, critical thinking and problem-solving skills (Du Toit, 2013; Soffel, 2016). This implies that there is a need to learn

and continue to learn. Hence, scholars contend that lifelong learning is a powerful key that opens the doors of the modern world (Du Toit, 2013).

With the little knowledge that I have as a teacher and assistant facilitator, I believe that you cannot effectively teach what you do not know. This implies that urgent action in the PD of teachers is needed – together with the teachers, not on or for the teacher. Hence, I deduce that teachers must participate in PD platforms, such as workshops, seminars and their CLP in schools, and they must speak out and share all their good practices.

Darling-Hammond et al. (2009) state that teacher PD initiatives must be effectively implemented and monitored, since it is evident that the purpose of education is change. The curriculum frameworks, PCK, assessment strategies, assessment structuring and teachers' perceptions of their traditional teaching should therefore also change. However, although the curriculum is changing, teachers' pedagogical content knowledge is not keeping up with the change (Saavedra & Opfer, 2012). Therefore, the changes in the curriculum, instruction and assessment have direct implications for professional development and the teaching profession.

According to Tella (2017), mathematics teachers ought to be able to reflect and evaluate before, during and after presenting a lesson. This idea is in keeping with the idea of Schön (1987), who refers to reflection before action, reflection in action and reflection after action. This reflection process, as stipulated by Schön (1987), encourages teachers as practitioners to make pragmatic decisions based on their reflection and come up with improved pedagogy. Teachers should master the basic skills of teaching mathematics with various teaching tools, teaching strategies, have a solid understanding of the content, and continuously upgrade their skills by engaging in PD programmes. The reflection process enables them to keep abreast of curriculum transformations to meet the needs of groups consisting of diverse learners in terms of learning abilities, racial groups, physical ability and socio-economic groups (Tella, 2017). The reflection process also enables learners to construct a positive link from their prior knowledge to currently acquired knowledge and how to make a connection between prior knowledge and newer knowledge. As a result, this will elevate learners' interest and motivation and elevate their desire to learn mathematics.

2.6 TEACHERS' PEDAGOGICAL INFLUENCE ON LEARNERS' PERFORMANCE

2.6.1 Teachers' role in learner performance and SIAS policy

Through international research and debates, such as those of Darling-Hammond, Amrein-Beardsley, Haertel and Rothstein (2012), it is evident that teachers play a huge role in impacting learning in terms of academic confidence and career development. In 2014, the Gauteng DBE introduced the SIAS policy. The aim of this policy was to ensure that teachers identify and assist learners who require additional support to maximise learner participation and inclusion during teaching and learning. As stipulated in White Paper 6, all learners in the classroom must receive fair, good quality and equal education regardless of their learning abilities. Since 2015, Gauteng teachers have been attending workshops regarding the SIAS policy. This policy seeks to prevent learners from dropping out of school before Grade 12. Through SIAS, teachers can offer the necessary interventions to learners by implementing curriculum differentiation, as explained earlier. We have seen that in South Africa, mathematics performance has been too poor, and it continues to be poor. Hence, the SIAS policy has been a significant intervention. However, in my observation, this policy is not effectively implemented in all the schools due to lack of knowledgeable school-based support teams (SBSTs) and learner support educators (LSEs); if SBSTs and LSEs can be well equipped and knowledgeable, the learner performance in all the subjects can improve.

2.6.2 Definition of pedagogical content knowledge

The literature shows that teachers whose learners are ranked as top achievers in TIMSS and in PISA possess higher pedagogical content knowledge (Mullis et al., 2012). Various scholars, such as Vorensky (2018), state that teachers' mathematics anxiety has tremendous negative consequences for learners' achievement and the quality of instructional practice. Researchers have found that the most significant factor that is inevitable in learner instructional performance is teacher quality (Kariuki, 2009).

2.6.3 Twenty-first century mathematics expectations

Regardless of all these educational changes taking place, the data of the Second Information Technology in Education Study (SITES) show that most teachers do not promote twenty-first century learning in their instruction (Voogt, Erstad et al., 2013). Furthermore, researchers believe that changes and adjustments in the curriculum should take place to make room for twenty-first century competencies. As a result, this will permit teachers to acquire new modernised teaching and assessing methods (Saavedra & Opfer, 2012). Effective twenty-first century mathematics teachers should: Acquire the foundational and meta-knowledge of the subject matter; have a repertoire of pedagogical strategies; use various mediums; make continuous reflections before, during and after presenting a lesson with learners and colleagues; find room for improvement; be willing to accept weaknesses, and work on improvements (Tella, 2017).

2.6.4 The stance of mathematics teachers in twenty-first century education

Teachers play a significant role in teaching and learning (Merchie, Tuytens, Devos & Vanderlinde, 2018). However, numerous reports argue that the quality of the education system cannot exceed the quality of its teachers; this is evident from learners' academic output and achievement (Bellibas & Gumus, 2016). Teachers' PCK is important in assisting them to know and understand their role (Vorensky, 2018). This implies that if mathematics teachers become knowledgeable and skilful about the technological transitions and advancements that are taking place in education – such as Mathletics – the so-called difficult subject of mathematics would be easy, fun and understandable for both learners and teachers (Dale, 2016). Thus, teachers must become conscious of their value in terms of the PD process skills they acquire. This may ultimately facilitate learning and the advancement of learners in becoming critical thinkers who can become active, viable and respected citizens of the country. Teachers should continue learning throughout their professional careers to remain relevant and to satisfactorily perform their jobs in the twenty-first century (Bellibas & Gumus, 2016).

Vygotsky (2012) contends that twenty-first century teachers should be constructivist teachers by becoming facilitators of learning and being able to integrate various teaching methods to accommodate all diverse learners in the classroom; as stipulated in the White Paper 6, no learner must be left behind regardless of their learning abilities. Again, twenty-first century teachers must be able to use various teaching and learning resources to maximise the full potential of all learners. They should further be willing to effectively guide learners through teaching and learning by using various approaches to facilitate learning efficiently and effectively. These twenty-first century competencies will maximise learners' understanding of the subject content and elevate learners' potential to be more curious and critical thinkers. Blake (2015) and many others, including Vygotsky (2012), attest that indeed learners are more willing to activate their zone of proximal development (ZPD) by engaging with other learners and they can articulate themselves during group work. When learners work together and guide each other, their confidence maximises, and they become more open and willing to share; hence, the learner-centred teaching and learning approach is fundamental in the twenty-first century. Constructivist teachers must be able to consider learners' preconceived knowledge as a baseline prior to assessment and plan a lesson in such a way that there will be a linear and contextual link to the new knowledge. Also, it must be relevant to everyday lives of learners for learners to link school knowledge and everyday knowledge.

Teachers need to engage in lifelong learning and learn how and when to use technological programmes like Mathletics to improve poor learner performance (Hilton, 2018). Teachers must continuously engage in PD initiatives to improve their teaching career to avoid a dormant, obsolete life. This can be done by furthering their higher education studies, training or actively taking part in workshops provided by the DBE. For example, in Gauteng, the DBE provides workshops, but these workshops take place over a short period. As a result, professional development is limited. Building on this, it is the sole responsibility of teachers to ensure that they remain lifelong learners who constantly update their skills (Van Driel & Berry, 2012).

The PCK and CK of the teacher determine the learners' understanding (Shulman, 1987). Schulman explains that PCK refers to the teaching methods, teaching and learning resources and various teaching approaches of teachers, and CK refers to the

subject knowledge of the teachers. Teachers daily interact with learners, which implies that they know the learners 'various learning needs and make decisions about curriculum delivery and curriculum differentiation (Cross, 2009). Thus, teachers need to partake in CPD initiatives. Teachers are expected to utilise various trending teaching tools and strategies that will create learning environments where learners' achievements are maximised (Desimone, 2009).

2.6.5 Collaborative teacher teams for ongoing development

Various researchers, including Bray and Tangney (2016), articulate that if mathematics teachers acquire effective and modern PD that is aligned with constructivist and connectivist teaching and learning approaches, their understanding and application of Mathletics will be maximised, and learner understanding, participation and performance in mathematics will improve. Attard (2016) has also argued that educational technologies do not fully support improved teaching and learning in education; for improved teaching to take place, teachers must effectively and efficiently guide, facilitate, support and monitor the learning process.

Teachers should work in collaborative groups (Smit & Du Toit, 2016) so that those who teach the same subject and the same grade can help each other to enhance their teaching. It is greatly beneficial if teachers work in groups to practice, share ideas and experiences regarding teaching strategies (Du Toit, 2013). What they learn as professionals is reciprocity, which can be implemented in their respective classrooms. The ideas that they share could contribute to coming up with a better teaching approach that can help learners improve their academic performance (Kassa & Mulugeta, 2015).

However, more could be done by professionals responsible for the professional training and development of teachers (McIntyre & Hobson, 2016). Professional developers in this context, which may include HoDs, PLC leaders and curriculum advisors, could ensure that teachers are diligently guided in engaging learners in meaningful quality teaching and learning. Through PAR, teachers can craft purposeful research questions and apply them during teaching and learning processes to improve

their performance output. However, the inquiry process during action research must not be biased. Many reform initiatives in PD have focused on the teacher as the key to improving learners' performance (Desimone, 2009). This is one of the reasons why veteran teachers need to have ongoing and regular opportunities to engage in peer mentoring and action learning. Skill updates enable teachers to relate to current trends in teaching strategies, improved curricula, new classroom management skills and the integration of technology in education.

Action research enables teachers to reflect on their PCK for development (Zuber-Skerritt, 2015; Whitehead & McNiff, 2006). During teacher-learner classroom interaction, teachers can reflect best on their practice. It may be easier for teachers to see which method of practice is better for improving learners' understanding, and their performance and achievement (Steyn, 2008; Tekin & Kotaman, 2013).

Improving teachers' knowledge, skills and competencies is one of the most important phases to guarantee improving learner achievement, as well as the general quality of education in schools (Muir, 2014). However, I argue that if teachers fail to apply the new ideas learnt during PD opportunities, learners may not benefit from teachers' professional development. It should be kept in mind that PD enhances teachers' skills and knowledge to improve classroom teaching and raise learners' achievements, understanding and competence. My proposition is supported by Kennedy (2016), who articulates that continuing PD can assist teachers in becoming lifelong learners. It further allows them to adjust more easily to the transformations that are taking place in the education system. Kennedy further highlights that there are nine models of CPD; the ones that are relevant to this study include action research, mentoring and community of practice (Kennedy, 2005).

2.7 PROFESSIONAL DEVELOPMENT INITIATIVES

2.7.1 Action taken to ensure teachers' readiness in the twenty-first century

The twenty-first century raises numerous questions and uncertainties regarding our education system (Mohyuddin & Khalil, 2016). New technological teaching

programmes, methods and resources are being introduced more rapidly and as a result, teachers are not fully prepared to integrate and implement these new changes. For teachers to be able to utilise and implement all these new changes they must acquire necessary skills and knowledge (Kariuki, 2009). Researchers contend that teachers need to engage in ongoing professional development (Matthews, Cook-Sather & Healey, 2018).

Various scholars, including Steyn (2008) and Ono and Ferreira (2010a), assert that workshops, seminars and conferences are the main traditional approaches to PD. These approaches are simplistic, one-dimensional and non-interactive views of teaching. Such approaches do not result in an intervention that is pragmatic, applicable and realistic; hence, they lack follow-up and provide no scope for teachers' development in their respective fields of specialisation.

Moreover, if the principles of self-relatedness (Du Toit, 2013) as an important ingredient of PD are not considered, teachers may not develop as independent professionals who can monitor their professional advancement or development. Hence, action research is indispensable. Recent literature has confirmed that rapid technological advances have greatly affected the education system nationwide.

Technology is now being used as a fundamental resource for teaching and learning. However, there has been a challenge in that most teachers, especially veteran teachers, have limited skill in applying these technological resources during teaching and learning. As a result, this significantly affects the performance of learners (Lawless & Pellegrino, 2007). To mitigate this shortfall, the government has invested funds to implement initiatives that focus on professional development to emphasise the use of technology-based pedagogical methods. These initiatives entail retraining in-service teachers together with newly appointed teachers. This ensures that technology integration during teaching and learning becomes a culture for improving teacher and learner performance output, and promotes quality education (Lawless & Pellegrino, 2007). However, report after report shows that these initiatives have a limited impact on teachers' pedagogical content knowledge due to their failure to apply what they have acquired during professional development initiative sessions, commonly referred to as workshops.

The initiatives for PD should focus on altering teaching practices; however, this is only possible if the curriculum is technology-based and effective technology integration should support the needs and objectives of the curriculum to improve teaching instruction and learners' understanding (Lawless & Pellegrino, 2007).

Researchers such as Geldenhuys and Oosthuizen (2015) have revealed that teachers simply sit and listen during workshops. They are not engaged; they are told what to do during teaching and learning without considering their own contextual factors. Hence, the rate of absenteeism increases sharply as the workshop continues because they get tired and bored. These workshops do not contribute to helping teachers improve classroom practice (Tienken & Stonaker, 2007). Role modelling is considered one of the attributes of the twenty-first century (Du Toit, 2019).

2.7.2 Criticism about current professional development approaches

PD approaches are criticised for not giving teachers adequate time and more practical and informative tasks that would help them to link what they learn during these initiatives to their classrooms and improve both their CK and PK (Desimone et al., 2002). PD initiatives do not address the incapacity and incompetency of teachers (Steyn, 2008). Therefore, teacher absenteeism is high during these PD initiatives (Mewborn & Huberty, 2004). I hypothesise that action research should be used to address the challenges faced by mathematics primary school teachers in exploring Mathletics during mathematics classes, together with action learning, which will maximise the teacher-learner relationship.

2.7.3 What needs to be done to improve teacher professional development approaches in South Africa?

PAR suits this study like a hand in a glove as it encourages teachers to be more proactive and responsible for decision-making by allowing teachers to reflect on their teaching practice (Zuber-Skerritt, 2015). Moreover, action research improves the professional and personal status of teachers and can bring a positive transformation

to classrooms and schools (McNiff & Whitehead, 2006). Mathematics teachers should be able to implement the curriculum in a way that will help learners to develop skills that they will use later in life. This empowers learners to be critical thinkers, analytical problem solvers and creative individuals (Van Driel & Berry, 2012). Constructivism should be the basis for teaching and learning to achieve quality education (Amineh & Asl, 2015; Desimone, 2009). Teachers need to adjust their PK and keep abreast of modern education to stay relevant (Hughes, 2005).

Academics, such as Goodyear (2006) and Du Toit (2013) posit that teamwork is essential in facilitating learning for teachers, making them aware that they must give learners a sense of ownership during teaching and learning. Learners must be allowed to showcase their talents, creativity and to share ideas.

2.8 PEER MENTORING IN THE COMMUNITY OF LEARNING PRACTICE (CLP)

2.8.1 Peer mentoring process

Peer mentoring takes place where a highly knowledgeable teacher who possesses certain skills, such as subject content or computer skills, helps other teachers to acquire such similar skills (Colvin & Ashman, 2010). Peer mentoring is important in providing support, PD for less knowledgeable peers, improvement of self-confidence, self-esteem and it also maximises problem-solving abilities. As a result, this helps improve job satisfaction and improves the positive working relationship and trust between individuals, and the entire work environment will be conducive to everyone. Peer mentoring creates opportunities for improved approaches that are validated by other professionals in the same field. Smit and Du Toit (2016) contend that peer mentoring is beneficial to all individuals involved in the CLP – those who are less knowledgeable and those who are more knowledgeable will learn from each other.

According to a study conducted by Inan and Lowther (2010), it is evident that support and peer mentoring is key in ensuring that teachers acquire contemporary teaching pedagogies, skills, knowledge and resources. Moreover, multiple reports show that teachers' years of teaching experience negatively affect their technology integration

and their readiness to integrate technology. Educational researchers accentuate the importance of peer mentoring between beginner teachers and veteran teachers as essential for ongoing staff development. Typically, in the peer mentoring process, experienced teachers share their expert knowledge, skills, teaching approaches, methodologies, school policies and classroom management, problem-solving in teaching and learning, and offer professional and personal support (Sánchez, Pinkston, Cooper, Luna & Wyatt, 2018).

There is a consensus in the literature that teachers need to form a collegial interaction and teamwork in their PLC to acquire quality PD (Van Driel & Berry, 2012). Based on the research, peer mentoring is one of the most important skills in the twenty-first century for quality learning to take place (Saavedra & Opfer, 2012). Perkins (2010) elaborates that people do not learn to play baseball by themselves, but learn to play with their peers and a coach; if they play by themselves, it will not be appealing or fun and learning will not be optimal (Perkins, 2010).

International literature concurs that peer mentoring is now a fundamental tool for teacher development (Frederiksen, 2015). It is believed by various scholars that peer mentoring leads to action research where colleagues have a shared, significant influence on one another's PD. This also brings about positive reflective professional learning, which benefits all involved (Matthews et al., 2018). Likewise, numerous scholars argue that when teachers mentor each other in a CLP, they feel empowered, as it boosts their self-esteem. By so doing, they tend to be more interested in participating in professional development initiatives and this engagement helps teachers to connect theory to practice quite easily (Matthews et al., 2018).

2.8.2 Peer mentoring for educational reform

Moreover, report after report shows that PD is a social and interactive process where professionals work together to develop each other's practice in a CLP by providing guidance and support to one another (Desimone et al., 2002; Smit & Du Toit, 2016). Additionally, Wenger (1998) strongly believes that knowledge is socially constructed; this implies that it is impractical not to engage with others in PD. As it is written in the

Bible, “Two are better than one because they have a good return for their labour: If either of them falls, one can help the other up” (Ecclesiastes 4:9-10). Furthermore, numerous authors (Adler, 2017; Shabani, Khatib & Ebadi, 2010; Vygotsky, 2012) reiterate that in the Zone of Proximal Development (ZPD), individuals learn best when working together. When persons with low ZPD and high ZPD meet, they work together to internalise the acquired concepts. Therefore, a change in cognitive and external stimuli takes place from which they will all benefit.

2.8.3 Peer mentoring for staff development

Peer mentoring enables action learning to take place where beginner teachers or newly appointed teachers from the institutions of higher learning enter the workplace – in this case the schools – and show veteran teachers how to effectively use educational technology, such as the newly introduced mathematics programme: Mathletics. Using this approach, veteran teachers become actively involved during their professional learning process and they rise to the challenges they come across. Presumably, in a reciprocal fashion, both groups of teachers learn from each other (Smit & Du Toit, 2016). Effective collaboration is fundamental as it enables teachers to work together in providing the support that is grounded in real-life experiences, as well as sharing ideas that can be beneficial for all participating individuals (Matthews et al., 2018). Scott & Hargreaves (2015) contend that collaboration bridges theory and practice and blends them to create helpful teaching and learning methods. A prerequisite for successful collaboration is the willingness, openness and confidence of teachers to share their weaknesses and strengths so that they can learn from each other in a reciprocal fashion (Matthews et al., 2018).

Effective mathematics teachers work closely with their colleagues in a CLP to ensure a conducive learning environment that accommodates all stakeholders involved (Muschla, Muschla & Muschla, 2010). Good mathematics teachers strive to improve their school by helping others to do well, by being involved in the school community and, above all, regarding lifelong learning as a priority. It is important to learn and continue to learn throughout employment. Social interaction and the need to operate

in a cooperative international and global environment is also essential as this will enable the smooth flow and sharing of information (Voogt, Erstad et al., 2013).

2.8.4 Peer mentoring in the CLP

A CLP refers to a group of individuals who encounter similar real-life challenges and are willing to come together and learn from each other by sharing their experiences (Pyrko, Dörfler & Eden, 2017). Moreover, scholars find that when people learn and think together, they become more knowledgeable, which also results in joint decision-making and knowledge creation that applies to all individuals (Pyrko et al., 2017). Social constructivism shows that the root of individuals' knowledge is found in their interactions with their surroundings and other people before their knowledge is internalised and maximised (Amineh & Asl, 2015).

2.9 MATHEMATICS TEACHERS' PRACTICE IN MODERN PRIMARY SCHOOLS

Mathematics is often viewed as the most difficult subject, even in the early years of primary school (Mohyuddin & Khalil, 2016). Gasser (2011) contends that teachers have the power to foster imagination by ensuring that they make the teaching and learning of mathematics fun and understandable by using the most favoured and recent resources and programmes to facilitate the learning process. The literature shows that the teaching and learning of mathematics has been a cyclical process of rehearsal, recalling, drills, memorisation and pointless repetition (Siddiq et al., 2016).

2.9.1 Cutting-edge mathematics teachers

Teachers are willing to share cutting-edge practice and take responsibility for engaging with their colleagues to keep abreast of what is happening. They are also willing to engage in peer teaching in scholastic environments and use numerous technological resources and programmes such as GeoGebra, Spellodrome, YouTube and Mathletics. Scholars have discovered that technology is a lamp for education in the Fourth Industrial Revolution, yet some teachers have not had the opportunity to learn

to maximise and internalise its pedagogical value in teaching and learning (IstenicStarčič, Cotic, Solomonides & Volk, 2016).

Moreover, technology integration in education has focused more on technology advancements rather than pedagogical competency (Kereluik, Mishra, Fahnoe & Terry, 2013). This implies that teachers should not only learn about new technological resources and programmes, but they should learn how to implement these technological resources effectively during teaching and learning. This should be done by acquiring the know-how and incorporating these resources in teaching to improve the quality of teaching and learning (Bray & Tangney, 2016). Teachers must strive to become constructivist teachers by facilitating learning in ways that will prepare learners for the world of work (Kereluik et al., 2013).

Education policies such as the CAPS, NPA, and NPPPPR should respond to the expanding demand for new technologies in education. The school curriculum should be learner-centred and respond to technology integration in education. The rationale for this, as justified by different scholars, is that educational technology has been an area of interest worldwide due to new improvements in the learning and teaching culture. This is often more enjoyable, fun and easy for the new generation of learners; however, this increase of technology which is welcomed by learners poses a tremendous challenge for veteran teachers (Eickelmann et al., 2012).

One of the most common aspects of constructivism is that learners should be actively engaged in meaning-making by relating the presented context to their prior knowledge to gain an in-depth understanding and acquire productive knowledge. The technological advancements in education compel effective modern pedagogical strategies of teaching and learning (Dabner, Davis & Zaka, 2012). There is also an urgent need for improvement in the curriculum to encompass content that is more relevant to the current standard. The curriculum should be structured in a manner that will allow learners to continually build on what they have already learnt and experienced, which implies that it should be learner-centred (Khalid & Azeem, 2012). Moreover, Khalid and Azeem (2012) posit that the school mathematics curriculum should have more practical technological activities that allow learners to link the school

content to the outside world. This will ensure that learners see the relevance of school knowledge (Khalid & Azeem, 2012).

Based on the literature, the constructivism approach is the best teaching and learning theory as it encourages modern learners to be active participants in the learning process by being more curious about their world (Zhou & Brown, 2015). Teachers are responsible for the arrangement of the subject matter, meaning that they are the curriculum developers, so they must be treated as such by the DBE; they must not be given ready-made resources but they must contribute during the process. Previous literature reveals that the majority of veteran mathematics teachers are resistant to change and are inattentive to the application of technology due to limited technological skills, a lack of technical support, a lack of access to equipment, a lack of adequate time for PD and ineffective technological leadership in their CLP (Wachira & Keengwe, 2011).

The effective application of technology during teaching and learning tremendously influences learners' performance in mathematics (Northcote, 2011). Technology improves teachers' pedagogical practice, learner participation, learner understanding and computation skills (Samuelsson, 2007). Moreover, technological programmes such as Mathletics increase fluency in basic mathematical skills, mathematical reasoning, and learner motivation to be resilient in mathematics (Muir, 2014; Nansen et al., 2012). According to the constructivist theory, mathematics is a dynamic process of inquiry that is continually expanding, and it supports a learner-focused model of teaching and learning (Cross, 2009; Cobb, 1994). Mathematics prioritises individuals' sense-making, supports the establishment of a learner-focused environment and encourages learners to be critical thinkers (Cross, 2009).

The twenty-first century requires skilled mathematics teachers who can improvise and adjust their teaching practice to meet the needs of diverse learners using various mediums, including technology (Anderson, 2016). However, for teachers to develop an interest in integrating technology into teaching and learning, the curriculum should include content that is technology-based for teachers to be eager to engage in professional development programmes that will enhance their readiness in this regard (IstenicStarčič et al., 2016).

The most favoured teaching approach is constructivism, but there now seems to be a shift to a connectivist approach. However, after reading several articles, I hypothesise that the combination of constructivism and connectivism can improve the instructional understanding of learners. Part of the rationale behind this hypothesis is that even when learners use technological tools, they must have a theoretical understanding of the subject matter before they can use any technological resource to access the information. CK is fundamental to successful teaching and learning. Learners cannot do data handling in Mathletics if they do not understand the theoretical content of data handling. I believe that theory is the best foundation for successful learning to take place, therefore I contend that constructivism should be equally implemented with connectivism during teaching and learning.

2.10 SUPPORT FROM THE DEPARTMENT OF BASIC EDUCATION (DBE)

2.10.1 Government intervention in ensuring effective teacher development

Darling-Hammond and McLaughlin (2011) argue that for teachers to take part in educational growth and development, adequate support from the DBE must be encompassed in policy documents, such as SASA (1996), Personnel Administrative Measures (PAM), Labour Relations Act (LRA), Employment of Educators Act (EEA, 76 of 1998), ELRC and the South African Council for Educators (SACE, 2007). However, for South Africa to achieve success in the PD of teachers, there is a need for sound policy development, implementation, proper management of quality teaching and learning, together with curriculum implementation and the authentic application of staff appraisal mechanisms via the Integrated Quality Management System (IQMS).

PD takes place on different levels, all of which are important (Van Niekerk, 2018). It is somewhat challenging for teachers to become lifelong learners if the support from other stakeholders such as the School Management Team (SMT), HoDs and School Governing Bodies (SGB) is not solid. However, the responsibility begins on an individual level, with commitment and dedication. Archibald, Coggshall, Croft and Goe

(2011) strongly believe that the intrinsic motivation of an individual opens the possibilities for success. This also enables other stakeholders to provide maximum support; if they observe that the individual is dedicated, they do offer support.

The government should provide some remuneration to assist teachers with financial costs, as recent research shows that teachers receive minimal financial support. This predicament hampers their participation and commitment to ongoing PD (Ono & Ferreira, 2010a). Teachers dedicate their time to finding new ways to provide for their families, instead of engaging in teacher professional development. Secondly, time is a huge challenge in South Africa, because teachers are expected to work for at least seven hours a day from Monday to Friday. Some teachers who conduct extra lessons also go to work on Saturdays. Extensive South African literature has found that minimal time is spent on PD and therefore teachers do not acquire much information within their time constraints. Again, teachers do not have much to say or contribute and, in most cases, teachers are given minimal hands-on activities and denied platforms to raise their concerns and views.

2.10.2 School principals' position in teachers' professional development

Amongst the most important stakeholders in the PD of teachers are school principals (Kelly & Cherkowski, 2017). As the managers of schools, principals should emphasise the upskilling and PD of teachers by providing time for CLPs among teachers. This would ensure that teachers attend workshops and cascade the information acquired and encourage other teachers to form CLPs by engaging with teachers from other schools (Kopcha, 2012). Multiple studies (Ntseto, 2015) show that school principals have sole mandate to improve schools by managing the schools and steering them on the right path by ensuring that their subordinates stay motivated and commit fully to their ongoing PD. School principals must ensure that teachers, learners and other stakeholders within the school strive for the development and betterment of the whole school (Van Niekerk, 2018).

2.10.3 Hindrances to teachers' professional development

Adequate support, time and resources need to be set aside for teacher development. However, Tienken and Stonaker (2007) argue that the reason why teacher PD programmes do not improve teaching practices is that teachers are not given ample time to implement what they have acquired. Teachers should have a say in the content of activities and the decisions that are made by the Department of Basic Education (DBE), because teachers are the ones who engage with learners and know what learners need to improve their instructional understanding and performance (Bray & Tangney, 2016). Teachers should be considered as partners in decision-making in terms of any improvements or changes in education. This would make it easy for teachers to practice, comply with and integrate any changes agreed upon (Milondzo & Gumbi, 2011).

2.10.4 Effective catalyst to ongoing teacher development

Teachers should be encouraged to work with all stakeholders. They should be treated as partners who can take the lead in their PD and not just as delegates who digest what can be offered to them (Attwell & Hughes, 2010). The literature clearly states that for teachers to upskill, they must receive one-on-one support from their facilitators. Additionally, research shows the importance of supportive relationships between teachers and facilitators. Establishing such relationships will enable teachers to open up and be willing to share their weaknesses.

Influential facilitators must be approachable, accessible, provide help and react to participating teachers in an appropriate manner that makes teachers feel that their contributions are meaningful and important. Influential facilitators must dress, speak and act professionally. They must have strong foundational skills and knowledge of the subject matter and be willing to transfer theoretical knowledge to practice (Linder, 2011). The intention in facilitating veteran teachers through the process of learning more about Mathletics was that I wanted the teachers to learn from me while I would be learning from them. They needed to know that we were partners in the learning process.

South African literature concurs that the key challenge that the DBE is experiencing in the PD of teachers is that the government is failing to allocate sufficient funding. Time is also a challenge because teachers must be at work at least for 7 hours daily from Monday to Friday and sometimes also do administrative work on Saturdays, such as marking scripts, setting tasks, compiling teacher preparation portfolios and preparing lessons. This implies that time and money are key hindrances in the development of teachers (Bush, Joubert, Kiggundu & Van Rooyen, 2010). The Department of Basic Education should thus prioritise the professional development of teachers.

2.11 Continuing Professional Development (CPD) for South African veteran primary school mathematics teachers in the twenty-first century

2.11.1 Mathematics teachers' footprint

The literature shows that teachers have a direct influence on learner performance (Gasser, 2011). Enlightened teachers voluntarily learn how to teach this new generation of learners and how to utilise new technologies for teaching purposes. They easily adapt to the curriculum shift by applying improved teaching strategies to influence the instructional understanding of learners positively. Several scholars (Zuber-Skerritt, 2015) posit that Continuing Professional Development (CPD) is the best way to help teachers to reskill. To boost their professional readiness and teaching pedagogy in their respective subjects and schools, action research is the best way to ensure that the professional status of teachers stays updated.

Countless studies and statistics point out that mathematics teachers are an area of interest worldwide because it is believed that mathematics is a difficult subject. For teachers to sustain the ever-transforming knowledge, which has become technologically based, teachers should attend effective development or enrol for programmes that are aligned with their field of specialisation. These programmes should emphasise the most challenging topics, as this will allow teachers to share their working practices and challenges and learn how to overcome these challenges. These

development programmes should enable teachers to openly engage in the sharing of their teaching strategies and build unison (Kriek & Grayson, 2009). Professional development for mathematics teachers in South Africa is not new; however, it has been conducted using traditional approaches that have yielded limited intervention in the PCK of teachers. It is thus high time to ensure that PD programmes respond to the individual needs of teachers realistically and pragmatically (Kriek & Grayson, 2009).

Inan and Lowther (2010) have found that although Mathletics resulted in positive learner outcomes in America and Australia, multiple studies also report that the majority of veteran teachers have limited technical skills; thus, they detach themselves from implementing Mathletics during teaching and learning. Cobb (1994) contends that effective professional development (PD) should be conducted through modern approaches that are constructivist to enable teachers to focus on real contextual practice. This will improve their teaching practice and allow them to share helpful strategies by engaging in teamwork with other staff members in the department, grade, and/or school level (Desimone, 2009; Kriek & Grayson, 2009; Bellibas & Gumus, 2016; Desimone et al., 2002; Du Toit, 2013). Effective PD involves deliberate assessment of and feedback on practices.

2.11.2 Influence of professional learning communities

Wenger (2000) has identified that a PLC is an effective approach that enables teachers to actively engage in peer teaching and professional learning. This is also where teachers can come together to share and reflect on their teaching approaches and strategies to improve their teaching pedagogy and learners 'understanding.

The main objective of a PLC is that teachers' practice needs to be enhanced at the school level before elevating it to the district, provincial and national levels. The same applies to quality education; it should start in primary schools before reaching secondary and higher institutions of learning. This is where my interest lies – in the professional development of mathematics teachers. Teachers have a limited understanding of the concept of CPD. They view CPD as activities that are aimed at upgrading teachers' knowledge. They do not consider PD to include their personal

development. Moreover, teachers are not allowed to have a say in their learning; as a result, they cannot identify their areas of need regarding CPD programmes. The characteristics of twenty-first century mathematics teachers are as follows: They become lifelong learners by engaging in continuous PD; teachers keep abreast of the latest technology; they are good collaborators and very active in peer interaction; they become critical thinkers and risk-takers. In addition, they: have an in-depth understanding of the PCK of the subject matter; possess strong organisational and managerial skills; are role models and represent their diverse communities; are problem solvers and interested in listening to learners' questions and ideas; serve selflessly and are committed; encourage hands-on activities; strive for excellent quality education, aware of their role in this "globalised era"; and they are facilitators, not tellers, and enable learners to take responsibility of their learning.

Mansour, Heba, Alshamrani, and Aldahmash (2014) highlight the importance of ongoing professional development for mathematics and science teachers as necessary for providing quality teaching and learning in twenty-first century education. Effective CPD also improves work relationships among colleagues by enabling smooth sharing of content knowledge and good classroom practices, whole-school growth, the understanding and implementation of school policies, procedures and practices, and the involvement of parent-related activities. As a result, the learner performance output both in terms of quality and quantity will improve (Ono & Ferreira, 2010b).

2.12 PARTICIPATORY ACTION RESEARCH IN THE COMMUNITY OF LEARNING PRACTICE

2.12.1 Participatory action research for refurbishing the teaching and learning of mathematics

Various stakeholders, including novice teachers, HoDs, deputy principals, school principals, facilitators of workshops, institutional development support officials (IDSOs) and circuit managers, use PAR as a powerful tool in education. PAR is used for various purposes, such as improving the situation in a school and improving the management and functioning of the school and staff development skills and knowledge, which are

valuable in the field of education (Hien, 2016). However, community engagement is regarded as the core element in PAR (Zuber-Skerritt, 2015).

PAR seeks to solve practical challenges within the community by involving community members (Wood & Zuber-Skerritt, 2013). Moreover, PAR should be done with people, not for people or to people; as such, it promotes social justice. From the literature, it is evident that scientific knowledge is created by scholars, scientists and theorists and implemented by practitioners like teachers. However, with PAR, practitioners can create knowledge that can be implemented by scholars' and vice versa (Zuber-Skerritt, 2015).

Within the CLP, individuals bring their personal experiences such as workplace, social and family experience, which they share. The various experiences are negotiated to bring out a coherent sense that will help all the members to develop. Wenger (1998) strongly posits that knowledge is socially constructed. Adding to this, a CLP is an integrated practice that involves participation and knowledge construction.

Wenger (1998) further points out that participation refers to members' active engagement by acting and having a strong connection in the community (Shabani et al., 2010). Active participation engenders mutual recognition and the constructive capability to debate facts and come together as individuals with a common ground. This is done with consensus that will enable the participants to develop and engage in self-reflection because this is when individual learning occurs. Furthermore, community engagement during PAR should be community-based not community-placed as this will enable participants to be actively involved in improving their community. This is how sustainable transformations and improvement in school communities take place (Zuber-Skerritt, 2015).

Vygotsky (2012) advocates that it is impossible to detach learning from its social context as all the cognitive functions occur effectively during social interactions with others in an integrated-knowledge community through scaffolding. Thus, I hypothesise that teachers can learn from each other in a CLP to improve their expertise.

Various researchers, including Day & Gu (2009), Wolvaardt & Du Toit (2012), contend that school principals as managers and leaders must be actively involved in initiating CLPs to encourage teachers to take part in peer mentoring (Smit & Du Toit, 2016). This approach may contribute to improving the quality of teaching and learning within schools. McNiff (2016) articulates that participants in action research are peers who are willing to connect learning to action by learning from and with each other. There is an emphasis on sharing knowledge that will decrease the learning difficulties of their peers. This will also permit individuals to internalise the learning into concepts and constructs that will make the learning process meaningful and fruitful.

2.12.2 Significance of the community of learning practice for mathematics teachers

Vygotsky (2012) states that mistakes, obstacles and frictions will arise within the CLP. However, the facilitator of learning or the leader should maintain peace and harmony by ensuring that all participants are fairly treated and respected. This spoke volumes to me. During my association with the teachers, I promoted collaboration and teamwork by ensuring that teachers shared their insights into Mathletics. Effective learning can be achieved if the teachers network in their CLPs where expert teachers or those who understand the content help others in their contextual settings. This will be achievable because they know each other better and they know their needs in more depth. The main components of PAR include commitment, collaboration, concern, consideration and change (MacDonald, 2012).

2.13 IMPLICATIONS OF THE POOR MATHEMATICAL PERFORMANCE OF LEARNERS IN THE SOUTH AFRICAN CONTEXT

2.13.1 The mathematics calamity in South Africa

Previous records obtained from the two main intergovernmental economic organisations – namely the Evaluation of Education Achievement (IEA) and the Organisation for Economic Co-operation and Development (OECD) – clearly show that mathematics performance in South Africa is a calamity. Bold et al. (2017) explain

that the majority of learners still lack basic mathematical comprehension after completing their primary school level. Based on this mathematical predicament, Bold et al. (2017) argue that it is not fair to judge the mathematical performance of learners in isolation; therefore, the importance of teachers' skills, knowledge and pedagogy is interdependent. This simply means that teacher quality is a prerequisite for any teacher development initiative (Bold et al., 2017).

Mathematics performance in primary and secondary schools is generally poor in most countries. However, the literature shows that South Africa is currently the worst (Adler, 2017). There are various reasons for poor performance. Aina and Philip (2013) find that the fear of mathematics as a difficult subject – preconceived by the community – is the main cause of poor performance. Moreover, poor teaching methods, the setting of the curriculum, lack of teaching and learning resources including technological resources, lack of parental involvement and overcrowded classrooms hinder the functional positive relationship between learners and teachers. The shortage of qualified teachers and qualified teachers who do not engage in CPD and are ineffective is a huge concern (Lowrie & Jorgensen, 2012), as teachers need to be lifelong learners so that their skills and this knowledge can be improved, aligned with and relevant to the current learning needs of twenty-first century learners (Megginson & Whitaker, 2017).

Bray and Tangney (2016) highlight the importance of making the learning of mathematics more interesting through learner-centred teaching and learning with the integration of technology. The learner-centred approach improves learners' interest in learning mathematics as it allows them to be more cooperative and curious, and permits them to apply their prior knowledge and problem-solving skills; as a result, they can contextualise the curriculum taught in schools into their everyday life. These include a teaching approach that enables learners to keep what they have learnt in their long-term memory while they are involved in the process of knowledge creation (Vale, Davies, Weaven & Hooley, 2010).

Mathematics is a subject that makes use of symbols and notations to describe numerical, geometric and graphical relationships (Aina & Philip, 2013; DBE, 2011). From the little knowledge that I acquired through reading journals, most of the scholars

have concluded that the poor performance in mathematics is caused by improper or limited pedagogical teaching methods, inappropriate CK, a lack of facilities – or rather a lack of the ability to use contemporary facilities such as technological teaching and learning resources and programmes – the content of the curriculum, and also the teachers' readiness in terms of professional standards (Aina & Philip, 2013).

2.13.2 Corollary of poor performance

Different studies show that the South African education system is very poor compared to other African education systems, including those of Nigeria, Ghana, Gabon, Zimbabwe and Namibia (Geary, 2011). Grade 12 results in most public schools are poor, which hinder learners from furthering their studies due to a lack of university access; as a result, this also leads to a high rate of unemployment, teenage pregnancies, a high rate of crime, an inability to actively participate in the economy, and irresponsible adults.

The main causes of the poor performance in mathematics, as mentioned in numerous South African studies, are as follows:

- Learners are promoted from one grade to another due to the age cohort, without mastering the content. The NPPPPR policy states that no learner can repeat a phase more than twice (Republic of South Africa, 2011). Most of the progressed learners do not cope in the higher grades, which also contributes to the high dropout rate in South Africa.
- Public schools in South Africa have the largest learner populations; therefore, overcrowded classes affect most of the schools. This makes it difficult for teachers to teach to the required assessment standards. The learner–teacher ratio is a setback for quality teaching and learning. Even applying the curriculum differentiation as stipulated in White Paper 6 is so challenging when faced with overcrowding.
- Teachers' incomplete curriculum coverage is due to a lack of or limited understanding of the content.

- There is insufficient teacher CK of the subject and limited use of technology teaching and learning resources.
- The teachers rely on textbooks through the traditional teaching approach.
- Primary school teachers are trained as generalists with a limited understanding of the content of the subjects they teach. Only in secondary schools are teachers appointed as specialists.
- There are limited learner and teacher support materials, such as lack of access to qualified LSEs and SBSTs, especially in public schools.

The National Assessment of Educational Progress (NAEP) results depict an improvement in mathematics over time. The trend falls far below the *No Child Left Behind* goal, which required learners to perform well by 2014. The NAEP results show that in Grade 8, only 47% of White learners and 54% of Asian learners rose above the advanced use of mathematical terminology and problem-solving skills (Lee, Grigg & Dion, 2007). This shows that the learning of mathematics needs to be prioritised, as we often see learners perform better in other subjects and most poorly in mathematics (Roschelle et al., 2010). Mathematics is a living subject that is impossible to live without (Geary, 2011).

National reviews increasingly report that poor mathematical performance has negative educational and economic long-term implications (Geary, 2011). Furthermore, a multitude of studies depicts that poorly performing learners have limited chances of good employment opportunities in functional companies and less chance of being accepted at institutions of higher learning. Due to limited knowledge about expenditures and liabilities, they also struggle with everyday routines that are associated with financial matters such as investments, savings, and exercising good judgement when buying cars or houses. Once employed, they are prone to smaller remuneration and less promotional opportunities (Geary, 2011).

2.14 MATHLETICS

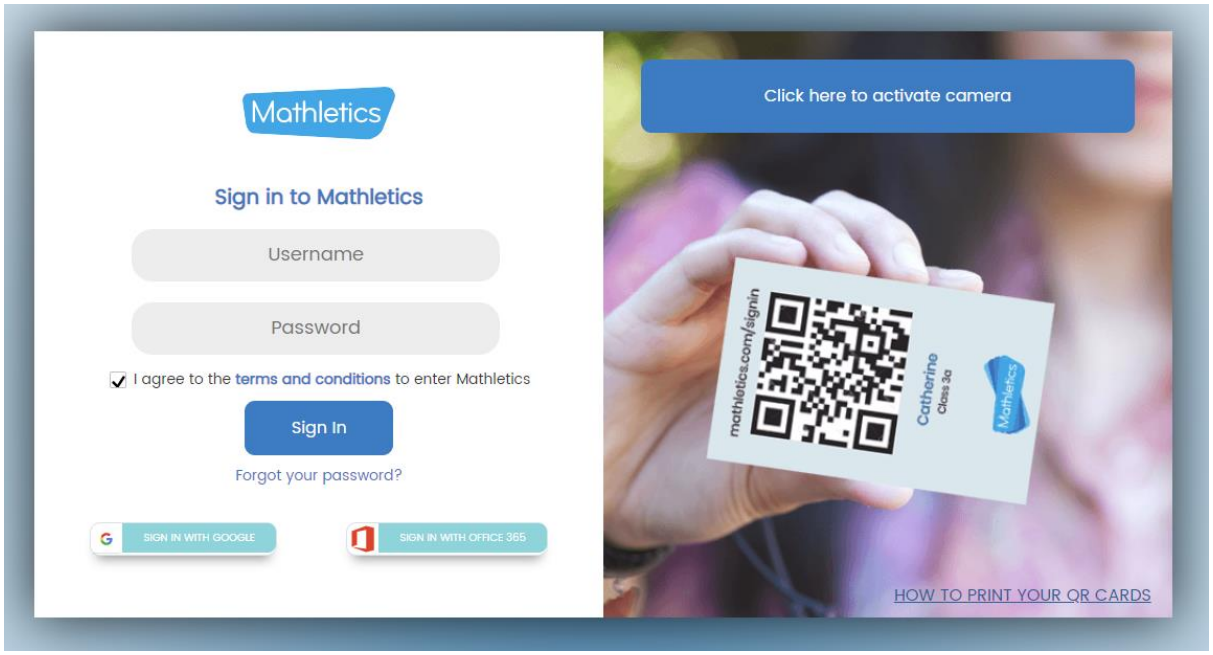
Dunn et al. (2018) explain that the Mathletics programme affords primary school mathematics teachers with step-by-step logical teaching approaches, methods,

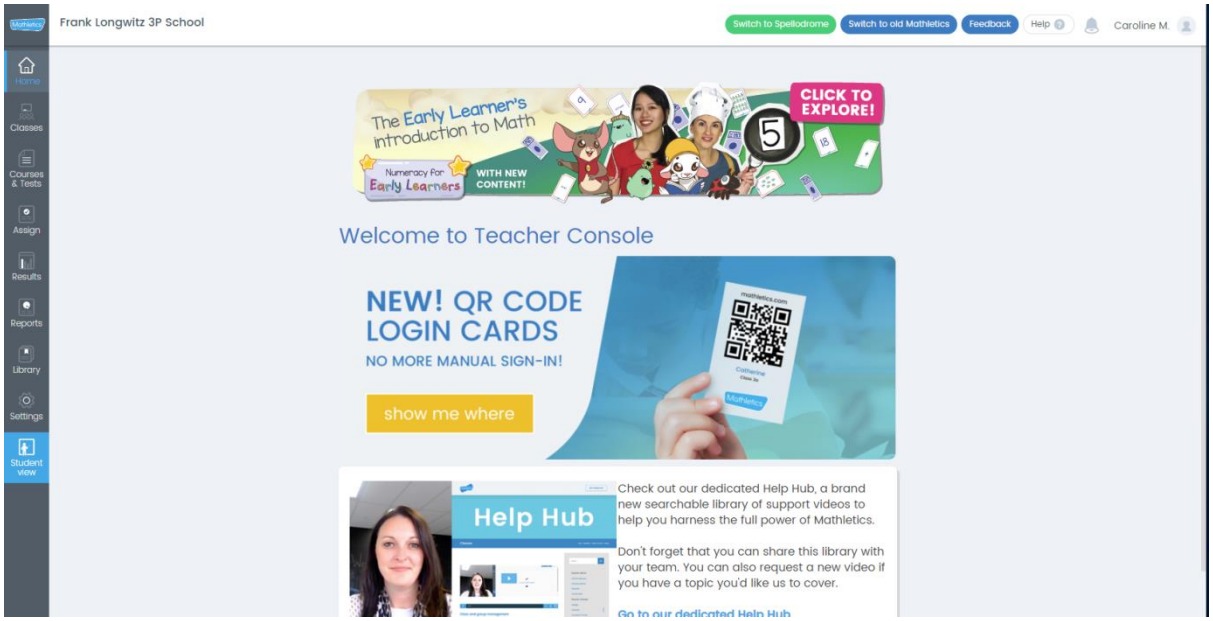
printable materials, videos and other necessary resources that promote and engage ultimate learner participation, understanding of the subject and achievement. Therefore, diversified debates between scholars prevail that with all these technological programmes that are presented in education, teachers should come up with the best teaching approach that will promote quality teaching and learning, and this should be implemented. Thus, numerous authors contend that a constructivist together with connectivist teaching and learning approach enhances mathematical understanding for both learners and teachers (IstenicStarčič et al., 2016). Building on this, Bray and Tangney (2016) posit that the social constructivist learning theory and connectivism correlates well with twenty-first century education where technology is fundamental, efficient and effective for teaching and learning to achieve quality education that prepares learners for the workplace in the Fourth Industrial Revolution.

Teaching with technology does not take place in isolation; teachers should acquire basic knowledge about their learners' diverse needs, the school, the availability of LTSM and the context to effectively teach with technology (Koehler & Mishra, 2008). Online learning programmes like Mathletics are now trending and they have been proven effective in inspiring learners to improve their self-directed learning. Further, these online learning resources and programmes support different learning styles, promote curriculum differentiation and encourage learners to apply mathematical skills at school and at home, which means learning takes place at school and outside the school (Passey, 2013). The steps required to use Mathletics are presented below to demonstrate how teachers are expected to use the programme. In the video, participants were creating access to Mathletics (online link supplied).

Link: https://youtu.be/XQ7s9ujVQxc

- The facilitator must log in and guide the participants to create passwords and usernames. The image below is the one that shows when participants login.





- **The following steps were followed:**

✓ Go tohttps://login.mathletics.com/

✓ After login, teachers will see the following on their screens: Home, Classes, Courses and Tests, Assign, Results and Reports.

✓ **Classes –** Classes consists of class and group management, student management, whole class and sign-in cards, which includes a class list and enable teachers to manage or sort the class in terms of identifying learners who need additional support.

✓ **Courses and tests** – These provide the facility to modify courses and tests to suit the learning ability of learners and view their test scores.

✓ **Assign** – Activities can be assigned based on the learning ability of learners from the same content or topic. The only difference will be the level of complexity.

✓ **Results** – The results give a view of the performance of learners.

✓ **Reports** – These track the progress of the learners and download and print the certificates for best performers.

✓ **Select the class** – There are classes from Grade 4 to Grade 9. However, during the data collection for this study, all teachers were expected to select Grade 6.

✓ I allowed the teachers to go through all the topics. Thereafter, the teachers completed activities from the same topic, which was addition and subtraction.

✓ Teachers had to press “my progress area” to view their results, their points and their progress.

- The participants would have seen a lot of topics from the curriculum policy (CAPS). The video based on the chosen topic is then played to initiate the learning process. They had to select a visual for computational learning, and the participants had to be very attentive because they could not proceed with the second step without understanding the first step. Mathletics is a cyclical process; if one does not understand the first step, you cannot proceed (Berry, 2016).

- The participants were assigned tasks to complete and they received instant feedback. Mathletics serves as an information-sharing hub between teachers, learners, parents and other education stakeholders, such as the facilitators. It thus entails functions such as learners’ performance, personal comments, formal and informal assessments, a discussion forum and instant feedback. All of these were explained to the participants.

- The teachers were guided on how to assign an assignment to learners, how to track learners’ progress, and whether learners are working on their assignment or not. Teachers can detect if learners need more theoretical content and practical tasks or demonstrations.

- The teachers were then guided on how to modify activities to meet their different learners’ learning pace with a secret setting called “the function”. This will enable learners with learning difficulties to have suitable work on the same topic as those peers without learning difficulties.

2.15 TWENTY-FIRST CENTURY CURRICULUM

2.15.1 Definition of a curriculum

The concept of a curriculum has various connotations and meanings. Numerous scholars contend that a curriculum is a guideline that directs teachers on what, when

and how to teach (Sivesind, Van Den Akker & Rosenmund, 2012). The curriculum is meant to facilitate learners' learning processes and teachers' practice for establishing a quality relationship between what is learnt and what can be used outside and inside the school, which can have an impact on education (Hunkins & Ornstein, 2016). As far as Voogt, Erstad et al. (2013) are concerned, there is a need for the restructuring of the curriculum because learners of this generation learn best when they are actively engaged with hands-on activities during teaching and learning.

2.15.2 Current South African mathematics curriculum

Research shows that CAPS (Green & Condy, 2016) focuses on meeting the stipulated time frame by pushing teachers to cover the curriculum and focus on quantitative learner achievement. This encourages learners to recall the given information and regards learners as *tabula rasa* without putting more emphasis on the qualitative content of the subject. It does not promote learner participation, hands-on activities are very limited and the integration of technology is minimal; thus, the current curriculum is teacher-centred (Dole et al., 2016). The current curriculum does not allow learners to apply their knowledge and skills; it restricts them, as learners do not plan their learning, which is not compliant with twenty-first century education (Davids, 2017).

Although South Africa has outstanding and well-resourced educational equipment compared to other African countries like Nigeria, Zimbabwe, Ghana, Zambia, and Gabon (Mouton, Louw & Strydom, 2012), South African learners are performing poorly compared to other African countries. The statistics show that 80% of Grade 4 learners do not understand what they read and most of them cannot read. This shows that urgent action should be taken to implement a flexible curriculum that will promote a learner-centred approach. Dole et al. (2016) suggest that if the current curriculum does not change and meet the needs of the new millennium learners, these learners and teachers will become bored and demotivated; thus, the overall performance will drop even further.

2.15.3 Revamping mathematics subject in primary schools

Studies show that the twenty-first century curriculum should be interdisciplinary, learner interest-driven, skill-driven, project-based, relevant, accurate and contextual. It should be linked to the real world, which will enable learners to effectively apply their prior knowledge in problem-solving contexts. Again, the use of technology during teaching and learning is inevitable (Qian & Clark, 2016). The new curriculum will require changes in the relationship between teachers and learners and the way in which assessments are conducted. The overall daily routine of teaching and learning will also require several adjustments to meet twenty-first century standards (Dole et al., 2016):

- *Interdisciplinary* – in today's world, all subjects are linked to one another and there is a flow of knowledge; for example, in Natural Sciences, learners are required to calculate volume, speed, time and mass. Mathematics learners are required to perform similar calculations; thus, teachers need to upskill and be able to adopt new methodological approaches that will maximise learner participation and instructional understanding (Symonds, Schwartz & Ferguson, 2011).

- *Technology, multimedia, and global classrooms* – technology is a fundamental tool in twenty-first century education to improve teaching and learning (Voogt et al., 2017). Teachers should be productive when dealing with day-to-day tasks and they need technology to perform daily activities: writing reports; lesson preparations; communicating with parents, colleagues and subject advisors, and making multimedia presentations. Teachers need to focus on current global issues during classroom discussions so that learners are exposed to the world outside the classroom. Professional development for teachers in the area of technology is needed; some teachers have received limited training in technology, which might negatively affect the quality of education.

- *Project-based curriculum* – One of the main foci of twenty-first century education is to encourage learners to engage in active learning (Green & Condy, 2016).

This can only be done if teachers are kept abreast of current research in education. This will facilitate their learners through self-directed learning and group work because active learning and collaboration go hand-in-hand (Van Laar, Van Deursen, Van Dijk & De Haan, 2017). Project-based and learner-centred learning methods are based on constructivist teaching and learning approaches.

- *Learner-centred and skills-driven curriculum* – This curriculum will encourage teachers to be facilitators or coaches rather than transmitters of knowledge, which is fundamental (Dole et al., 2016). Learners should be allowed to plan and organise their learning using various multimedia. Learners should collaborate effectively with other learners in and outside the school; they should express themselves and engage in communication with their teachers and peers and be able to raise questions and solve problems in a creative manner (Van Laar et al., 2017).

Learners acquire and retain knowledge when they are fully engaged in their learning, they easily integrate preconceived knowledge and they relate to what they are learning in schools to real-life contexts, which is why there is a need to restructure the curriculum (Dole et al., 2016). A learner-centred approach helps learners to acquire twenty-first century learning skills such as mastering content through self-directed learning, effective communication, critical thinking and problem-solving abilities.

2.15.4 Curriculum knowledge that needs to be addressed

The current teaching approaches and the curriculum are failing to educate the youth of today (Mishra & Mehta, 2017). Therefore, some scholars who work in this area contend that to meet the standard of these learners and enable them to acquire an education that will be of good use to them, three key issues need to be addressed in the twenty-first-century curriculum. These are foundational knowledge, meta-knowledge and humanistic knowledge (Kereluik et al., 2013).

- *Foundational knowledge* is the most important knowledge that we need to possess; this includes good communication skills and being able to access and analyse information from various mediums. You cannot obtain information if you do not have a clear framework that directs you and helps you to choose what is important and needed and what is not, or whether to use a computer, the internet or a book. This is what we call foundational knowledge, which is the capacity to determine if you are on the right track (Mishra & Mehta, 2017).

- *Meta-knowledge* is the knowledge about the knowledge or the ability to effectively analyse, act and utilise the acquired knowledge in a beneficial manner, using, for example, creativity, problem-solving, critical thinking, communication, and collaboration (Kereluik et al., 2013).

- *Humanistic knowledge* refers to the values that we bring to knowledge and action, such as one's emotions and ethical considerations in handling matters that are related to one's social life, work-related issues and cultural competences. Learning is more than being able to look for facts and recalling information – as used to happen in previous centuries. It is about being knowledgeable, creative and innovative and being able to use multiple platforms to express yourself and teach others in a constructive manner (Serdyukov & Serdyukov, 2017).

2.16 THE IMPORTANCE OF LEARNING THEORIES IN EDUCATION

2.16.1 Teachers' knowledge of learning theories

It is paramount for teachers to know and understand learning theories, so that they can make analytical decisions about teaching and learning that will improve the quality of our education system. It is further essential for teachers to know their roots or where they come from and where they are going; this will influence the how, why, what and when of the curriculum. It will lay a solid foundation and guide teachers on how to act and react as far as professionalism is concerned. Teachers will be encouraged to partake in PD programmes when they know themselves better (Mezirow, 2018).

Before one can understand learning theories and their construction, it is best for one to have a sound knowledge of learning and how it is acquired.

2.16.2 The definition of learning in an educational setting

Various scholars define learning differently. However, there is a common ground where scholars agree that learning is about acquiring new knowledge and being able to apply the knowledge in new contextual settings by linking prior knowledge. If an individual cannot apply what they have learnt, it means that learning did not take place. Learning is a cyclical process; it does not end at a certain stage. Professionals must continue learning to avoid becoming obsolete (Kegan, 2018). Moreover, effective learning results in the transformation of a person's behaviour in and outside of the school environment. As the twenty-first century progresses, where there is a lot of technological transformation in education, teachers need to be familiar with various learning theories.

Educational learning theories have a substantial influence on the restriction of the curriculum to meet contemporary standards. Again, teachers need to stay abreast of various learning theories so that they can be more effective and knowledgeable about paradigm shifts and be able to apply the relevant learning theories. This will create optimum learning during the instructional process (Sandars, Patel, Goh, Kokatailo & Lafferty, 2015). There is a need to identify the theories that inform the use of technology in education. Learners learn differently, which is why teachers' knowledge of various learning theories is paramount for creating the best and lasting memories for learners. This will also ensure that learners learn for understanding, not for recalling information (Malone & O'Shea, 2014).

Prominent learning theories have emerged in previous years. However, since technology is now trending in education, it is important for learning theories to address these transformations (Stephan, 2017). As far as various scholars are concerned, there are a considerable number of learning theories (Kegan, 2018). However, the ones that guided this study include behaviourism, social constructivism and connectivism.

2.16.2.1 Social constructivism

Concerning this study, Carrillo & Flores (2017) posit that veteran teachers have limited knowledge in the area of educational technology. However, based on the constructivist approach, I hypothesise that if veteran teachers are given enough support and guidance through formal PD to upskill their pedagogical content knowledge, we can see the tremendous transformation in their classrooms, in how they teach, prepare lessons and interact with their learners. For meaningful learning to occur, learners should be fully engaged in the learning process and share their experiences and ideas while they collaborate with their peers and scaffold knowledge (Barak, 2017). Social constructivism is a view that the knowledge created during learning is based on the background of the individuals and their joint understanding. Moreover, learning takes place when tasks allow learners to make meaning; this so-called meaning can only be achieved if learners are hands-on and they contribute positively (Veletsianos, 2016).

Soviet psychologists believed that a child's development is dual; firstly, it takes place on a social level during interaction with others and secondly, on an individual level with each person. Scholars posit that the social constructivist approach has a direct application in twenty-first century teaching and learning. Lee (2002) states that the constructivist approach encourages learners to think about what they are learning. The twenty-first century is viewed as the era of transformation, normally referred to as the Fourth Industrial Revolution due to these new technological resources and programmes. This means that teachers' PCK should be updated. However, the literature shows that teachers are not willing to engage in new teaching and learning approaches due to their lack of exposure to or limited knowledge of these advanced methods (Barak, 2017).

2.16.2.2 Connectivism

The ability to know how to do things relies on the skill of making connections with other individuals and resources, such as machines, technology and programmes. Again, the most important thing in the learning process is the ability to identify the knowledge that

is needed via various mediums (Veletsianos, 2016). Connectivism, a concept developed by Siemens (2005) is a new learning approach, referred to as the learning theory for the digital age (Anderson, 2016). Connectivism addresses the shortfalls of behaviourism and social constructivism in twenty-first century education. However, all these learning theories are important, but there is one that is more relevant in this millennium; namely, connectivism (Anderson, 2016).

Since we are now surrounded by a multitude of technological tools and programmes in education, one can say without a doubt that new pedagogical content approaches to teaching and learning are fundamental to sustaining the quality of the twenty-first century education system. Connectivism stresses the fact that networks must be established regardless of formal education; learners and teachers must be enterprising people and expand their knowledge and skills by sharing with others via social networks. They should also create scholarly interactions to exchange information, learning tools and ideas (Veletsianos, 2016). However, numerous scholars emphasise the importance of technological connectivism.

Technology expands the connectivism between teachers, the learners and parents. It is now easy for all stakeholders in education to share information, teach and assist one another via the social environment that is created by technology (Mattar, 2018a & 2018b). It is evident that technology has impacted our society, tradition, culture and education system (Greenhow & Lewin, 2016).

Learning is no longer isolated; it is now diverse and requires participation because we are living with an influx of information. It is, therefore, necessary for people to network to share the load that we carry via technology (Greenhow & Lewin, 2016). For learning to be successful, it should take place in a CLP where all the individuals contribute to each other's learning. This also encourages teachers to continue learning to stay current.

The literature shows that most teachers, especially veteran teachers, are still in the denial phase (Orlando, 2014). They are aware that technology in education is now a reality, but they are still holding onto traditional teaching approaches where they view themselves as the carriers of information via teacher-centred approaches. Such old teaching approaches are regarded as obsolete by various scholars (Goldie, 2016).

International scholars posit that for connectivism to yield a positive impact on teaching and learning, teachers need to acquire appropriate PCK in the area of technology in terms of its application and integration. They must be willing to be lifelong learners and seek upskilling through formal professional development, like enrolling for courses at institutions of higher learning or in informal settings where teachers teach each other in their CLPs within schools (Orlando & Attard, 2016).

Connectivism enables learners to connect via social networks and collaborative tasks. The connectivist theory is based on the idea that even after formal education takes place face-to-face, people continue to learn and acquire new skills and knowledge through networking with technological tools. Siemens (2005) found that learning takes place in various ways. Learning becomes successful when diverse people combine their different ideas and come up with a common conclusion that will be beneficial to everyone (Siemens, 2005). Furthermore, for one to continue learning, making connections is helpful.

Journals increasingly report that the most favoured approach for presenting mathematics is connectivism. I was hence interested to assist teachers to understand the Mathletics programme for them to be able to teach their learners better. Doubtless, technology is causing a paradigm shift, which implies that teachers need to be prepared for this shift to sustain their jobs and stay relevant (Klinger, 2011).

2.17 INTENDED PROFESSIONAL DEVELOPMENT INITIATIVES FOR PRIMARY SCHOOL MATHEMATICS TEACHERS

Teachers' PD is defined differently by various scholars. However, the consensus between these scholars is that PD refers to the formal and informal activities that teachers engage in, both inside and outside of the school. This allows them to improve their teaching pedagogy, skills and knowledge to the benefit of the learners and the school (Ono & Ferreira, 2010a). An educational paradigm shift, which disregards teachers' input, participation and their professional status, does not succeed. Moreover, professional development initiatives that ignore the structures and policies created by teachers do not impact teachers' pedagogical content knowledge (Ono &

Ferreira, 2010a). For CPD initiatives to yield tangible results for teachers, their learners and the school community at large, and the teachers, together with learners, must be at the centre of it all. They should therefore give their full participation. CPD initiatives must provide space for teachers to meet, share, talk, learn and also create friendships that are meant for learning and developmental purposes. This is where teachers will share teaching resources, ideas, motivational talks and experiences. However, the most important element that should be the main focus or an umbrella for the success of teachers' CPD initiatives is that they must provide ample time for teachers to reflect on what they have learnt during the workshops and to put their learning into practice during teaching and learning to thoroughly observe and reflect (Joubert, Back, De Geest, Hirst & Sutherland, 2009).

PD initiatives should enable teachers to plan the curriculum daily with a creative mindset, set learning goals for learners and ensure that the goals are achieved. These should further assist teachers to create a conducive learning environment by employing effective, inclusive classroom management skills, and to learn to use technology to differentiate the curriculum in response to various learners' needs. Teacher PD initiatives that have been used in the past include workshops, seminars, conferences and courses (Ono & Ferreira, 2010a). These initiatives have been criticised by teachers and researchers for not yielding any positive results in teachers' practice. The same is observed in both developed and developing countries. Thus, numerous researchers contend that twenty-first century PD initiatives must have the following properties to effectively respond to teachers and learners' needs:

- **It should be an ongoing process and be school based**

  Ongoing PD initiatives are critical for both veteran and beginner teachers. However, many reports show that veteran teachers are the ones who encounter challenges in keeping up with the rapid transformations presented in the curriculum. Thus, various scholars emphasise that veteran teachers should commit themselves to ongoing PD to stay abreast of new curriculum resources and learning how to use and access them. Teachers must also learn how to improve their PCK in a manner that will improve learner achievement and instructional understanding, and how to relate to learners in a technological age

like this one. Effective PD is ongoing; it does not have a time limit. This enables teachers to practice and implement what they learn and have time to observe and reflect and make room for improvements.

The one-size-fits-all approach normally implemented in workshops does not yield any positive output, because teachers have different needs. For example, one teacher might struggle with assigning tasks to learners using Mathletics, while other teachers might struggle with identifying learners' progress via Mathletics. Thus, it is important for PD initiatives to unpack all the challenges that teachers face and offer pragmatic and effective solutions. Research shows that the current PD initiatives focus more on theory, so scholars contend that PD initiatives should blend both theory and practice. PDs should have more tasks that are practical, hands-on learning, clear assessments and learning tools. As we all know, teachers have busy lives and for PD to be successful, PD initiatives should be accessible anytime and anywhere, which means that technology must be effectively integrated.

- ***Professional development initiatives should be curriculum-based***

  Current PD initiatives should solely focus on the curriculum to help teachers to master the content of the subject. This should be done by unpacking all the challenging topics to help teachers understand and teach these to learners. Recent research shows that the best PD initiatives emphasise subject mastery and how to teach the mastered content. New millennium teachers are obliged to acquire the ability to create and present content to learners in a profound manner that will encourage learners to fully participate. This will further meet the educational needs of these millennium learners and render the information applicable in their daily lives, while preparing them for the future world of work.

The most important element in teaching and learning is teachers' understanding of the content and being able to teach the content so that the learners' understanding and their participation will be maximised. The curriculum should teach and emphasise twenty-first century expertise. Teachers must be adequately trained to integrate technology into the content and pedagogy. Collaborating with universities is essential in ensuring that teachers stay abreast of and acquire new ideas, knowledge, skills and

practices concerning technology integration in teaching and learning. According to Ono and Ferreira (2010a), the human brain searches for meaning, patterns and connections. Thus, current PD initiatives need to be based on constructivist teaching and learning, which will promote learners' participation, knowledge creation, practical and applicable assessments to everyday life, community-based knowledge, and should directly link to the school context.

Table 3: Traditional vs twenty-first century approaches to teaching and learning

Traditional approach	***twenty-first-century approach***
1. Teachers are trained to follow systemic patterns.	1. Teachers are prepared to be empowered individuals who are ready to take risks at any time and be agents of change in an educational setting.
2. Promotes passive learning.	2. Promotes active, participatory and action learning.
3. Expert-centred/driven.	3. Teachers facilitate and conduct their own learning, which suits the learning and teaching needs of their learners.
4. Positivist- and behaviourist-based.	4. Constructivist- and connectivist-based.
5. Limited inclusion of teacher input and classroom realities.	5. Teacher guide, support and monitor teaching and learning process.
6. Chalkboard and paper-based.	6. Technology-based.
7. Theory, theory, theory and theory!	7. Hands-on, demonstrations and more practical tasks.
8. Teacher-centred.	8. Learner-centred.

2.18 CONCEPTUAL FRAMEWORK

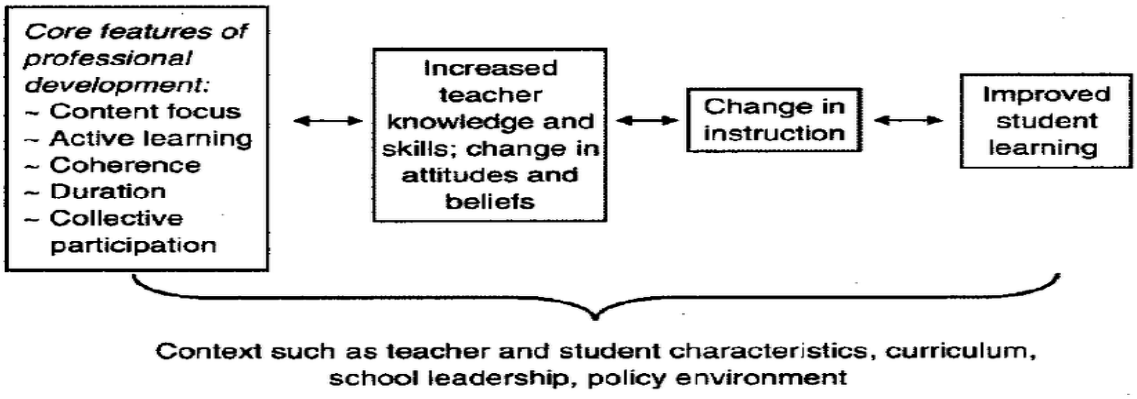


Figure 2: Teacher Professional Development (adapted from Desimone, 2009)

The conceptual framework in this study was influenced by the concept of PD. This concept assisted me to find suitable criteria to assist veteran primary school mathematics teachers to improve their performance output. This was done by integrating the Mathletics programme during teaching and learning. PD is the primary mechanism that can be used to ensure that teachers continually upgrade and upskill their PCK (Kelly & Cherkowski, 2017).

Due to the rapid transformations that are taking place in education, such as curriculum shifts and technology integration during teaching and learning, teachers are expected to upskill. The best strategy for upskilling, as supported by policymakers, curriculum developers and subject advisors, is PD in the form of peer mentoring of teachers by other teachers; this should be prioritised (Desimone & Pak, 2017). The main objective of PD for teachers is to build a collaborative work ethic that will generate practical change and improvements in terms of teaching and learning. It is envisaged that this teaching and learning will use new teaching tools that drive to produce quality

educational outcomes for teachers, learners and all other stakeholders (DiPaola & Wagner, 2018).

PD decreases the work difficulties of teachers by taking them out of isolation and bringing them to other teachers who share the same experience. These teachers are also willing to share with their peers how to approach specific curriculum topics and how to ensure that learners' instructional understanding is maximised (Knight, 2018). Teachers' challenges arise when they implement newly learnt methods in the classroom without success; this is when teachers need to come together as a team and work together in mitigating these challenges. However, for effective PD to take place, adequate support and guidance from expert teachers or facilitators, together with the teachers' willingness and readiness for pedagogical improvement, is fundamental (Du Toit, 2013).

During PD, teachers should be engaged with both practical and theoretical tasks (Kennedy, 2016). Various scholars posit that practical tasks, together with theoretical tasks, lead to a deeper understanding of the studied topic. The theoretical aspect encompasses the foundational knowledge for the practical to be internalised. This means that knowledge will be put into practice (Cooper & Arcavi, 2018). Teachers will explore new ideas, share critical feedback and recommendations for instructional improvement as they encounter these in the classroom so that they can come up with a pragmatic solution (Desimone, 2009).

Literature shows that teachers must be actively involved in the process of learning and change for them to experience and rationalise the CPD in a real-life contextual setting (Joubert et al., 2009). Scholars believe that the PD of teachers is directly proportional to the opportunities offered by CPD and this leads to teachers changing their teaching practices, attitudes and beliefs; this results in improved learner performance and behaviour (Joubert et al., 2009). According to Whitehead and McNiff (2006), the application of action research helps to identify problems in schools and enables teachers to develop pragmatic solutions to problems. Action research can be used by an individual teacher to improve their teaching strategy and it can also be applied by a group of teachers in peer mentoring to improve how teachers conduct classroom

interaction with learners and promote better learner academic achievement (Desimone, 2009).

Various authors (Desimone et al., 2002; Tondeur et al., 2012) propose that PD is one of the most effective frameworks in the twenty-first century for improving the quality of teaching and learning. PD occurs in multiple contexts; it can take place when individual teachers are learning and when teachers teach other teachers, and within social systems where teachers reciprocally learn from other professionals.

The conceptual framework adopted in this study encourages action learning, peer mentoring, reflecting on lessons, group discussions and teacher study groups to be functional. It regards teachers as the participants and initiators of knowledge, not just recipients of information (Kennedy, 2016).

For the PD process to be considered effective in improving teaching practice and instructional achievement, it should include the following core features: (1) Content focus; (2) active learning; (3) coherence; and (4) duration and collective participation (Desimone & Pak, 2017). The majority of teachers possess the knowledge that can improve the quality of teaching and learning; however, the challenge comes when knowledge is not disseminated from teacher to teacher, teachers to learners and learners to teachers. Knowledge does not yield any positive results if it is not shared (DiPaola & Wagner, 2018). According to Merchie et al. (2018), more needs to be done towards the effectiveness of the PD of teachers (Merchie et al., 2018). The following core features must therefore be added: (5) School-based; (6) trainer quality; (7) ownership; and (8) pedagogical content knowledge.

(1) Content focus – This feature is solely based on teachers' PCK of the subject. It refers to how learners learn the content and it also relates to learner achievement as the evidence that content is being mastered (Desimone & Pak, 2017). The subject matter, including assessments, class tests, examinations and the overall achievement of learners through the improved pedagogical practice of teachers during PD, is essential (Korthagen, 2017). Recent literature puts more emphasis on teachers' understanding of the content and their ability to use various teaching strategies and curriculum differentiation for accommodating learners' diverse needs (Kafyulilo et al.,

2016). This also implies that if teachers understand the application of Mathletics, learners will benefit from it.

The focus is on developing constructivist lesson plans that will stimulate and engage learners during teaching and learning. However, the success of this lies in an active CLP; hence, if the CLP is not functional, learners and teachers will perform minimally. The achievement of learners is directly influenced by teachers' content knowledge (Trorey, 2017). The focus on content should be based on content that is the most challenging for teachers (Merchie et al., 2018). It is not helpful to re-teach what teachers already understand. Mathletics is one of the topics that veteran mathematics teachers find challenging because they hardly use technology, as opposed to beginner teachers, who are technology 'gurus' (Berry, 2016), which is why veteran teachers were the area of interest for this study.

(2) Active learning – Active learning occurs when teachers work together in the form of peer mentoring, where they share their teaching pedagogies, classroom management strategies and teaching experiences. This is also where teachers practise and implement what they learn in their CLPs. Teachers should be fully engaged during learning and reflect on what they are learning (Du et al., 2017). After observing and engaging an expert or more skilled teachers in the form of action learning, teachers should implement what they are learning and see if they need further clarification in some areas.

Marton (2018) contends that feedback during active learning should be pragmatic and explicit. It should further enable teachers to teach other teachers, use various modes of teaching and learning and acquire an improved understanding of the content being studied. If learning does not result in understanding, then it is not learning. Merchie et al. (2018) hold the view that when teachers observe other teachers, plan lessons together and indulge in informative discussions, this will upskill their PCK and boost their self-esteem by enabling them to be more open and to constructively share ideas. They also become more capable of accepting their weaknesses in a scholastic and professional manner. This will open up more opportunities for active learning (Körkkö, Kyrö-Ämmälä & Turunen, 2016). The process of learning is presented in a learning pyramid (Fig. 2.3).

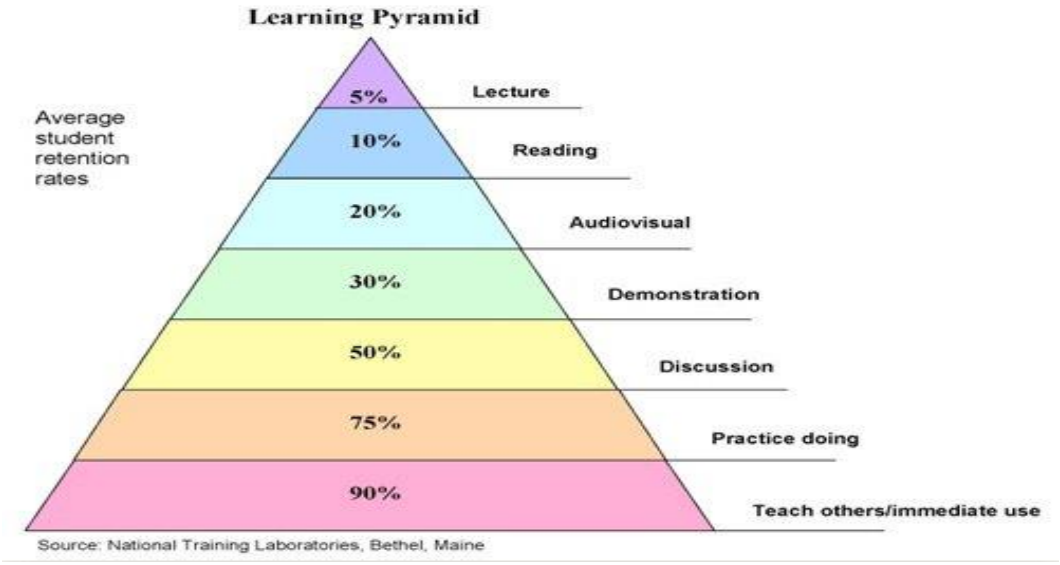


Figure 3: Learning pyramid

Development programmes that are contextualised are more likely to have a direct, positive impact on teachers and learners because they are integrated into the real life of the teachers and learners. They provide opportunities for professional interaction, hands-on activities or action learning that will last in the long-term memory of teachers and professional communication amongst teachers (Kennedy, 2016). Active learning moves away from the traditional learning theory to a constructivist instructional approach. This shift is imperative in twenty-first century education (Darling-Hammond, Hyler & Gardner, 2017).

(3) Coherence – PD should be congruent with the required content standard according to the CAPS document, the ATP, the assessment plan (AP) and school-based assessments (SBA). It should be clear what, when and where teachers should learn and why they have to learn specific topics (Darling-Hammond et al., 2017). Teachers must learn what is relevant, and whatever each teacher learns should align with their knowledge and beliefs to form a strong coherence with constructivism as a philosophical concept, guiding them to operate in teaching and learning (Kennedy, 2016). For example, when teachers are dealing with data handling, the emphasis during PD should be on data handling. When PD is aligned with what teachers are doing in their daily instructional practices, then it is more likely to yield positive outcomes for both teachers and learners (Desimone & Pak, 2017). The Mathletics

programme is also aligned with the South African mathematics curriculum, which will help teachers to understand it more easily (Berry, 2016).

(4) Duration – If teachers are offered substantial time to learn, practice, implement and reflect on newly acquired or improved teaching methods, teachers' PCK can improve beyond school level (Darling-Hammond et al., 2017). Allowing time for teachers to reflect on what they have learnt, how they managed to implement what they learnt and adjust their teaching practice could help teachers to upskill easily. In this study, I had more than one session where teachers were able to reflect on Mathletics. Feedback and reflection were the central foci of my sessions as this study was based on PAR. Giving them opportunities to consider intellectual and pedagogical changes in which they plan, analyse and reflect on their teaching practices allows teachers to create ample time for discussion and feedback on learners' assignments to make a way forward for learners' instructional understanding and achievement.

(5) Collective participation – Effective PD encourages collective participation because active learning takes place when individuals work together constructively (Desimone, 2009). Darling-Hammond et al. (2017) contend that PD is effective and active when it allows teachers to engage physically, cognitively and emotionally through hands-on activities, sharing, discussions, simulations, visual representations, applications, reflections and follow-up sessions. Collective participation can be achieved when teachers teaching the same grade, phase, subject or in a school, work together to build interactive learning communities through action learning and peer mentoring. Two heads are better than one, which implies that nobody succeeds alone. Henry Ford once said that coming together is a beginning, keeping together is progress and working together is a success.

(6) *School-based* – PD is important for maintaining excellence in every teacher's practice, both at school and outside the school environment (Tack, Valcke, Rots, Struyven & Vanderlinde, 2018). Numerous scholars contend that for PD to be meaningful and realistic, it must be aligned with the school's academic plan. Individual teachers, who form the school's CLP, must drive this plan. If schools work with other schools collaboratively to extend their practices in sharing information and relevant

teaching practices, it is proven by various scholars that this can lead to improved quality of teaching and learning.

2.19 Conclusion for Chapter 2

Improving mathematical performance is a challenge across the world (Genlott & Grönlund, 2016). The advancement of technology in schools is indirectly proportional to teacher PD. Recent literature shows that the readiness of teachers to effectively respond to these various technological programmes is in arrears (Genlott & Grönlund, 2016). In today's society, there is a pressing need for teachers to adopt effective teaching approaches that promote learner-centred learning environments. The improvements in technology have introduced new teaching and learning approaches in mathematics that directly respond to the learning needs of today's learners. A study conducted by Muir et al. (2018b) has found that the Mathletics programme is rapidly changing how mathematics is being taught and learnt. Siemens (2014) finds that the new millennium learners' learning preference is founded in technology because they were born and bred in a technological era, as opposed to the previous generation, which is often called the Born Before Technology generation (BBT). Millennium learners prefer teaching and learning through technology such as Mathletics. However, most veteran teachers are still using obsolete traditional teaching approaches where learners are viewed as absorbers of information. Traditional teaching approaches encourage the recall of pre-set mathematical facts. Recent literature shows that the learners of today are interested in knowing how and why things work (Muir et al., 2018b). Muir (2014) posits that Mathletics is the programme most favoured by learners, teachers and guardians. Mathletics brings motivation to the learning of mathematics (Nansen et al., 2012). I have drawn on the facts presented by various studies, which state that Mathletics improves learner performance. However, from my point of view and the little teaching experience that I have accumulated over three years (2015–2018), I beg to differ. As an SP mathematics teacher based in Gauteng, I argue that no matter how technological programmes and resources are introduced in schools, if teachers lack skills and competence in applying these programmes, the availability thereof will be in vain. I am one teacher who has consistently attended the workshops provided by the department and they have

yielded no results in my teaching practice. In fact, I have noticed the following in the workshops:

- Workshops are conducted by subject advisors who do not appear to have any idea of what is happening in classrooms.
- Subject advisors tell teachers what to do without engaging with the teachers. They also put teachers under pressure to finish the curriculum without teaching the curriculum content in depth. This does not improve learners' performance.
- Teachers must be their own subject advisors, or rather facilitators, to take responsibility for their professional readiness. They should do this by engaging in peer monitoring and collaborating with their colleagues in a CLP. This will allow them to gain confidence and be able to apply newly trending resources and programmes.
- Technological programmes such as Mathletics, GeoGebra and many more are introduced; however, teachers are not guided to effectively apply them during teaching and learning.
- Teachers are voiceless in the workshops and the length of the workshops is not realistic; teachers tend to become exhausted and bored. In Gauteng DBE, workshops are presented on Saturdays from 08:00 to 15:00, which is not convenient for teachers. Teachers are also parents, grandparents and family members; therefore, on a Saturday they must attend to family responsibilities. All PD must take place from Monday to Friday or during school holidays.
- In the workshops, it is only talk, talk, talk, theory and more theory!

I hypothesise that for Mathletics to yield positive results in South African mathematics education – compared to America, Australia, China and other African countries (Qian & Clark, 2016) – South African mathematics teachers, together with subject advisors or facilitators, need to step-up and take action in upskilling. This can be done by engaging in CPD initiatives, which will help them to acquire new information that will assist them to stay abreast of new or improved teaching and learning programmes, resources and methods. According to MacManus (2018), mathematics teaching in primary schools should be based on an effective collaborative discussion between teachers and learners, between learners, between learners and parents and between

teachers, learners and parents. Learners should be engaged in more practical tasks and demonstrations and must own their learning and take full responsibility.

Enough practical hands-on tasks and problem-solving tasks that encourage the application of mathematics in the everyday life of learners are required. Moreover, there must be tasks that stimulate learners' critical thinking skills. Teachers must improve their teaching practices and be able to differentiate the curriculum using various resources, including technology (Serdyukov & Serdyukov, 2017). However, teachers must keep in mind that learners' understanding, achievement and participation are paramount during teaching and learning. This means that learner-centred teaching approaches such as constructivism and connectivism must be employed. Curriculum transformation is inevitable in ensuring that these new millennium learners acquire skills and competencies that will enable them to contribute actively in their social development and that of the economy (Stronge, 2018). Curriculum transformation should be concurrent with teachers' PD so that teachers contribute effectively to curriculum matters.

The methodology employed in this study is discussed in Chapter 3.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 INTRODUCTION

This study was conducted using a PAR design whereby as a researcher I engaged in action learning with the participants, where they learnt how to use Mathletics during teaching and learning. The reason for using the PAR design was to ensure that participants take full responsibility by contributing and sharing their own experiences and challenges openly and freely without fear of being judged or undermined for their inability in using Mathletics. Also, they had to understand that the main goal of this collective learning or action learning is to improve and upskill our confidence and ability to integrate technological learning and teaching programmes such as Mathletics. As Zuber-Skerritt (2015) has stated, effective collaboration between researchers and the community must be harnessed so that the theory can be practised and developed by both community members and the researchers for the benefit of all society. In this regard, I am the researcher and my participants form part of the community.

The decision to use the PAR design was motivated by the research carried out by other scholars in developing the professional status of beginner teachers and in assisting teachers with limited knowledge in a certain subject or work-related expertise, such as classroom management. The findings of such studies yielded positive results (Smit & Du Toit, 2016). The findings showed that classroom readiness, including the teaching styles and practices of these beginner teachers, improved tremendously (Smit & Du Toit, 2016).

In this study, I worked hand-in-hand with primary school teachers from Gauteng who had been teaching mathematics for more than 15 years and yet were struggling to integrate Mathletics into teaching and learning. I sat with the participants and collectively, we came up with a plan of action to find the root cause of their limited use of Mathletics and planned how we could remedy the situation. We suggested pragmatic remedial strategies that they could implement in their respective practices. In PAR, the main goal is to work with the participants to address the challenges that

they face and to implement practical solutions that will transform or improve the situation (Du Toit, 2012). Thus, the intent was to improve veteran primary school mathematics teachers' understanding of Mathletics.

3.2 RESEARCH METHODOLOGY

Research methodology refers to the approaches that are used to collect data, which are used as the foundation for explaining, predicting or interpreting data. The literature shows that there are three main research methodologies: qualitative, quantitative and mixed methods. In this study, I used a qualitative research methodology. Qualitative methodology enables the researcher to work together with the participants in their natural setting to gain a deeper understanding, make sense of, share information, interpret the phenomena and allow both the participants and the researcher to learn (Berger, 2015).

Qualitative research is characterised by its intent, which relates to understanding social natural life. It aims to answer questions such as what, how and why, rather than using numbers and measurements and questions, such as how many and how much, which are based in qualitative research (Bricki & Green, 2007). Furthermore, in qualitative research, samples are small and do not necessarily represent the broader population. The most outstanding benefit of the qualitative approach is the general belief that both participants and researchers are joint developers of new knowledge, considering the prior knowledge of the participants. Thus, a social constructivist approach was used as it leads to practical solutions to challenges (Jorgensen, 2015).

The most advantageous part of using the qualitative approach is that it provides rich, detailed information directly from the participants. It also provides relevant contextual information and gives the researcher adequate time to have a close relationship with the participants. This helps in the analysis and interpretation of data (Taylor, Bogdan & DeVault, 2015). Qualitative methodology is concurrent with this research design (PAR). I hypothesise that, together with the participants, we did obtain real solutions to the challenge faced by veteran primary school mathematics teachers.

3.2.1 Epistemological perspective

This study was addressed through social constructivism. Social constructivism is concerned with how knowledge is co-constructed and understood (Bryant & Bates, 2015). Additionally, Vygotsky (2012) contends that social constructivism is essential for bringing improvement and solving teaching and learning challenges in the twenty-first century education system. He further strongly believed that social influence has a great impact on educational settings. This implies that teaching and learning lie solely in the hands of its community members and all decisions pertaining to education are taken by the members (Ültanir, 2012).

The point of convergence for social constructivism is that knowledge is acquired through engagement, rather than receiving information and recalling it as it is (Powell & Kalina, 2009). It therefore implies that there is no absolute knowledge and it also means that teachers should move away from traditional teaching approaches to learner-centred approaches. For effective learning to occur, learners should construct their own meaning based on their prior knowledge and experiences, such as personal views, religious views, cultural background and their socio-economic status (Khalid & Azeem, 2012).

Social interaction allows for individuals to understand phenomena from the perspective of others in a reciprocal fashion, and to construct high-quality schema where all involved individuals benefit (Powell & Kalina, 2009). Social constructivism was developed by Vygotsky based on the assumption that learning and knowledge cannot be discovered by individuals. Active learning occurs in social activities such as interacting, collaboration and communicating. Furthermore, individuals within society create meaning when they interact with each other and with the environment in which they live (Bryceson, 2007). The main purpose of social constructivism is to solve problems through social interaction by providing support to the involved individuals (Amineh & Asl, 2015). It also allows for experts or more experienced and less expert or less experienced participants to learn from each other in a reciprocal fashion (Sembrich & Batdi, 2015).

Social constructivism enables the researcher and participants to work together through PAR in finding real, practical solutions to the challenges faced by the participants. It allows the researcher to be reflective and strategic yet unbiased by so doing. This will also increase the chances of obtaining trustworthy data from the participants (Tekin & Kotaman, 2013).

I further hypothesised that my association with veteran mathematics teachers through the application of PD assisted both of us (the researcher and participant) to become pedagogically enriched as we worked to identify new knowledge systems. This further promoted the acquisition of new pedagogical understanding in the integration of Mathletics into teaching and learning. Shulman (1987) finds that when involving teachers in identifying areas of their need, knowledge becomes a communal project that is enhanced by the closeness of relationships between the researcher and participants. The application of the social constructivist approach makes learning realistic and relevant (Amineh & Asl, 2015).

As the use of educational technology increases in education, teachers' are being placed under more pressure because they need to be able to analyse and effectively use technology to meet the required standard of twenty-first century education (Orlando, 2014). In my view, social constructivism is a tangible solution to the challenges faced by mathematics teachers in their limited use of Mathletics. The literature shows that constructivist teachers are good scaffolders, tutors and facilitators of learning; they also share teaching practices with their peers (Khalid & Azeem, 2012). Moreover, they are open to new ideas that will result in improved teaching practices, they consider learners as co-constructors of knowledge in the classroom, they are interested in the learning of their learners and they promote learner-centred classrooms. Constructivist teachers are also good at promoting effective cooperative learning communities and are committed to becoming lifelong learners to keep abreast of new developments in education. Such teachers view themselves as agents of change; thus, all mathematics teachers need to learn how to apply Mathletics during teaching and learning for the interest and learners' understanding of mathematics (Muir, 2014).

I suggest that veteran teachers should work together with beginner teachers, as the latter tend to be highly skilled in educational technology. Such collaboration can aid veteran teachers in integrating new technology into their classrooms. Morales (2016b) attests that the professional learning of teachers among teachers can profoundly improve teaching and learning. Additionally, social constructivism stresses the importance of learners' social interaction with knowledgeable individuals in society. The same applies to teachers who are learning about new concepts; they should thus actively collaborate amongst themselves and be willing to help each other.

3.2.2 Participatory action research design

PAR improves professional practice through reflection and study and helps the researcher to put theory into practice, improve schools and empower teachers (Zuber-Skerritt, 2015). Du Toit (2013) explains that it is the teacher's sole responsibility to actively engage in PD for upskilling, which entails one teacher helping other teachers to participate in PD.

When I pass on in this world, I want to be remembered as a teacher who made a difference in other teachers' careers; a teacher who contributed greatly, not just in writing but pragmatically; a teacher who stood firm for other teachers when this profession is being undermined daily due to our remuneration. I want the new generation of learners to be interested and enrol in education. According to MacDonald (2012), those who engage in PAR are brave because they are willing to speak for the voiceless, powerless, oppressed and marginalised people – such as South African teachers – who are being mocked over their low salaries and low levels of qualification (MacDonald, 2012). Moreover, as mentioned earlier, my sole intention with this study was to investigate how teachers can be assisted in the understanding and application of Mathletics. Studies such as mine will only be successful when teachers participate and take control by raising their views and concerns.

PAR is research with and for people facing educational challenges in practice. It can be utilised to empower teachers and other education stakeholders by using their own knowledge (Mertler, 2016). In PAR, the researcher is the facilitator that offers support

and guidance to ameliorate the challenges faced by the participants. The researcher should grant all the participants' equal opportunity, treat them fairly, encourage open collaboration, and value the participation of every participant – bearing in mind that the interest of the participants matters. Furthermore, the success of PAR lies in the active engagement and participation of its participants.

Moreover, De Waal (2015) highlights that when technology is used correctly with the appropriate skills, teachers can remain current with educational standards. They may also adopt improved methodological practices that will enable them to teach diverse learners, knowing what to teach and how to teach using multiple teaching resources that will encourage maximum learner participation. However, Morales (2016) asserts that PAR is one of the best research methods to use in the current era to improve the teaching practice of teachers and to encourage teachers to actively engage in self-directed learning.

Smit and Du Toit (2016) show that PAR allows novice teachers to actively participate in mentoring interventions as in their study. The participating novice teachers were able to raise questions and openly address the challenges that they encountered; thereafter, probable solutions were offered by experienced teachers. Therefore, it is assumed that through mentoring and action learning, participants will learn and greatly improve their professional readiness (Zuber-Skerritt, 2015). Thus, I posit that the use of PAR in this study improved the understanding and confidence of integrating Mathletics during the day-to-day teaching and learning of mathematics.

Various authors, including Taylor, Fleisch & Shindler (2019) shows that South African learners are failing dismally to master mathematics as a subject from primary school level to tertiary level. It is speculated that these learners lack basic mathematical skills and this challenge may continue due to teachers' lagging professional status, which is affected by the ever-changing curriculum (Jorgensen & Dole, 2011). If teachers can be pragmatic, realistic and proactive with PD, their teaching practice might drastically improve, and they could regain their self-esteem. This can also result in learners' positive attitudes, leading to improved learner engagement during teaching and learning, understanding of the subject and academic achievement and increased

enrolment in the field of mathematics, sciences and technology in the institutions of higher learning.

As stated earlier, the aim of using PAR was to describe and understand the participants' points of view, drawing on their daily lived teaching experiences. It permits self-reflection for all the engaged individuals (MacDonald, 2012). PAR is practical: it takes place in a natural context or rather in the local community of the participants; it is concerned with social challenges and promotes local solutions; it allows for democratic decisions, and its main foci are transformation and improvement (Coghlan & Brannick, 2014). Furthermore, PAR is a cyclical process of planning, implementation, reflection and participation of participants with the researcher during action research. The researcher and the participants work together and share ideas with the intention of the betterment of their organisation. In this study, I worked with veteran mathematics primary school teachers on the application of Mathletics during teaching and learning. Although I am not yet a veteran teacher, I learnt much by interacting with them.

MacDonald (2012) argues that every challenge emanates from within a community; thus, it would be easy for community members to solve a problem as they are more familiar with the challenge than an outsider who does not understand the root cause of the challenge. The literature shows that Mathletics is becoming a commonly used programme in mathematics in schools (Pilgrim et al., 2012). However, teachers are struggling to cope, which negatively affects learners' achievement. Therefore, the researcher embarked on the journey of investigating how teachers can be assisted to understand and use this programme. Additionally, Phillips, Desimone and Smith (2011) propose that for PAR to yield authentic outcomes, the research must be done with people, not to or for people. In this study, the participants were expected to participate in a mathematics workshop where they were required to bring their CAPS document and their laptops or cell phones. As noted by various authors, PAR includes a spiral of reflective cycles of planning a change, acting and observing, replanning and observing again, and reflecting on the entire process. Thus, it simply shows that this process is continuous.

I guided the participants in the process of downloading Mathletics. Everyone received a username and password. Secondly, a topic of interest was chosen by the teachers from the mathematics curriculum. I worked with the teachers on how to assign activities to learners and how to check if learners are doing their work while using Mathletics. Thirdly, the participants were given additional tasks to complete using Mathletics. When they were finished together as a team, we reflected on the challenges that they had encountered in completing the tasks and we rectified their mistakes. Each session was approximately 30-40 minutes long. During the follow-up workshop, the participants observed my facilitation of learning and asked questions; some teachers opted for more workshops, which was further discussed, and appropriate arrangements were made. I offer workshops with Mr Frank Longwitz, the co-ordinator of Mathletics in Gauteng, who is also my life coach and mentor.

Next, I discuss the three cycles of PAR which are relevant to this study.

Cycle 1 – The first stage diagnosed the challenges confronted by participants not being able to adapt to the newly introduced Mathletics programme. As a result, participants had low self-esteem, which may have manifested from learners questioning the participants as to why they did not apply Mathletics in the classroom during teaching and learning. These learners share information with their peers, so they find out that in some schools Mathletics is used, especially in schools where teachers are young or newly appointed.

Cycle2 – The next stage investigated the exact challenges of the participants regarding Mathletics and the possible suggestions to counter the identified challenges presented by the situations surrounding learning and teaching.

Cycle 3 – At this stage, all suggestions agreed upon by both the facilitator and participants in Cycle 2 guided and monitored participants on how to use Mathletics. As the facilitator, I further guided and supported the participants in their classrooms to implement what they had learnt from the instructions gained from learning Mathletics. With this cycle, any new challenges faced by the participants during the application of Mathletics in teaching mathematics were then addressed to aid the participants on how to further teach in the classroom when applying their knowledge of Mathletics. I adopted the spiral model from Smit and Du Toit (2016), with an emphasis on peer

mentoring. I believe that PAR is aligned with peer mentoring because as the researcher, you guide, support and mentor the participants.

MacDonald (2012) supports the fact that PAR assists in mitigating the challenges that teachers face to improve the quality of teaching and learning in classroom engagement with learners. Similarly, PAR may alleviate the specific challenges faced by veteran mathematic teachers. I worked together with teachers from Pretoria West who had been teaching mathematics for more than 15 years and yet were struggling to use Mathletics.

I sat with the participants and collectively we put in place a plan of action to determine the root cause of their limited usage of Mathletics and planned how to remedy the situation. We then suggested remedial strategies that they should implement in their respective practices. This formed part of Cycle 1 of the PAR project. Using different stages, the plan was executed by the participants. Where they encountered any challenges, they consulted each other because some participants had understood and mastered the skill of using Mathletics. However, I established a strong working relationship with my participants and still contact all of them. I also invite them to other workshops that I conduct which are work-related. Different data collection methods were used, and the teachers raised the challenges that they encountered during the implementation of Mathletics as part of keeping a reflective journal (Smit & Du Toit, 2016).

PAR, in general, is about transformation (Du Toit, 2012) and improvement. To have a broader perspective of the topic of this study, it was essential to employ qualitative methodologies. This assisted me, the researcher, to obtain rich and in-depth data (Maree, 2007) for a better understanding of the phenomenon under inquiry which is assisting veteran primary school mathematics teachers to understand the use of Mathletics.

For me to have trustworthy information in PAR, I remained unbiased and open-minded, yet recorded activities that took place during the observations and interviews (Friedman & Rogers 2009). I then gave the participants equal opportunities to express themselves in terms of the challenges that they encountered in the daily teaching and

learning of mathematics; they also shared their good teaching practices. They highlighted that mathematics teachers must be flexible enough and must use real-life examples; they ask all their learners to bring along tangible objects during teaching and learning. PAR is not only used in education, but it is also used in other disciplines that wish to improve the working conditions, experience and job satisfaction of staff members. However, in education, it has been used to improve pedagogical teaching strategies, PD, educational programmes, policy development, and the education system as a whole (MacDonald, 2012).

3.3 NON-PROBABILITY SAMPLING

In this study, I used purposive and convenience sampling. Purposive sampling ensures that the researcher chooses the sample unit that best suits the objective of the research and which will answer the research questions (Palys, 2008). I selected eight participants who had been teaching primary school mathematics for more than 15 years in the Gauteng Tshwane South District Circuit 2 in Pretoria West. I spent quite a lot of time with the participants to become familiar with them, hoping to get more in-depth information for the study.

To be more precise, I invited more than eight mathematics teachers to take part in this study, so that should one or two opt out during the execution of the project, I would at least have a good number of participants remaining. It was convenient for me to conduct the research in Gauteng, because that is where I work; thus, it was advantageous for me when considering time, distance and cost issues.

3.4 DATA COLLECTION AND DOCUMENTATION

I collected data for the study via semi-structured interviews and participant observations. The participants were veteran mathematics primary school teachers who had at least 15 years of teaching experience. The interviews and observations were conducted at a convenient time and venue preferred by the participants. The time allocations for the interviews and observations were 45 minutes and 30 minutes, respectively, because I did not want to consume much of their time. As a teacher, I am

aware of the pressures they are facing, such as marking the informal assessment tasks and other day-to-day preparations. The normal routine of teaching and learning was not disturbed. The interview was audiotaped, and the transcriptions were done on my computer. The observation checklist is orderly, written on the observation paper and is in my possession. All these documents and the data are kept in a safe place. After completion of the research, all materials will be stored in the SMTE department, according to the policy requirements of the University.

3.4.1 Participant observation

In participant observation, the researcher becomes a participant to understand the social and contextual setting from the participant's point of view (Jorgensen, 2015). In my case, as a mathematics teacher, I worked very closely with these veteran teachers daily. It was easy for me to understand their challenges and concerns regarding Mathletics and other online mathematics programmes because I am also a mathematics primary school lead teacher in Gauteng and facilitate district mathematics workshops. During the data collection period, I became familiar with the teaching styles, values and beliefs of these veteran teachers, because I know and understand the Gauteng Department of Education policies which guide our daily teaching, such as CAPS, ATP, NPA, NPPPPR, APIP and others. I also understand the frustration that these teachers encounter daily due to our unstable and rigid curriculum, which changes gradually without consultation and input by the teachers. I also understand why these veteran teachers are struggling to keep up with these transformations, because more and more teaching and learning programmes are being introduced, yet teachers receive limited developmental workshops on these programmes and they do not get any follow-up workshops. In my case, we had follow-up workshops on Mathletics and I also access and assess their development online. I benefited a lot by being a participant observer; I discovered that some teachers were struggling with some easy calculations and conversions, such as long division, volume and capacity. Further, they confessed that they did not teach long division because they did not understand it themselves. Out of my busy schedule, I made time to go and teach them long division. They also requested me to teach their learners during teaching and learning hours, which I did.

Jorgensen (2015) contends that the observer must live with the participants and become part of their community. I became a part of my participants; they invited me to supervise and teach the curriculum content that is considered to be difficult by learners. The principals of Patogeng Primary School, Phuthaditshaba Primary School, Mahlahle Primary School and Mabafeng Primary School invited me to conduct workshops with their mathematics teachers in Grades 4–7. It was easy for me to develop these teachers in Mathletics because I knew their challenges; together we strategised on the best solutions that can address the challenges. I was constantly reminded that as the researcher, I should remain unbiased and keep in mind that I am there to collect data (Lareau, 2018), not to manipulate the situation or to judge, although I am conducting workshops for other curriculum content. I was able to collect the data successfully. Participant observation encourages the researcher to be objective and not allow the emotions or feelings to influence the observation process.

The participants within the CLP and I, as the principal researcher, were actively involved in the research process. Participant observation enabled me to gain an in-depth understanding of how these veteran teachers perceived the introduction of Mathletics and their reaction in applying constructivist teaching, which is learner centred (Du Toit, 2013).

3.4.2 Interview

Jacob and Furgerson (2012) view interviews as a way through which the researcher asks participants questions to answer the research questions under study. Semi-structured interviews are a qualitative method of inquiry that enable the researcher to combine a preconstructed set of questions with any questions that arise during the interview (Bryman, 2017; Jacob & Furgerson, 2012). I used a semi-structured interview to collect data from the participants to gather an in-depth understanding of their limited usage and comprehension of Mathletics.

Using semi-structured interviews as a research data collection method ensures getting true knowledge of the subject being researched naturally from the contextual

environment (Turner III, 2010). It also helps to raise and discuss issues pertaining to the research that the researcher did not include in the preconstructed questions. I constructed the interview questions before the interview to avoid divergence from the research and to ensure that there is uniformity (Macan, 2009). Semi-structured interviews are more reliable because participants give first-hand, contextual and valuable information to the researcher.

3.5 DATA ANALYSIS AND INTERPRETATION

In my study, I used content analysis. Content analysis is used to analyse textual data (Maree, 2014). It is a systematic coding and categorising approach used to explore textual information to determine trends and patterns of words used, their relationship, structure and discourse of communication. The purpose of content analysis is to describe the characteristics of the content by examining who says what, to whom and with what effect (Vaismoradi, Turunen & Bondas, 2013).

Data analysis is a process of ordering and making sense of the collected data. This is where the researcher makes sense of the large amount of collected data; the data is summarised and interpreted (Ngulube, 2015). Moreover, the process of data analysis is the most important step in qualitative research. Ngulube (2015) finds that this process is time-consuming and stressful, yet beneficial, as this is where the researcher obtains answers to the research questions such as: What does this data mean? What are the major themes emerging from the data? Do the data contribute to the continuous understanding of the field? Data analysis in qualitative research takes place during the process of data collection. Qualitative data analysis is guided by the viewpoint of the researcher in relation to the researcher's knowledge of the topic under study.

The questions that are normally asked during the process of data analysis are: What common themes or patterns emerge that link to the objective of the study and how are these themes and patterns related to the foci of the study? The answers can be used to expand or redirect; the answers to these questions will guide the researcher if

additional data collection is needed. My data analysis consisted of recording, transcribing and coding the data.

3.5.1 Recording of data

As mentioned earlier, data were collected using semi-structured interviews and participant observation. I wrote down all the observations and also used audiotape recordings to ensure that during member checking it would be easy for me to provide original data to the participants and my supervisor, as it is attested by various scholars such as Moser and Korstjens (2018) that this is of great help during the transcription process. During the interview I used the audio to record the questions and answers. All my participants were given pseudonyms; the 8 participants were called P1, P2, P3, P4, P5, P6, P7 and P8. P stands for participant. When I transcribed the data, it was easy because the audio was switched on while transcribing. I also used a video tape to record while I conducted workshops for Mathletics, and I took photographs in the field. I worked closely with five other master's students from other departments on the University of Pretoria's Groenkloof campus during data collection. We met every Friday to reflect on the challenges we encountered in the field and to share the good practices, supporting each other. During member checking, we listened to the audio and checked against the transcription, double-checking the work.

3.5.2 Transcription

Transcription involves the translation or transformation of the recorded data to text. In the study, I translated the data from the audio to text. Various studies (Gibbs, 2018) illustrate that transcription is about reflecting on theory and shaping it. I think it is about putting pieces of collected data into meaning-making. I can add that it is about making sense of what you collect from the participants. This is where the researcher is required to make critical choices and apply critical thinking skills focusing on answering the research question. Thus, it is important for the researcher to be flexible and keep the objectives and aims of the study in mind. The researcher must be selective in terms of which data is relevant to the study.

3.5.3 The coding process

The coding process involves the grouping and labelling of segments of data. Coding helps with providing the researcher with an idea of the data (Strauss, 1987). Coding helps with arranging the data in sequential order by classifying and categorising it. This process assists the researcher to organise and group the coded data into families because they share common characteristics. Strauss (1987) contends that the process of coding enables the researcher to identify the similarities, differences, sequence, correspondence and causation of the data. It also identifies biographic information of the participants, including age, gender, research site and the number of years' teaching experience in mathematics. The information was tabulated in Chapter 5 of this study. The identified themes were also aligned with the research questions in Chapter 5.

3.6 POSSIBLE CONTRIBUTION OF THE STUDY TO KNOWLEDGE CREATION

Report after report increasingly shows that Mathletics is being used as a fundamental tool for teaching mathematics to FP, IP and SP learners who are aged between five and 15 years nationwide (Muir et al., 2018a). The use of Mathletics has caused learner performance to improve significantly and parents' involvement is also improving (McCombs, Whitaker & Yoo, 2017). However, literature shows that parents and guardians who are more involved in their children's learning progress are educated and are financially stable; hence, in most cases they are committed and know the benefits of providing academic support to their children (Boonk, Gijselaers, Ritzen & Brand-Gruwel, 2018). Ninety-seven per cent of teachers in Arab countries such as Algeria, Saudi Arabia, Qatar, Somalia, Sudan, Lebanon, Syria and Palestine agree that Mathletics improves the attitude of learners towards mathematics and that learners are becoming more interested in the subject (Odine, 2015). The literature shows that in South Africa there are very few schools that use Mathletics due to teachers' limited skills and knowledge of using Mathletics – not only Mathletics, but technological learning and teaching tools are a challenge to South African teachers, especially older teachers or veteran teachers, as stated in this study. Berry (2016) argues that the rationale behind the poor performance of mathematics in the South

African context lies in teachers' misapprehension and lack of PCK of Mathletics and other teaching and learning technological tools and programmes.

I assumed that this study would be an eye-opener to teachers, especially veteran teachers, about using technology during teaching and learning. Rapid improvement in educational technology is one of the key driving forces for teacher PD because teachers must be prepared and respond effectively to the current teaching methodologies and curriculum transformations. Again, a source such as Gilakjani (2012) shows that learner performance and the interest in the subject is directly linked to teachers' PCK. Therefore, this puts great pressure on teachers to upskill and stay updated about the recent teaching methods, programmes and resources.

3.7 POSSIBLE LIMITATIONS OF THE STUDY

The focus was on veteran primary school teachers who have been teaching mathematics for at least 15 years and are based in the Pretoria West Circuit 2 Tshwane South District (D4) in Gauteng, as most schools in Gauteng have computers, tablets and access to Wi-Fi. Mathletics is only introduced from Grade R to Grade 9 and can only be accessed online. Therefore, this study was not done in the FET sector (Grade 10-12). I was not able to generalise the findings of this study to a larger population due to my small sample and collecting of data using a subjective qualitative approach. The study conducted by Odine (2015) shows that in South African primary schools, the Mathletics programme is mostly used in Gauteng because most of the schools have accessible and furnished LTSM, free access to WI-FI and is normally used by the younger generation of teachers because they are more knowledgeable about technology and because most schools in Gauteng have computers and tablets (Odine, 2015). Hence, my study focuses on helping veteran teachers to reach the same level as the younger generation of teachers when it comes to technological teaching and learning.

3.8 POSSIBLE DELIMITATIONS OF THE STUDY

In this study, I did not work with learners, because Mathletics is newly introduced. Therefore, it is necessary to ensure that teachers understand this programme before it can be implemented during learning and teaching – teachers cannot teach what they have limited knowledge about. I had adequate time to create strong relationships with the participants and this allowed them to feel comfortable expressing themselves during the data collection period. When engaging in hands-on tasks for Mathletics, teachers opened up, were more cooperative and asked questions openly. However, most of the participants did not possess laptops and used my laptop. Only two out of eight participants had laptops and most stated that they use the school computers. They write their work and request their admin clerks to type it for them. This is stressful because during the administration of the formal tasks, the admin clerks complain about their workload. Again, only three out of eight schools have a projector. Only one school out of eight had a functional computer centre with more than 60 computers. Most of the participating schools use their computer centres to store the feeding scheme stocks, as they do not have computers.

3.9 CREDIBILITY AND TRUSTWORTHINESS

Credibility concerns the trustworthiness of the collected data regarding whether the findings represent the original information collected from the participants (Anney, 2014). Trustworthiness encompasses the credibility, transferability, confirmability and transferability of the findings (Connelly, 2016).

- Credibility is obtained by engaging in lived experiences with the participants, accurate observations and recording, triangulation and member checking. As explained earlier, member checking was conducted by me and my study team whereby we listened to the recording and checked that the transcription was aligned with the participant's response. Moreover, credibility is about whether the views and interpretations of the participants are authentic and genuine to such an extent that if circumstances change slightly, the findings will be the same (Anney, 2014).

- Transferability refers to the generalisability of the findings and is more about providing proof to the readers that the research findings can be applied or transferred to other settings and populations (Connelly, 2016). However, in the study, generalisability is a challenge, due to the small number of participants; this implies that if we generalise, we will not find a true reflection.
- Confirmability refers to the degree to which the findings can be confirmed by others or the degree of consistency and repeatability of the findings in different contextual settings. I also hypothesise that if I had a reasonable number of participants, the above would apply to the study.

According to Palaganas, Sanchez, Molintas, Visitacion and Caricativo (2017a), the researcher can ensure the confirmability of the findings by employing an audit trail and reflexivity. An audit trail is normally used when writing the analysis of the results. This is where the qualitative researcher gives an in-depth explanation of the collected data, data analysis, interpretation and data coding to fully explain the meaning of the themes. Reflexivity is about the ability of the researcher to be critical, selective and analytical in every step of the research (Palaganas et al., 2017b).

Moreover, reflexivity refers to the degree to which the researcher, in my case the principal researcher, plays an active role in influencing or being influenced by the participants yet being able to manage the situation and collect the data effectively. Numerous authors including (Palaganas et al., 2017a) conclude that reflexivity makes the research process transparent. In short, this implies that the researcher must be more attached during the research process to acquire more information, which will help the researcher during the coding and interpretation of the findings. Palaganas et al. (2017b) believe that reflexivity is more personal and is often influenced by personality and who we are – such as position, educational level, class, sex, ethnicity, socio-economic class, and political and religious views.

In qualitative research, the researcher must be immersed in the participants' world to obtain greater culture and context. This will increase the chances of acquiring the core challenges and, by so doing, the quality of data collection and analysis will improve (Twining, Heller, Nussbaum & Tsai, 2017). Twining et al. (2017) posit that triangulation

and member checks are the best methods to address credibility. As a beginner researcher, member checks and triangulation guided me in obtaining credible and trustworthy findings:

- Member checks ensure that there are no inconsistencies or internal conflicts. Moreover, Anney (2014) posits that all qualitative researchers need to undergo the process of member checking because it is inevitable to obtain credibility. Anney (2014) further emphasises that member checks are the "heartbeat of qualitative research". Firstly, I went through member checks with the participants to verify the findings. I also consulted with other members of the study group, which includes five master's students at the University of Pretoria, to ensure that I made corrections if necessary. During data collection with the study team, we also shared our challenges and how to overcome them. I did not encounter any challenges, because they considered me as their colleague and a facilitator. Secondly, the findings were submitted to my supervisor in electronic form, as videos, audio and also the CD to double-check.

- Triangulation involves the use of different methods and sources to corroborate the findings (Twining et al., 2017), such as using different interviews, focus group discussions or participant observation (Anney, 2014). I ensured the trustworthiness of the findings by using different data collection methods and perspectives, which helped to produce more comprehensive findings (Noble & Smith, 2015). I invited the participants to comment on the interview transcripts. I further remained unbiased throughout the data collection process.

3.10 CONCLUSION

Report after report (Venkat & Spaull, 2015) shows that most learners in developing countries like South Africa encounter tremendous challenges in mathematics due to lack of teaching and learning resources and socio-economic factors. A teachers' subject knowledge is the major contributing factor to this poor performance, which causes learners to disengage themselves from mathematics. In most cases, the leading cause is the limited PCK of teachers. Moreover, educational technology is

expanding this gap (Goos, 2010). Veteran teachers are caught up in the middle of upskilling their mathematical CK, PK and technological PCK. Some scholars (Vivian, Falkner & Falkner, 2014) attest that the Australian Curriculum and Reporting Authority (ACARA) together with England have made it compulsory for teachers to integrate technology in all subject areas during teaching and learning. This was done by ensuring that teachers participate in free online computer courses for this initiative to be successful. Teachers were encouraged to work together and share their computing skills and resources with other teachers. The rationale behind this is that the majority of the learners already have access to technological devices at home (Siemens, 2014); as a result, teaching and learning must correlate and be aligned with what the learners experience outside the classroom. To bridge the gap between mathematics that is learnt at school and the lives of learners outside the school, education must be aligned, and learning should not be kept within the school walls. Hence, technology in education is a key factor in twenty-first century education because technology enables learning to take place everywhere and any time (Attard, 2016).

The extensive corpus of the literature shows that technology has changed teaching and learning greatly. This leads to an educational paradigm shift (Vivian et al., 2014) and It is also evident that the learning of mathematics shifts from the traditional view of recalling and memorisation to an approach that is more realistic and hands-on and that encourages problem-solving, which is a constructivist and connectivist approach.

❖ Connectivism in mathematics – the ubiquitous nature of technology in education requires teachers who are willing to collaborate effectively in the CLP and who make use of technological resources and programme during teaching and learning with adequate knowledge and skills. Teachers who understand the value and power of unity in the learning environment are teachers who are confident enough to share their expertise equally with their colleagues (Siemens, 2014). Teachers who are willing to facilitate learning and guide learners, not teachers who encourage learners to recall and memorise, are in demand.

A large body of research shows that the connectivist approach is the most preferred in twenty-first century education, which is technology-based and online (Hilton, 2018).The literature clearly shows that new millennium learners are technology gurus,

thus it is important to ensure that teaching and learning should take place via technology. However, one needs to recall that the CK of the subject matter should be the central point, no matter which teaching medium or resource is used. Learners must share and teach what they learn with their peers for them to conceptualise and internalise what they are learning. Again, this can successfully be accomplished with the use of technology.

❖ Constructivism in mathematics – The basis of the constructivist approach, as pointed out by Vygotsky (2012), is that learners should actively engage in knowledge creation and explore information by themselves under the supervision and guidance of the teacher. Again, this approach suggests that during teaching and learning, learners must link their prior knowledge for them to make meaning of what they are learning. This implies that instructional proceedings should be learner-centred, not the other way around. Teachers should not be dictators and tellers, merely giving answers to the learners – learners must be actively engaged and be eager to learn (Shabani et al., 2010).

Teaching involves the participation of learners, teachers, parents and the community at large. However, teachers are the control centre in providing quality teaching and learning to learners. Therefore, teachers must try to upskill their professional practice through effective PD to ensure that learners acquire an education that will open up opportunities for furthering their studies and participating effectively in our economy through their employment. However, various scholars (Du Toit, 2013) contend that PD should be a priority for teachers, and that they must be committed, dedicated and push themselves to become lifelong learners. CPD will assist teachers to be aware of how their societal and educational practices affect learners' real-life experiences, academic performance and the decisions they make in their academic journey.

Focusing on recent educational teaching methods, resources and programmes is inevitable. Therefore, mathematics teachers should ensure that they understand the application of Mathletics during learning and teaching processes so that they can help learners to conceptualise and realise their potential in learning mathematics.

The next chapter comprises the data analysis and findings collected in the field.

CHAPTER 4 DATA ANALYSIS AND FINDINGS

4.1 INTRODUCTION

Chapter 3 outlines the research methodology of the study. Chapter 4 presents the analysis and interpretation of the research findings. The PAR design was applied in this study to acquire an in-depth overview of developing the professional status of veteran primary school mathematics teachers through the use and application of the Mathletics programme during teaching and learning. Although there is extensive literature in South Africa regarding online mathematics programmes, little is known about the implementation of these programmes by veteran primary school mathematics teachers. This applies especially to the Mathletics programme, because it has only recently been introduced in South African schools. The data were collected in primary schools located in the Tshwane South District (D4) Circuit 2 in Pretoria, Gauteng.

I obtained in-depth views of the participants on how to improve their professional status as mathematics teachers. We also covered adapting newly introduced technology-driven mathematics programmes, such as Mathletics. We also discussed how to effectively implement these programmes during teaching and learning to improve the academic performance of learners and improve learner participation and learner interest in the subject of mathematics from an early age in primary schools.

As outlined in Chapter 3, qualitative research methodologies were employed for gathering rich, naturalistic and grounded data to provide realistic findings (Green & Thorogood, 2018).

The research results are presented as an analysis of the qualitative data obtained from the participant observations and the semi-structured interviews, which were audio-taped.

To ensure anonymity, codes were used when referring to the responses of the participants. In this data analysis, the eight veteran teachers who participated were given code names from P1 to P8. P stands for participant.

4.2 BIOGRAPHICAL INFORMATION OF THE RESEARCH PARTICIPANTS AND THE RESEARCH SITES

Table 5 shows the biographical information of the teachers who participated in this study, outlining their age, gender, research site and the years of teaching experience.

Participants	Age	Gender	Research site	Experience in teaching mathematics
P1	44	Female	Classroom	14 years
P2	49	Female	Classroom	10 years
P3	57	Male	Staff room and classroom	30 years
P4	40	Female	School hall and classroom	13 years
P5	49	Female	Staff room	20 years
P6	59	Male	Staff room	30 years
P7	53	Male	Library	30 years
P8	45	Male	School hall	20 years

Table 4: Biographical information of participants

The above table shows the biographical information of the Tshwane South (D4) Circuit 2 veteran primary school mathematics teachers who participated in this study. Five were female teachers and three were male teachers and their ages ranged between 40 and 59 years.

4.3 ALIGNMENT OF THE RESEARCH QUESTIONS AND IDENTIFIED THEMES

Table 6 shows the order of the research questions and the themes identified.
In this section, themes were identified.

Table 5: Research questions and themes

RESEARCH QUESTIONS	THEMES /SUB-THEMES
Which mode of Continuing Professional Development should be used by veteran primary school mathematics teachers to improve their understanding of Mathletics?	Theme1: Mode of Continuing Professional Development for veteran primary school mathematics teachers in mastering the use of Mathletics during teaching and learning ❖ Workshops; ❖ Seminars; ❖ Conferences; ❖ Courses; ❖ PLC meetings; ❖ Team building; ❖ Peer teaching; ❖ Development; and ❖ Mentoring.
Which professional initiatives help veteran mathematics teachers improve their teaching practice in the twenty-first century?	Theme 2: Professional initiatives in the twenty-first century for veteran primary school teachers THE INITIATIVES MUST BE: ❖ In-depth knowledge of the subject matter; ❖ On-going development; ❖ Theory must be linked to practice; ❖ Mandatory; ❖ Connected to the school assessment plan and the curriculum; ❖ Collaboration; ❖ Recognition for teachers;

RESEARCH QUESTIONS	THEMES /SUB-THEMES
	❖ Accessibility of professional development; ❖ Reviewing the curriculum and teaching methods; and ❖ Application of educational technology.
What can be done to ensure successful Professional Development (PD) for veteran mathematics primary school teachers?	<u>Theme 3:</u> Empirical professional development for veteran primary school teachers: ❖ Lack of support from the relevant stakeholders, including school SMTs, HODs, subject advisors, facilitators and grade leaders. ❖ Workshops do not focus on the practical part of the curriculum deliverance, methodologies, pedagogies and implementation (content focus). ❖ Unrealistic duration of workshops. ❖ Environment not conducive to teaching and learning of twenty-first century skills; ❖ Lack of adequate development, support and guidance.

RESEARCH QUESTIONS	THEMES /SUB-THEMES
	❖ Involvement in curriculum development; ❖ Active learning/action learning; ❖ Coherence.
How can Mathletics be applied in the professional development processes of veteran primary school mathematics teachers in South Africa?	Theme 4: The application of Mathletics in the PD of veteran primary school mathematics teachers in South Africa: ❖ Lack of technological teaching and learning resources; ❖ Knowledge of the integration and application of Mathletics; ❖ Support, monitoring,andguidance.

4.4 RESEARCH THEMES

This section highlights the most common CPD programmes currently presented in the Gauteng Tshwane South District (D4) Circuit 2 in Pretoria West for veteran primary school mathematics teachers. It is important to find out how these modes of CPD are implemented to track how programmes such as Mathletics can have an impact on the daily teaching and learning of mathematics subject. It also allows teachers to assess their progress in terms of how they affect learners' academic performance and achievement.

4.4.1 Theme 1: Mode of continuing professional development for veteran primary school mathematics teachers in mastering the use of Mathletics during teaching and learning

Workshops, phase meetings, seminars and conferences

The data collected during the interviews show that workshops, phase meetings, seminars and conferences are common traditional practices of ensuring that teachers upskill, improve or acquire modern PCK. This includes integrating new teaching methods, resources, curriculum differentiation, educational programmes and teaching resources. However, the findings show that teachers are aware that CPD no longer follows traditional methods due to the technological transformations that are taking place in education (Darling-Hammond et al., 2017). As a result, PD modes must meet contemporary learning and teaching needs. Participants mentioned a number of aspects that they regard as counteracting their PD. Some of these are tabled below. P1, P2, P3 and P4 commented on their experience regarding the current format of PD opportunities, such as workshops, seminars and conferences.

Respondent	Response
P1	*Workshops, seminars and conferences are no longer useful for us, because we know that the facilitators will not focus on the most challenging subject content as to how to teach a particular content, they will only preach on the easy content. Again, facilitators spend more time telling teachers what to do in their classrooms, meanwhile they do not know what teachers are facing in their contextual settings.*
P2	*There are a lot of online mathematics programmes that are introduced in the workshops and conferences such as Khan Academy, Coolmaths, Mathletics, and IXL Maths-online practice, GeoGebra, Matholia and Singapore Maths. However, we as teachers, we cannot introduce all these programmes to learners if we do not have the necessary resources and skills.*

Respondent	Response
P3	*Our submissions and contributions are not taken seriously by the facilitators. To them we know nothing; they give us a lot of useless information; that is why we do not implement what is given to us in the workshops because it is irrelevant.*
P4	*We just go to the workshops to sign the attendance register because if the school was not represented by at least one teacher, the facilitators will come and visit the school, they will demand learners books, DBE books, preparation files, so to avoid all this we just go there attend and come back but, to be honest with you we do not learn a single thing.*

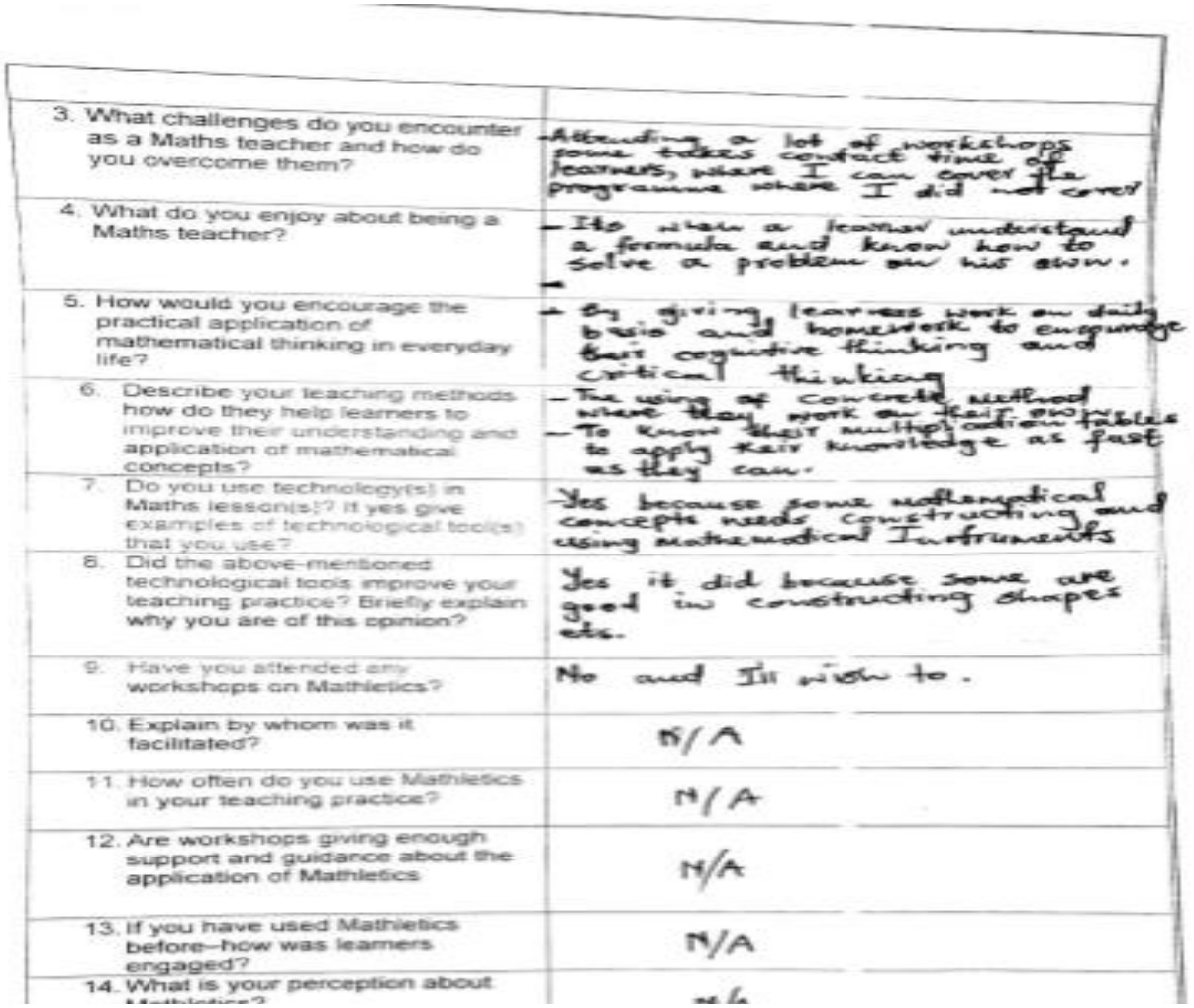
These findings clearly show that the traditional mode of CPD for teachers is no longer relevant. Teachers must engage in active professional learning where they take control of what is being done in workshops, seminars and conferences (Laurillard, 2016). If teachers do not contribute to their own learning, no effective learning will take place. This merely implies that it will be impossible for teachers to keep abreast of contemporary learning and teaching methods and as a result, learners will be highly disadvantaged.

❖ **Courses**

Another important mode of CPD for teachers is furthering studies or enrolling for short courses. This is explicated in the next table.

Respondent	Response
P3	*Since I started working in 1998, I never enrolled for any course. I believe in professionalism, so I did not want to absent myself from work because I will look like an incompetent person. Again, I do not see the relevance of furthering my studies because here in South Africa, teachers are not paid based on their qualifications. I have a diploma, but I earn more than teachers who have honours degree.*
P5	*Enrolling for courses means that I have to cut on my family spending, as a result, this will bring conflict. Teachers receive minimal*

Respondent	Response
	remuneration; I cannot afford to take care of the bills and my studies. If I apply for a bursary, where am I going to get the time to study? We are given 36 days per cycle; I cannot afford to exceed my days because if I do so I will get leave without pay.
P2	*I have a master's degree in law, policy and management, however, I feel like I wasted my years of studying because I am a PL1 teacher. What I hate about our profession is that qualifications do not count, is only experience that counts. I applied for promotional posts for several times, I attended a lot of interviews, unfortunately I did not receive any appointment.*
P7	*I applied for Advanced Certificate in Education (ACE) for mathematics in intermediate phase at UNISA in 2014, since that year, my confidence in teaching mathematics has improved. As a result, my learner achievement has improved. I used to teach the Grade 4s and 5s only now I teach the entire grades at school from Grade 4 to Grade 7. I was appointed as a PLC leader in my circuit by my facilitator. I also assist in the workshops.*



3. What challenges do you encounter as a Maths teacher and how do you overcome them?	- Attending a lot of workshops some takes contact time of learners, where I can cover the programme where I did not cover
4. What do you enjoy about being a Maths teacher?	- I do when a learner understand a formula and know how to solve a problem on his own.
5. How would you encourage the practical application of mathematical thinking in everyday life?	- By giving learners work on daily basis and homework to encourage their cognitive thinking and critical thinking
6. Describe your teaching methods how do they help learners to improve their understanding and application of mathematical concepts?	- The using of concrete method where they work on their own - To know their multiplication tables to apply their knowledge as fast as they can.
7. Do you use technology(s) in Maths lesson(s)? If yes give examples of technological tool(s) that you use?	- Yes because some mathematical concepts needs constructing and using mathematical instruments
8. Did the above-mentioned technological tools improve your teaching practice? Briefly explain why you are of this opinion?	Yes it did because some are good in constructing shapes etc.
9. Have you attended any workshops on Mathletics?	No and I'll wish to.
10. Explain by whom was it facilitated?	N/A
11. How often do you use Mathletics in your teaching practice?	N/A
12. Are workshops giving enough support and guidance about the application of Mathletics	N/A
13. If you have used Mathletics before–how was learners engaged?	N/A
14. What is your perception about	n/a

2 | Page

Figure 4: Interview template

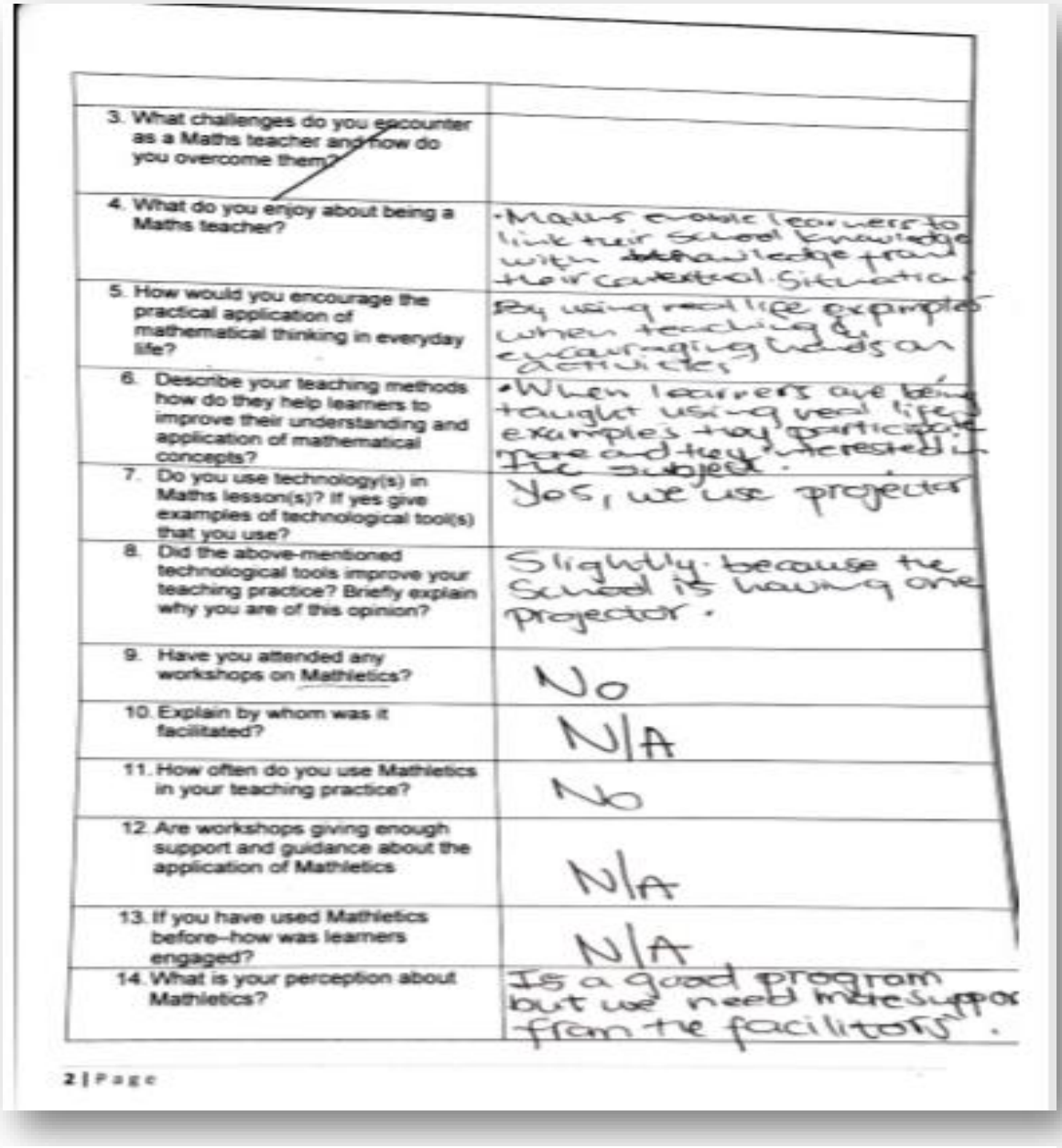
Based on these findings, one can see that most of the veteran teachers were not familiar with online courses because they complained about taking study leave. If they were to receive development about online courses, time would not be an issue for them as financial constraints were the prime factor hindering these teachers from enrolling in courses.

❖ PLC, team building, peer teaching and mentoring

PLC is recognised as the best agent for improving the quality of teaching and learning in twenty-first century learning environments (Hallam, Smith, Hite, Hite & Wilcox, 2015). Participants share their opinions in the following table.

Respondent	Response
P8	*When teachers come together and share their teaching strategies, experiences and tools, there is no way in which other teachers will not learn one or two things; remember when teachers learn their learners will learn too!*
P1	*The thing I like about PLC is that it enables teachers to participate in issues pertaining to their development and it enables teachers to feel inspired by sharing their own experiences. No one is considered an expert like when we attend the workshops.*
P6	*PLC promotes team building, peer teaching and internal mentoring of teachers. PLC allow teachers to collaborate at a school level and work together as a team and determine what works well for the learners and what does not. PLC enables more knowledgeable teachers to share their experiences with novice teachers. Again, novice teachers who are technological gurus are afforded an opportunity to teach the veteran teachers on how to use these newly introduced online teaching tools.*
P3	*I am the PLC leader in circuit 2 D4. I ensure that mathematics teachers in my circuit stay updated with any information. I visit nearby schools and share my teaching tools with them; I organise in-house team building with my facilitator whereby teachers are afforded an opportunity to share their challenges and together as a team we come up with a solution.*
P4	*At school we have a PLC leader, if we encounter any challenges, we invite her to our classrooms to observe her lessons. She is so helpful she assists us with these technological tools presented to us. It is not good to be in an environment where they do not value your contribution. Whatever suggestion that you put on the table, it is pushed down because you are not in the leadership position, hence the very same people who are in leadership do not develop and support teachers. They put more emphasis on the school politics rather than the development of the teachers, but in the PLC*

Respondent	Response
	meetings, we feel valued and welcomed our contributions are warmly accepted.



3. What challenges do you encounter as a Maths teacher and how do you overcome them?	
4. What do you enjoy about being a Maths teacher?	•Maths enable learners to link their school knowledge with their contextual Situation
5. How would you encourage the practical application of mathematical thinking in everyday life?	By using real life examples when teaching & encouraging hands on activities
6. Describe your teaching methods how do they help learners to improve their understanding and application of mathematical concepts?	•When learners are being taught using real life examples they participate more and they interested in the subject.
7. Do you use technology(s) in Maths lesson(s)? If yes give examples of technological tool(s) that you use?	Yes, we use projector
8. Did the above-mentioned technological tools improve your teaching practice? Briefly explain why you are of this opinion?	Slightly because the school is having one projector.
9. Have you attended any workshops on Mathletics?	No
10. Explain by whom was it facilitated?	N/A
11. How often do you use Mathletics in your teaching practice?	No
12. Are workshops giving enough support and guidance about the application of Mathletics	N/A
13. If you have used Mathletics before–how was learners engaged?	N/A
14. What is your perception about Mathletics?	Is a good program but we need more support from the facilitors.

2 | Page

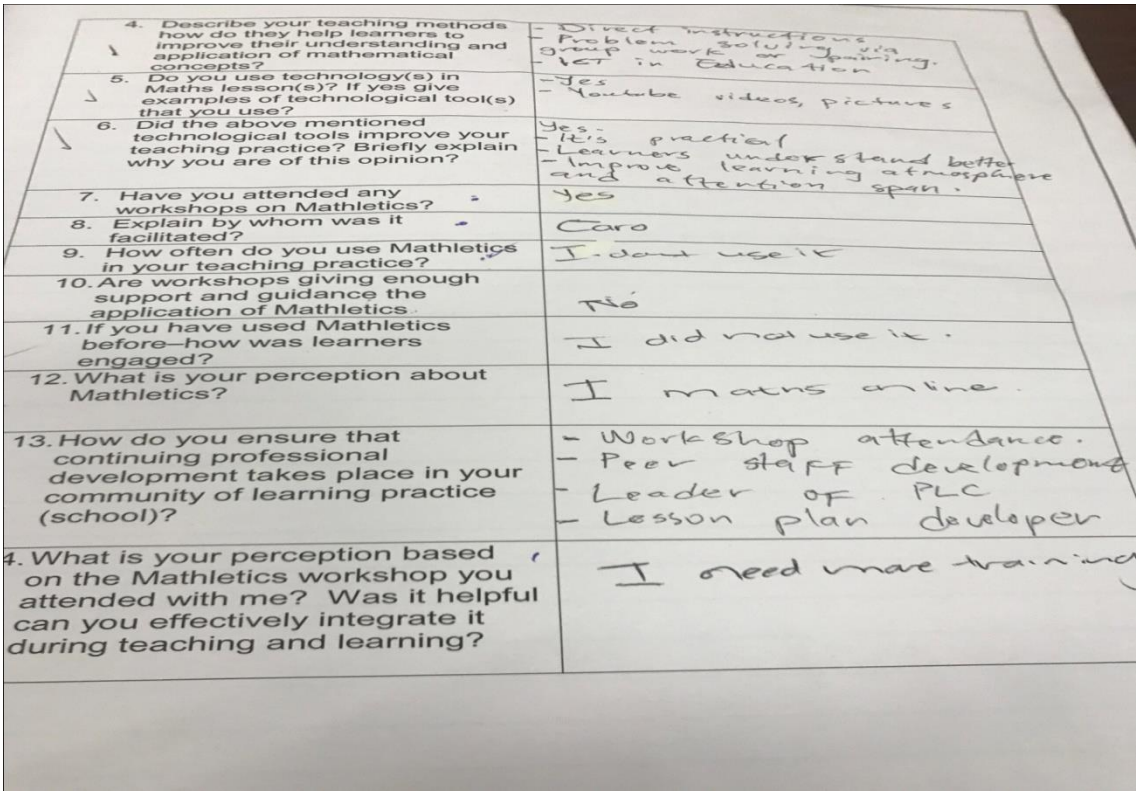
Figure 5: Interview template completed

4.4.2 Theme 2: Professional initiatives in the twenty-first century for veteran primary school teachers

All eight participants who were engaged in this study shared the same sentiments about the transformations brought about by technology in education. They were aware that the predominant mode of traditional CPD mentioned in the first theme does not yield any positive results in their teaching practice. The participants called for professional initiatives that would be ongoing, collaborative, connected to the school curriculum and assessments, would dig deep into the subject matter in terms of the pedagogy and content, provide more opportunities for practical applications with the integration of technological teaching and learning resources and programmes, would encourage teachers to be lifelong learners, help them to perceive learners as co-constructors in the teaching and learning process and allow teachers to participate in curriculum matters.

Respondent	Response
P3	*My daughter look here, uhm…uhm…uhm…at school we only have four computers; one for the principal, one for the clerks, one for the deputy principal and one for teachers. We do have Tshwane Wi-Fi, but we do not use it for teaching and learning purposes. Learners do access these so-called social media that they use now days such as WhatsApp and Facebook but not for learning. So now if you want to teach me this Mathletics, how am I going to implement it to my learners?*
P1	*Look here young lady, uhm … as teachers we are not stupid. In most cases, we notice errors in the textbooks, but we pretend like we did not see anything because we are regarded as idiots, they just give us textbooks without requesting for our inputs.*
P8	*We long for the day where the curriculum developers would invite teachers for the amendment of the curriculum because we all see that our curriculum needs to be adjusted. They introduce technological programmes like the one you are talking about, Mathletics, but as teachers we don't know how and when to integrate it because it is not in our curriculum and out ATPs.*

Respondent	Response
P7	*You know what? The South African education system is far from transformation, there is no correlation between the curriculum and the technological tools that are presented to us. Uhm…look, it is practically impossible to integrate online teaching and learning tools while you do not have sufficient Wi-Fi, yes, we do have Tshwane Wi-Fi. However, it is not strong enough; sometimes it only connects when you are in the staffroom not in the classroom. It has limited coverage. So, I cannot embarrass myself in front of the learners.*
P6	*In 2010 we received like 15 laptops from the department and I have like 105 learners for mathematics. No matter how one is good with sharing, it is impractical to utilise 15 laptops for 105 learners and all the learners from Grade 4 to Grade 7 were using these 15 laptops. The laptops ended up disappearing one by one, now as we speak, we do not have any laptop. In South Africa, we are admiring other countries we want to be like them, but as long as we lack the basic teaching and learning tools, educational technology won't be pragmatic.*



4. Describe your teaching methods how do they help learners to improve their understanding and application of mathematical concepts?	- Direct instructions - Problem solving group work or learning. - VET in Education
5. Do you use technology(s) in Maths lesson(s)? If yes give examples of technological tool(s) that you use?	-Yes - Youtube videos, pictures
6. Did the above mentioned technological tools improve your teaching practice? Briefly explain why you are of this opinion?	Yes- - It's practical - Learners understand better - Improve learning atmosphere and attention span.
7. Have you attended any workshops on Mathletics?	Yes
8. Explain by whom was it facilitated?	Caro
9. How often do you use Mathletics in your teaching practice?	I dont use it
10. Are workshops giving enough support and guidance the application of Mathletics	No
11. If you have used Mathletics before–how was learners engaged?	I did not use it.
12. What is your perception about Mathletics?	I maths online.
13. How do you ensure that continuing professional development takes place in your community of learning practice (school)?	- Workshop attendance. - Peer staff development - Leader of PLC - Lesson plan developer
14. What is your perception based on the Mathletics workshop you attended with me? Was it helpful can you effectively integrate it during teaching and learning?	I need more training

Figure 6: Interview template before Mathletics workshop

Based on these interviews with the participants, it is evident that the participants strongly supported the idea of transformation in the area of educational technology. However, the participants elaborated on the issue of a lack of teaching and learning resources and continued support by the facilitators and the CPL cluster leaders or lead teachers. In practical terms, for instance, one can learn to find a general solution to a trigonometric equation. However, this is done with adequate support and thorough hands-on development and demonstrations. Furthermore, twenty-first century professional initiatives for veteran primary school mathematics teachers must:

- encourage networking and the establishment of professional relationships between veteran teachers, beginner teachers and teachers from different schools who teach the same subject or phase.
- promote hands-on, practical and action learning.
- support peer teaching wherein teachers who teach the same subject and grade from the same or different schools have an opportunity to engage in peer teaching and share teaching and learning resources.

- promote informal peer mentoring at school level that will create further opportunities for improved teaching and learning methods that are based on constructivism and connectivism.
- encourage teachers to improve their skills and knowledge to avoid dormant, obsolete teaching and learning. This should be done by continuously engaging in personal PD initiatives such as furthering their studies in higher education and development in their personal capacity; and teachers who engage in personal development must receive recognition in monetary terms, receiving certificates or obtaining promotional posts without paying bribes so that other colleagues can be motivated to do the same.
- Facilitators must encourage the functionality of the PLC. Teachers must elect lead teachers in their clusters or CLP who will monitor, guide or offer support in terms of the teaching methods, resources or guidance. This will enable teachers to actively engage in peer teaching and professional learning where teachers come together to share and reflect on their teaching methods. By so doing, this will improve the quality teaching, learning and learner academic performance.
- ensure that, in the workshops, the focus must be on the topics that are challenging for learners. Teachers must share practices on how to deal with challenging topics and they must engage in practical tasks.
- guide, support and mentor teachers on the twenty-first century classroom management skills and how to make the teaching and learning interesting and maximise learner participation and achievement.

4.4.3 Theme 3: Empirical professional development for veteran primary school teachers

The participants similarly expressed their dissatisfaction with the current PD initiatives. Most of the participants explained that they did not receive adequate support from the relevant stakeholders, including SMTs, HoDs, subject advisors and grade leaders. Moreover, the length of the workshops is unrealistic as one cannot learn new methods of teaching within a few hours from 08:00 to 15:00 on a Saturday. Additionally, their contextual settings are not conducive to teaching and learning in the

twenty-first century due to a lack of teaching and learning resources, overcrowding of classrooms, lack of parental involvement, learners not interested in education, SGB members not addressing teachers' and learners' needs in terms of LTSM procurement and school principals not interested in motivating their subordinates, which also leads to dysfunctional schools.

According to Ntseto (2015), for schools to be declared functional, leaders and managers must be effective and provide the highest support and leadership to all staff members by valuing their contributions and involving them in important decision-making structures at school and encourage their subordinates to attend ongoing PD initiatives (Ntseto, 2015). Furthermore, various studies propound that the most realistic and practical solution for the barriers to effective teaching and learning lies with education managers and leaders, including HoDs, subject advisors, facilitators, IDSOs, SMTs and SGB members. If the above-mentioned education managers and leaders do not lead by example and are not motivated, neither will the staff be motivated. Leaders must support, lead, guide and inspire.

This is what some of the participants had to say:

Respondent	Response
P8	*Uhm…let me be honest with you and please make sure that the school principal do not hear this because it is an internal arrangement with the SGB members …hahaha, we do have a computer laboratory but it does not have computers, it is mainly used to store learners feeding schemes and the cooking utensils because we have minimal storage. As a result, this laboratory it is not functional due to the unavailability of computers.*
P4	*Eish …eish ……to be honest with you, in 2014 we were given 50 laptops, till today no one used the laptops including myself, because if we spoil them we have to repay the damage so to be safe it is better to stay away. As the HoD, if something goes wrong, I must account. I am tired of accounting, I am only left with oneyear, and next year I am retiring so I want to go home peacefully.*

Respondent	Response
P6	*I am working with Funza Lushaka students who are young like you; they are putting the school principal under pressure to buy computers. At first, I was against their request, now I fully support them. This Mathletics that you are talking about, one of them was teaching me but I do not understand at all. As the HoD, I really want to see my department doing well, they are promising me that if they can get the laptops, and maths performance of our learners will improve! Ohyes! I trust them, they are hard workers.*
P7	*I am old, but I like technology and I can use technology, in fact, I use technology almost every day to communicate with my lectures and I also do my assignments online. Look … I am doing my honours degree at the University of Pretoria through distance education. You know what? I have been begging the school principal and the SMT for like five years now to go out there and ask donations to buy computers, but till today nothing has been done.*

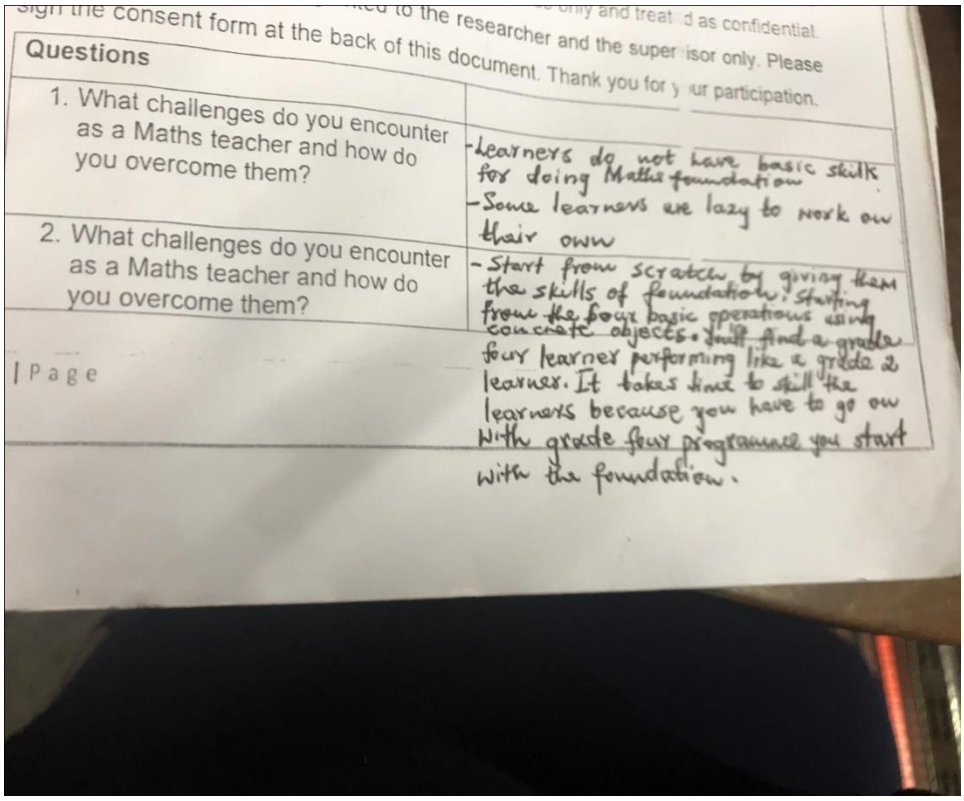


Figure 7: Responses regarding the challenges that the participating teachers encountered

The veteran teachers who participated in my study highlighted the fact that the use of technology has been inevitably growing rapidly, but the South African educational department has been lagging with the provision of educational technological teaching and learning resources and the current curriculum which is CAPS does not complement the Fourth Industrial Revolution's objectives, or rather the twenty-first century education mission and goals. Again, teachers, especially veteran teachers, are not well prepared for twenty-first century teaching methods, teaching and learning environments. Handling these technology-born learners is quite a challenge for the majority of the teachers. Teachers have accepted that these millennium learners use technology more effectively – they are more knowledgeable about these technological teaching and learning resources and programmes. As a result, learners are the ones who suffer the most due to the professional inequities of teachers. Building on this, the veteran teachers also mentioned that teachers are being excluded in matters concerning curriculum development and policy development; as a result, this exclusion is not doing any justice to them or their learners:

Respondent	Response
P4	*I heard about this Mathletics and online mathematics, our facilitator encouraged us to use it, but personally I do not know-how to use it. He told us that we must access the following Tshwane South mathematics website:www.mathsts.co.za. Hahaha …yes, I saw Mathletics on this website, but I cannot use it. I downloaded some activities, but I cannot imagine using it in front of my learners! These kids are experts when it comes to technology!*
P1	*Uhm …Look here ma'am, how do you expect me to implement what I do not understand? If I do not understand what am I going to teach my learners? For instance, this Mathletics, how can I integrate it when I do not have enough computers and the skills to use it?*
P3	*As a teacher, my sole responsibility is to ensure that these innocent kids acquire quality education that will open up job opportunities or learning opportunities. However, if we do not have basic necessary tools to offer them quality education, I feel like we are robbing them the future they that they deserve.*

Respondent	Response
P8	*The MEC of education in Gauteng province and the minister are trying their best in ensuring that South African schools, more particularly Gauteng schools, keep up to date with ICT, but it takes a group work to achieve tangible output. Mr Lesufi must get support from his colleagues if he does not receive support, no transformation will take place. We will only sing the song of ICT in education, but actions will be dormant.*

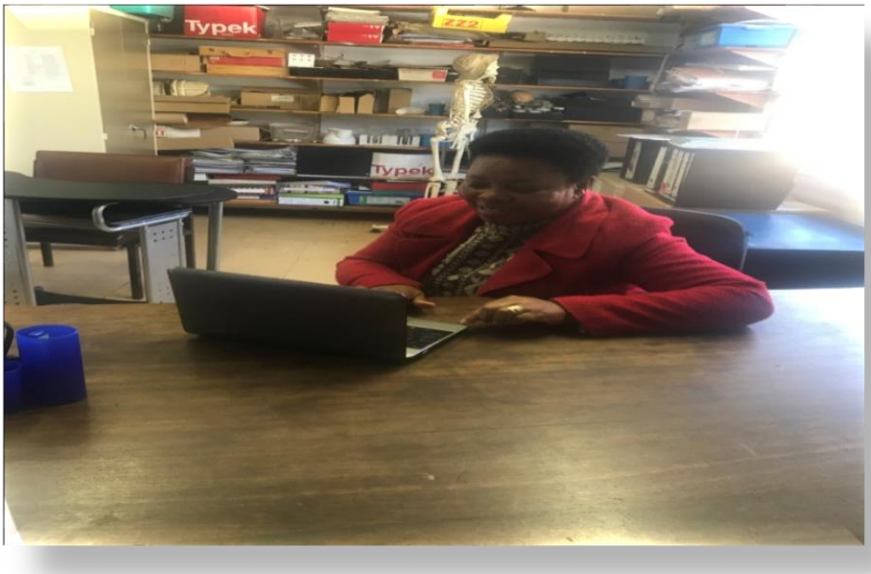
4.4.4 Theme 4: Application of Mathletics in the professional development of veteran primary school mathematics teachers in South Africa

A lack of technological teaching and learning resources, insufficient knowledge of the integration and application of Mathletics, and inadequate support, monitoring and guidance were the main hindrances identified by the participants. The veteran teachers that I interviewed were highly aware that educational technology is transforming at an alarming rate; therefore, it was inevitable for them to possess the required knowledge, skills and the willingness to provide quality education that meets the needs of our millennium learners. Participants have articulated that South Africa in general is currently experiencing a shortage of technological teaching and learning resources. In public schools, they even lack basic learning resources such as exercise books, textbooks and other stationery. Also lacking are technological teaching and learning resources that enable learners to become constructors of knowledge, not just *tabula rasa* learners who are not active participants during teaching and learning (Eickelmann et al., 2012). Most of the participants expressed their views about Mathletics and other online mathematics programmes as follows:

Respondent	Response
P5	*I mentioned the issue of lack of teaching tools, but adding on this again, one can have all the tools but if you cannot use them then they are useless uhm…uhm...the point I am trying to raise here is that uhm…more training is needed, not just these once-off workshops that we attend but thorough training where teachers gain in-depth understanding, you get what I mean?*
P6	*Uhm…uhm … I also think that when it comes to technology, most of the facilitators, they need to be trained because most of the facilitators were teachers like ourselves, but they were fortunate enough to get promotional posts. Uhm… in the workshops, if they want to connect their laptops, they normally ask these young teachers to assist them to connect their laptops with the projectors …uhm so what's the difference between myself and such a person? So, this simply shows that majority of veteran teachers together with the veteran education leaders needs to be trained when it comes to these ICT things*.
P3	*Before the introduction of these technological online things, I enjoyed being a teacher, but now I feel like learners are gradually becoming teachers because in most cases if I am trying to show them a video, they are ones who are assisting me and if something goes wrong with my laptop, they assist me hahaha…hahaha…my learners normally say to me, "Sir the only time you are humble is when you want us to help you with your laptop, we guess you must bring the laptop everyday so that you become humble" hahaha...*
P1	*Well to be honest with you, every time when I use a tablet to teach, my learners become so interested, even the ones that do not ask questions in class, they participate but unfortunately I only have one tablet, I wish they all had their tablets.*

The participant in the photograph below (photograph used with permission) requested that before we can start developing them on Mathletics we must assist them to learn basic computer skills such as typing, sending emails, downloading and searching on

the internet; thereafter it will be easy for them to access and use Mathletics and other learning programmes.



4.5 ALIGNMENT OF THE CONCEPTUAL FRAMEWORK AND THE IDENTIFIED THEMES

The conceptual framework adopted in the study was that of PD. To be functional, this conceptual framework aims to put the following theories into practice for the betterment of South African education – more particularly mathematics subjects, as various studies in the literature (Modisaotsile, 2012) show that learners perform poorly in mathematics in almost all the grades – action learning, peer mentoring, peer teaching, teamwork, reflecting on lessons, group discussions, teacher study groups, the social constructivist and connectivist approach to teaching and learning, and a CLP. (Du Toit, 2014). This framework regards teachers as the participants, constructors of knowledge, agents of change, curriculum developers and implementers and initiators of knowledge based on constructivist and connectivist teaching and learning (Kennedy, 2016). For the PD process to be considered as effective in improving teaching practice and learner achievement, it should include the following core features: (1) Content focus, (2) Active learning, (3) Coherence, (4) Duration and (5) Collective participation (Desimone & Pak, 2017). The participants

provided their insight based on each of the core features of PD with regard to Mathletics, which are discussed in the sections below.

4.5.1 Content focus

Content focus is solely based on teachers' PCK of the subject. It refers to how learners learn the content and it also relates to learner achievement as evidence that content is being mastered (Desimone & Pak (2017). The subject matter, including assessments, class tests, examinations and the overall achievement of learners through the improved pedagogical practice of teachers during PD, forms part of content focus (Korthagen, 2017). Recent literature places further emphasis on teachers' understanding of the content and their ability to use various teaching methods, programmes and curriculum differentiation to accommodate diverse learners' needs (Kafyulilo et al., 2016). Therefore, this shows that for learners to perform best, teachers must know the content very well and be able to use various methods and implement curriculum differentiation to ensure that all learners, regardless of their learning ability, benefit and understand from the curriculum. This also implies that if teachers understand the application of Mathletics, learners will also benefit.

Respondent	Response
P6	*To be honest with you, in the workshops, we do not dwell deeper in the content, especially when it is a hands-on activity. We normally focus on the theory, then that's it. Whether you understand or you do not understand, we move on.We are scared to confess that we do not understand because you will look like an incompetent teacher, so I personally believe that if teachers were to work in groups, we were going to benefit a lot, uhm…you see…these young teachers, they understand these technology stuff. So, if we were to be in groups between us old crocks and new teachers, we normally call them Funza Lushaka teachers, I am telling you that we were going to learn a lot. I am the HoD, but I learn a lot from my Funza Lushaka teacher; she is the one who organises excursions for our learners, she is the*

Respondent	Response
	one who brings new ideas and coordinates the extra-mural activities so old teachers and new teachers must work together.
P3	*Mathematics is a practical subject, in most cases during the workshops we deal with calculations but we uhm… uhm…we once attended this workshop called ICT in mathematics education, that's where I heard the word Mathletics. You know what … uhm… you see. Uhm… facilitators do not emphasis on this online thing because they are aware that we do not have basic tools. They do encourage us to implement them, but it is impossible, I cannot implement what I do not understand.*
P7	*I stopped attending workshops long time ago because they repeat one thing repeatedly, they do not share with us new teaching ideas and in most cases, they do not tackle these difficult content-like fractions, they only focus on the easy content so that does not benefit me at all*.

The teacher in the photograph below, used with permission, is an HoD. During the subject meetings he encourages the teachers to share their good practices and they have a class visit timetable where they conduct class visits and afterwards reflect and not criticise each other, but develop each other in a scholastic fashion.

4.5.2 Active learning

Active learning occurs when teachers work together to carry out peer mentoring or peer teaching, where they share their teaching pedagogies, teaching methods, classroom management strategies, teaching experiences, teaching resources and where teachers practise and implement what they learn in their CLPs with their learners. Teachers must be fully engaged during learning and reflect on what they are learning (Du et al., 2017). After observing and engaging an expert or more skilled teacher in the form of action learning, teachers should implement what they are learning and see if they need further clarification in certain areas:

Respondent	Response
P1	*In the workshops no active learning is taking place we just go there, sit and listen to what the facilitators are telling us; we do not have a say, even if we do not understand what they are telling us we just pretend as if everything is ok no one cares about teachers; no one is willing to listen to our contributions and this is really frustrating that is why teachers are absenting themselves from the workshops we only send these young teachers because us we are tired of hearing one thing every time*.
P6	*I once attended a MST (Mathematics, Sciences and Technology) conference at Nigel Secondary School in Gauteng East on the 18th of August 2018 hahaha … uhm I even regret why I attended. I attended several lessons on mathematics, they taught us on how to use a scientific calculator instead of teaching us how to use a computer imagine who doesn't know how to use a calculator? My daughter let me tell you, majority of the teachers of my age need more hands-on, practical training on technology. We do not want to be told what is ICT or that Mathletics we want to touch the mouse and do it ourselves*.

4.5.3 Coherence

PD should be congruent with the required content standard according to the CAPS policy, ATP, AP, and SBA. It should be clear as to what, when and where teachers should learn and why teachers have to learn certain topics. Teachers must be able to add their own contributions, they must not be given a prior prepared recipe like a cooking recipe, where their voices are silenced and their expertise is not considered (Darling-Hammond et al., 2017). With little experience as a teacher, I believe that giving teachers lesson plans that they did not help write is killing the creativity of teachers. During data collection I met great, excellent teachers who were willing to bring positive changes; they also showed me the most embarrassing errors in the Grade 6 term 3 GPLMS.

In the photograph below, I was with two participants (photograph used with permission), both Grade 6 mathematics teachers from neighbouring schools and PLC leaders in Circuit 2. We went through the errors in the GPLMS. They also discussed that some teachers who are not careful continue teaching learners these mistakes. It is therefore important for teachers to take part in any matter related to the curriculum. We also discovered numerous mistakes in the Platinum and Head Start Grade 6 mathematics textbooks.

The participants shared the same sentiments, saying that teachers must learn what is relevant; whatever teachers learn should be aligned with their knowledge and beliefs to form a strong coherence with constructivism and connectivism as the most relevant philosophical concepts guiding the veteran primary school mathematics teachers in their teaching and learning in twenty-first century education (Kennedy 2016). For example, when teachers are dealing with data handling, the emphasis during PD should be on data handling, not on the other topic. When PD is aligned with what teachers are doing in their daily teaching and learning practices, then it is more likely to yield positive outcomes for both teachers and learners (Desimone & Pak, 2017). The Mathletics programme is also aligned with the South African mathematics curriculum; this will help teachers to understand more easily (Berry, 2016).

Respondent	Response
P5	*In most case, the information that we receive from the workshops is not aligned with what is happening in the classrooms, for example, this Mathletics that you are talking about is not in the curriculum, so why am I stressing myself to learn about it? I think this Mathletics is for rich schools, not the township or rural schools.*
P4	*I prefer to stick to use a blackboard because it is no good use to implement technology while learners do not understand simple mathematical content. I think learners will be further confused if I use technology. Again, if I use technology, I will concentrate on the screen rather than explaining the content. So, I do not see myself integrating technology in my classroom and I have never seen Mathletics in the CAPS document.*

4.5.4 Duration

As a primary school mathematics teacher in Gauteng, from experience, we normally attend workshops on a Saturday from 08:00 to 15:00. Teachers do receive breakfast and lunch, which is a bonus. However, teachers get tired before the end of the session; some do not attend due to family responsibilities like weddings, funerals and other relevant matters. The attendance is too poor on such days. What I have observed in

the workshops is that facilitators deny teachers the opportunity to show their creativity and express their views due to time constraints. Facilitators read from their PowerPoint slides and they do not engage teachers during the workshops. The time span from 08:00 to 15:00 is too long and they will not acquire anything when their minds are exhausted. Facilitators only visit schools when the teachers are underperforming. I believe that they must also visit the best performing schools, so that they can see how they are maintaining and managing to keep their best performances and perhaps request teachers from such schools to share their expertise in the workshops, PLC meetings and seminars. If teachers are offered substantial time to learn, practice, implement and reflect on newly acquired or improved teaching methods, the PCK of teachers can improve beyond school level and this will boost their confidence in applying what they acquired in the workshops (Darling-Hammond et al., 2017). Thus, there is a need for sufficient time for teachers to reflect on what they have learnt, how they managed to implement what they learnt and adjust their teaching practice and methods. This can help teachers to upskill easily and it will motivate them in participating in in-service PD. Intellectual and pedagogical periods of change in which teachers plan, analyse and reflect on their teaching practice allows teachers to create ample time for discussion and feedback on learners' assignments to make a way forward for learners' understanding and achievement.

Respondent	Response
P4	*We just go to the workshops to sign the registers; we do not really learn anything. On Saturdays, we normally attend from 08:30am to 14:00pm; we learn a lot of things within a limited duration. Let me clarify what I say uhm …the subject advisors tell us a lot of things within a short period of time, but sometimes we do learn uhm…let me stop right here. Uhm… again, we receive the booklet as the evidence that we attended but …*

Photograph used with permission

4.5.5 Collective participation

Effective PD encourages collective participation because active learning takes place when individuals work together constructively, sharing their varied expertise, discussing, demonstrating and guiding each other (Desimone, 2009). According to Darling-Hammond et al. (2017), PD is effective, efficient and active when it allows teachers to engage physically, cognitively and emotionally through hands-on activities, sharing, discussions, simulations, visual representations, applications, reflections and follow-up sessions. The following participants (photograph used with permission) shared that the lead teachers and HoDs must ensure the functionality of teamwork. If HoDs and lead teachers exhibit teamwork, welcome individuals' opinions and demonstrate a participatory leadership style and respect, all the teachers – definitely veteran primary school mathematics teachers – will engage in teamwork. Participants below were sharing about their experiences on how workshops are conducted and observed limited collective participation of the teachers.

4.6 PARTICIPANT OBSERVATION

Due to time constraints, the researcher was engaged in participant observation with two participants only, P8 and P4. During the participants' observations, I invited Mr. Frank Longwitz, the Mathletics manager in South Africa, to do hands-on development for Mathletics and he honoured the invite. He assured us that if we needed further development, we could contact him at any time to make arrangements. Moreover, he has partnered with the Gauteng DBE. The researcher observed the following during the participants' classes, but they refused to be video-taped. They said they were not comfortable yet but would be as soon as they mastered Mathletics and would first apply it with their learners. But during the observation, teachers only introduced the theoretical part of Mathletics; they were only explaining what Mathletics is and why it is used during teaching and learning. I recorded this in my journal.

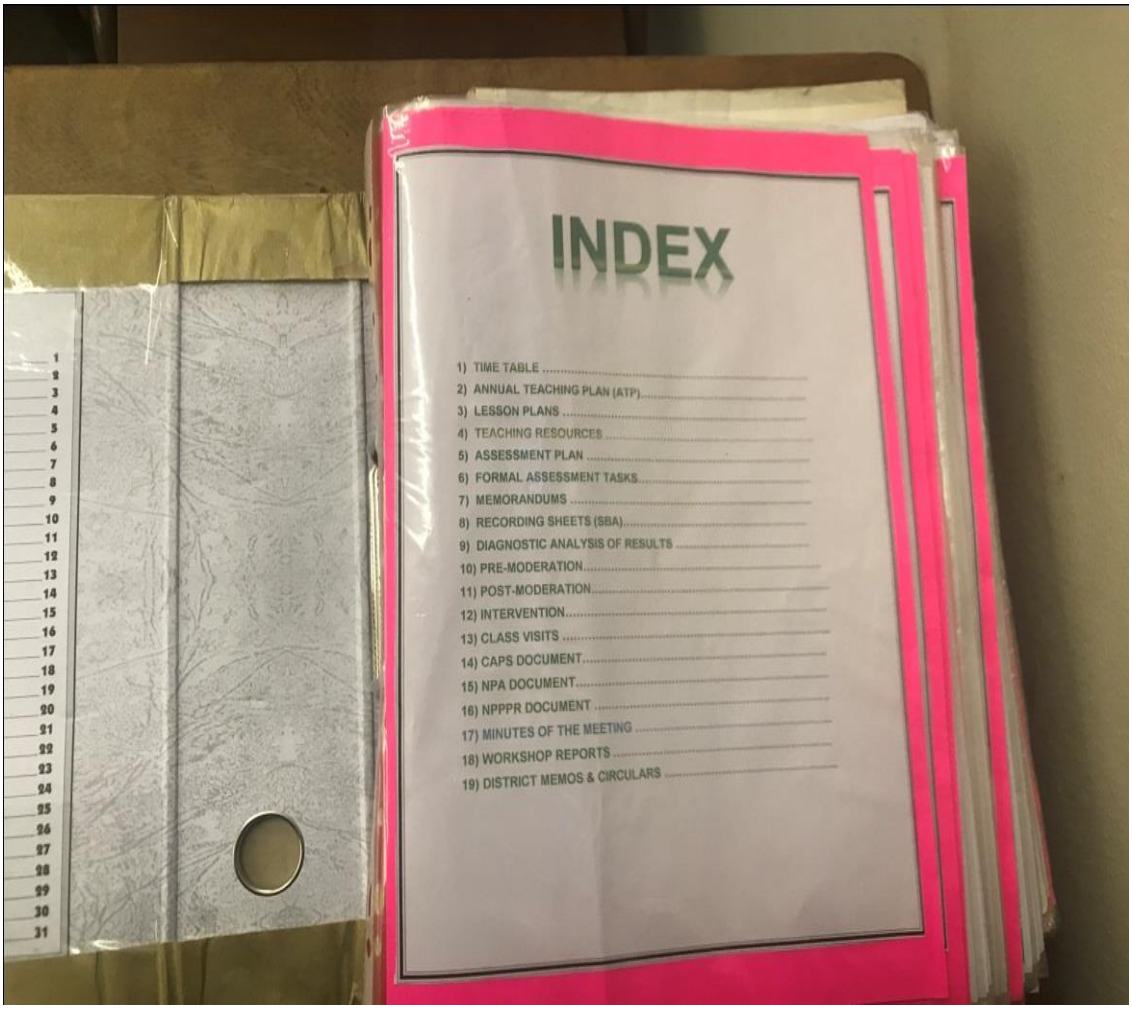
4.6.1 Availability of technological tools in the classrooms

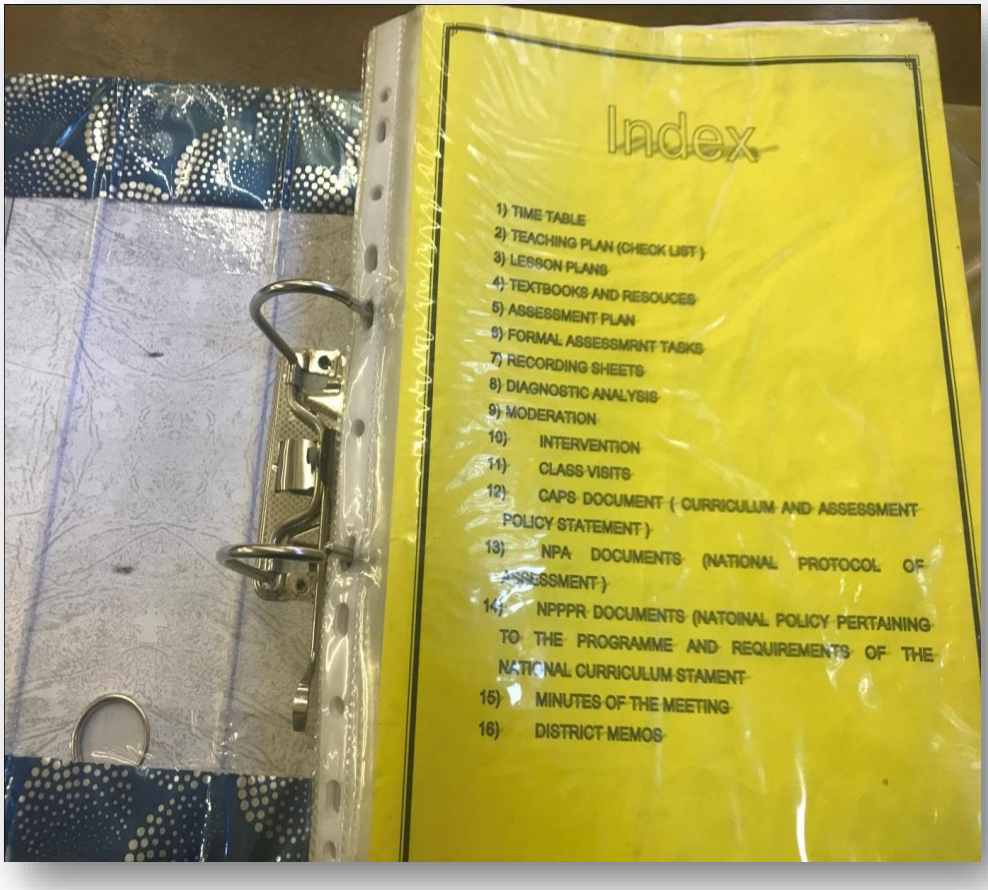
Neither of the participants had technological tools in their classrooms. This simply shows that educational technology is not a reality for them yet. They told me during the interview session that they did not have technological tools, which I witnessed. Their classrooms were overcrowded with as many as 60 learners in a class. This could present another challenge for teachers in using technology during teaching and learning, because they must ensure that learners do not destroy the resources. I have observed that maintaining discipline in overcrowded classrooms is a challenge. Teachers spend more time disciplining learners than teaching. Moreover, teachers in such classrooms do not cover the curriculum in the stipulated time due to marking the numerous formal and informal tasks and controlling learners' books. The photograph below was used with permission. The participant in this photograph mentioned that his school once received 15 tablets from Tshwane South District, but he had 5 tablets, not enough to share among his 60 learners. He just kept the tablets in his HoD's office. In this photograph, we were demonstrating the long division method both on the chalkboard and on the Mathletics programme. The participant was pleased that

Mathletics is quick and less confusing, while traditional methods of calculating long division are too long and confusing.

4.6.2 Mathematics teacher preparation files

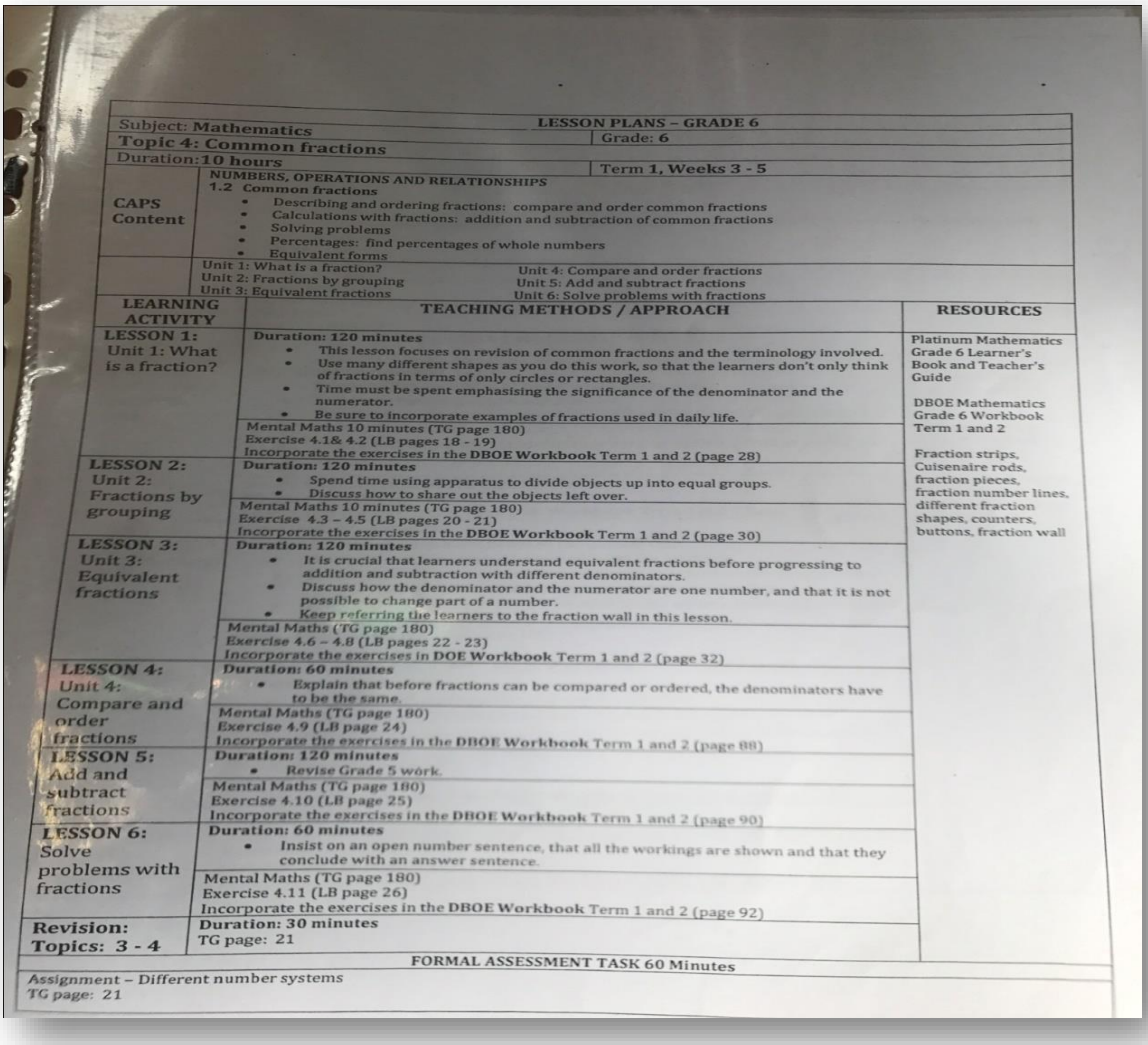
Both participants had preparation files that were up to date with all the necessary documents, including lesson plans, mark sheets, formal tasks and their memorandums, assessments plans, personal timetables, diagnostic analyses of the results, phase and staff meetings, and policies and district circulars. I was impressed to see their preparation files. However, as mentioned earlier, they did not have any technological teaching and learning resources. We had to use my laptop and my projector when I assisted them to create passwords for Mathletics. We went for follow-up visits with Mr Frank Longwitz. Most of the participants had limited technological know-how; this must end if we want to improve the quality and standard of our education (Orlando, 2014; Day & Gu, 2009; Plair, 2008).


INDEX
1) TIME TABLE
2) ANNUAL TEACHING PLAN (ATP)
3) LESSON PLANS
4) TEACHING RESOURCES
5) ASSESSMENT PLAN
6) FORMAL ASSESSMENT TASKS
7) MEMORANDUMS
8) RECORDING SHEETS (SBA)
9) DIAGNOSTIC ANALYSIS OF RESULTS
10) PRE-MODERATION
11) POST-MODERATION
12) INTERVENTION
13) CLASS VISITS
14) CAPS DOCUMENT
15) NPA DOCUMENT
16) NPPPR DOCUMENT
17) MINUTES OF THE MEETING
18) WORKSHOP REPORTS
19) DISTRICT MEMOS & CIRCULARS



4.6.3 Lesson plans aligned with the mathematics CAPS document

My participants' lesson plans were aligned with the CAPS document, but the lesson plans are already made at district level. The Grade 6 mathematics lesson plan template is shown in the photograph below (used with permission).



LESSON PLANS – GRADE 6

Subject: Mathematics | Grade: 6

Topic 4: Common fractions

Duration: 10 hours | Term 1, Weeks 3 - 5

CAPS Content: NUMBERS, OPERATIONS AND RELATIONSHIPS
1.2 Common fractions
- Describing and ordering fractions: compare and order common fractions
- Calculations with fractions: addition and subtraction of common fractions
- Solving problems
- Percentages: find percentages of whole numbers
- Equivalent forms

Unit 1: What is a fraction?
Unit 2: Fractions by grouping
Unit 3: Equivalent fractions
Unit 4: Compare and order fractions
Unit 5: Add and subtract fractions
Unit 6: Solve problems with fractions

LEARNING ACTIVITY	TEACHING METHODS / APPROACH	RESOURCES
LESSON 1: Unit 1: What is a fraction?	Duration: 120 minutes • This lesson focuses on revision of common fractions and the terminology involved. • Use many different shapes as you do this work, so that the learners don't only think of fractions in terms of only circles or rectangles. • Time must be spent emphasising the significance of the denominator and the numerator. • Be sure to incorporate examples of fractions used in daily life. Mental Maths 10 minutes (TG page 180) Exercise 4.1& 4.2 (LB pages 18 – 19) Incorporate the exercises in the DBOE Workbook Term 1 and 2 (page 28)	Platinum Mathematics Grade 6 Learner's Book and Teacher's Guide DBOE Mathematics Grade 6 Workbook Term 1 and 2 Fraction strips, Cuisenaire rods, fraction pieces, fraction number lines, different fraction shapes, counters, buttons, fraction wall
LESSON 2: Unit 2: Fractions by grouping	Duration: 120 minutes • Spend time using apparatus to divide objects up into equal groups. • Discuss how to share out the objects left over. Mental Maths 10 minutes (TG page 180) Exercise 4.3 – 4.5 (LB pages 20 - 21) Incorporate the exercises in the DBOE Workbook Term 1 and 2 (page 30)	
LESSON 3: Unit 3: Equivalent fractions	Duration: 120 minutes • It is crucial that learners understand equivalent fractions before progressing to addition and subtraction with different denominators. • Discuss how the denominator and the numerator are one number, and that it is not possible to change part of a number. • Keep referring the learners to the fraction wall in this lesson. Mental Maths (TG page 180) Exercise 4.6 – 4.8 (LB pages 22 - 23) Incorporate the exercises in DOE Workbook Term 1 and 2 (page 32)	
LESSON 4: Unit 4: Compare and order fractions	Duration: 60 minutes • Explain that before fractions can be compared or ordered, the denominators have to be the same. Mental Maths (TG page 180) Exercise 4.9 (LB page 24) Incorporate the exercises in the DBOE Workbook Term 1 and 2 (page 88)	
LESSON 5: Add and subtract fractions	Duration: 120 minutes • Revise Grade 5 work. Mental Maths (TG page 180) Exercise 4.10 (LB page 25) Incorporate the exercises in the DBOE Workbook Term 1 and 2 (page 90)	
LESSON 6: Solve problems with fractions	Duration: 60 minutes • Insist on an open number sentence, that all the workings are shown and that they conclude with an answer sentence. Mental Maths (TG page 180) Exercise 4.11 (LB page 26) Incorporate the exercises in the DBOE Workbook Term 1 and 2 (page 92)	
Revision: Topics: 3 - 4	Duration: 30 minutes TG page: 21	

FORMAL ASSESSMENT TASK 60 Minutes

Assignment – Different number systems
TG page: 21

Figure 8: Grade 6 lesson plan 1

It is like a cooking recipe – teachers do not have any say. This calls for curriculum leaders, including curriculum developers and facilitators, to work hand-in-hand with all stakeholders, starting at grassroots level with the teachers to reform the curriculum. If the foundation of the house is not strong, it will certainly collapse. If teachers are excluded during crucial matters and then requested to implement what is finalised in their absence, they will not be interested. If they notice minor mistakes, they will not be interested in editing the errors. Inclusion is essential to ensure that the use of technology during teaching and learning is not only prescribed but integrated into the curriculum to provide quality education for twenty-first century learners. Technological tools such as Mathletics also ensure that learner activities are varied to meet the learning needs of all learners, regardless of their learning and physical abilities. It

enables teachers to be proactive in promoting a learner-centred constructivist approach (McKeown, 2015). Where Mathletics is used, various international scholars state that learners take control of their learning and that participation and interest in learning mathematics is improved.

4.7 SUMMARY OF THE CHAPTER

In Chapter 4, the responses of the veteran primary school mathematics teachers to the semi-structured interview questions were aligned with the themes identified in this study and the conceptual framework. The emerging findings were compared with the literature review and the conceptual framework.

Chapter 5 presents the summary of the findings. Conclusions are drawn and future recommendations based on this study are made. I also suggest avenues for possible future research on the topic.

CHAPTER 5 SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

Chapter 5 gives an in-depth summary of the research findings in the form of themes that are aligned with the research questions and the conceptual framework. The findings are discussed in relation to the reviewed literature on the topic. The study investigated the professional readiness of veteran primary school mathematics teachers with the intent to equip them with the necessary contemporary skills to use Mathletics during teaching and learning. This was done through a PAR approach. Previous research has shown that very few articles about the use of Mathletics during teaching and learning have been published due to teachers' limited acquisition in this area (Muir, 2014). Previous literature focused more on explaining the theoretical part of Mathletics, instead of analysing its practicability in terms of assisting teachers to implement Mathletics.

In recent years, the inadequacy of veteran primary school teachers in applying Mathletics and other online teaching and learning programmes has been a major concern (McKeown, 2015). According to Nansen et al. (2012), the inability of teachers to use Mathletics has contributed to the poor learner performance in mathematics. With the increased use of technology in education nationwide, it is evident that schools all over the country are utilising technology for teaching and learning purposes (Wachira & Keengwe, 2011). For teachers to positively contribute to the current and future education environment, they should be digitally literate and able to effectively use technology during teaching and learning and be willing to be active agents of change by improving the quality of teaching and learning (Voogt, Erstad et al., 2013). Building on this, it is important to develop teachers to gain an understanding of how to effectively use technological programmes such as Mathletics and other online learning programmes during teaching and learning. This must be done in ways that will enable learners to construct meaningful and connected knowledge based on the constructivist

and connectivist learning and teaching methods; learners must be able to link what is taught at school with real-life context for them to internalise what is learnt (Ertmer & Ottenbreit-Leftwich, 2010).

The participants in this study were veteran primary school mathematics teachers who had been teaching mathematics at a primary school for at least 15 years in Tshwane South District (D4) Circuit 2, Gauteng, South Africa. Data were collected through a semi-structured interview and participant observation with two of the participants, for which they declined to be videotaped. However, I was given permission to observe them during teaching and learning; they allowed me to check their preparation portfolios and they explained all the content inside their portfolios.

5.2 SUMMARY OF THE RESEARCH FINDINGS

The summary of the research findings is based on the four themes identified and the conceptual framework, which answered the research questions. The themes are discussed in relation to the literature on the research topic and the conceptual framework of this study. The research questions were as follows:

PRIMARY RESEARCH QUESTION

- ***Which mode of continuing professional development should veteran primary school mathematics teachers use to improve their understanding of Mathletics?***

The above question was answered with the data from the interview and participant observations. This research supported the reality that technology has tremendously affected our society, traditions, culture and education system (Greenhow & Lewin, 2016). The findings indicate that learning is no longer isolated; it is now diverse. However, it requires the collective participation of different education stakeholders on various levels because we are living and working with an influx of information that requires critical thinking skills and the ability to analyse the information. It is therefore necessary for people to network to share the load (Greenhow & Lewin, 2016).

New technological teaching resources, methods and programmes are being introduced but teachers, especially veteran teachers, are only partially prepared to integrate and implement these new changes in education. The literature shows that the majority of veteran teachers lack technological skills and knowledge because, during their in-service training in the educational colleges, technology was not the primary resource, compared with contemporary teaching and learning (Kariuki, 2009). Teachers must actively participate and contribute to PLC meetings, in-house team-building meetings, peer teaching, hands-on demonstrations in peer mentoring and establishing professional relationships with their colleagues from the same and different schools or in the same and different phases.

SECONDARY RESEARCH QUESTIONS

- ***Which professional initiatives can veteran mathematics teachers implement to improve their teaching practice in the twenty-first century?***

It was hypothesised by the participants that the best PD initiatives to assist veteran primary school mathematics teachers are to actively engage in a CPD that is solely based on teamwork and that will promote the participation of every teacher. The majority of the participants supported the view that teachers must be their own facilitators and take full responsibility for their professional readiness by engaging in peer mentoring and collaborating with their colleagues in a CLP. This will allow them to gain confidence and be able to apply newly trending teaching methods, resources and programmes. This research indicates that teachers need to engage in ongoing PD that will enable them to stay relevant (Matthews et al., 2018). Teachers' networking will allow them to understand and learn from the perspective of others who reciprocally share similar experiences. They will also be able to construct high-quality schema where all involved individuals exchange and share ideas in a fair and professional approach that will benefit all the involved teachers. They will also be able to reflect on their teaching practice and share teaching resources (Powell & Kalina, 2009). PD initiatives should enable teachers to plan the curriculum daily with a creative mindset, set achievable and realistic learning goals for learners and ensure that learning outcomes and objectives are achieved. Again, teachers must be able to create conducive learning environments by employing effective, inclusive classroom

management skills and learning to use technology to differentiate the curriculum, which will respond to various learners' needs, as stipulated in White Paper 6 that no child must be left behind regardless of their learning abilities, socio-economic status, and geographic settlement, Physical ability, racial group or religious group (MacManus, 2018). The preferred professional initiatives that were recommended by the participants are as follows:

I. Functional PLC or CLP with lead teachers appointed by teachers to supervise, facilitate, monitor and provide support to ensure that teachers acquire adequate support that will enable them to provide quality teaching and learning.
II. Workshops that link theory with practice and are based on the school curriculum that promotes practical activities, welcomes teachers' contributions and take place at a convenient time for teachers – not on Saturdays as is currently the case.
III. Teachers who teach the same subject, grade and phase must engage in peer teaching and mentoring; they can also share teaching and learning resources and methods.
IV. Teachers who teach the same subject, grade and phase must establish accessible communication, such as creating a WhatsApp group, Facebook group and SMS, and ensure that there is a smooth channel where they contact each other for work-related purposes and information sharing.
V. Teachers, together with their SMTs, must establish friendships by networking with staff members from nearby schools through which they can borrow and share learning and teaching resources.
VI. Veteran and beginner teachers must work together within or outside their schools; this will allow them to learn from each other reciprocally. For example, beginner teachers might share their technological knowledge and their newly acquired teaching methods from institutions of higher learning, while veteran teachers share their classroom management skills, discipline and other practices from their long service. This could benefit both groups (Semerci & Batdi, 2015).

- ***What can be done to ensure successful PD for veteran mathematics primary school teachers?***

The one-size-fits-all traditional approach that is normally utilised in workshops where facilitators talk, talk, talk and talk without engaging teachers in practical tasks does not yield any positive outcome because teachers have different needs in terms of the PCK of subjects they teach and are working in different contextual settings. For example, one teacher might struggle with assigning tasks to learners using Mathletics, while other teachers might struggle with identifying learners' progress via Mathletics; some teachers might lack teaching and learning resources as articulated by my participants earlier on. Thus, PD initiatives need to unpack all the challenges that teachers face and address them individually using PAR, where local solutions are implemented to solve local challenges and teachers facing local challenges take full responsibility during the decision-making process, and offer pragmatic, realistic effective solutions to the challenge that is faced.

Effective PD should be conducted through modern methods that are constructivist and connectivist-centred to be aligned with twenty-first century education standards that will enable teachers to apply what they acquire in the PD initiatives to their everyday teaching and learning. It will maximise the learning potential of learners and improve the quality of education that will prepare learners for the employment after completing Grade 12. Whether they go straight to work or enrol in the institutions of higher learning, they must have the necessary skills from primary and secondary schooling. This enables teachers to focus on real, contextual practice to improve their teaching practice and sharing methods through teamwork among staff members at the department, grade and school levels (Desimone, 2009; Kriek & Grayson, 2009; Bellibas & Gumus, 2016; Desimone et al., 2002; Du Toit, 2013). Effective PD entails the deliberate assessment of reflection and feedback on practices.

- ***How can Mathletics be applied in the professional development processes of veteran primary school mathematics teachers in South Africa?***

In the twenty-first century, technological transformations are affecting how we live, work, learn, and access and use information (Voogt, Erstad et al., 2013). In today's world, certain competencies are needed for an individual to be productive and contribute effectively to the world economy, such as problem-solving, collaboration, communication, utilising technology to access and share local and global information (Klinger, 2011). However, these twenty-first century competencies are not well implemented in the education sector; they are only talked about in terms of theory, but they are not put into practice. Competencies needed in the modern world include digital literacy, productivity, adaptability, teamwork, literacy, numeracy, curiosity, critical thinking and problem-solving skills. These imply that there is a need to learn and continue to learn; hence, scholars contend that lifelong learning is a powerful key that opens the doors to the modern world (Du Toit, 2013).

The school curriculum, CAPS, should comprise twenty-first century competencies to prepare and equip learners with necessary skills and knowledge for them to be able to compete and participate effectively in Fourth Industrial Revolution workplaces. The same applies to teachers; they must be adequately developed for them to be able to apply and integrate technology resources and programmes into their daily teaching and learning processes (Mishra & Mehta, 2017). Collaborating with universities is critical to ensure that teachers stay abreast of the current teaching methods and acquire new ideas, knowledge, skills and practices concerning technology integration during teaching and learning. Ono and Ferreira (2010a) expound that human brains search for meaning, patterns and connections. Thus, current PD initiatives need to be based on constructivist and connectivist teaching and learning – this will promote learner participation, knowledge creation by learners, practical and applicable assessments of knowledge to the everyday life of learners and community-based learning – and should directly link to the school context. Learners must be equipped with relevant and quality education that will enable them to compete and perform well both on national and international standardised tests, such as the Mathematics Olympiad at school, cluster, district, provincial and national level, and the ANA and NBT.

5.3 RECOMMENDATIONS

The following recommendations are based on the findings of this study.

- Technology is now being used as a fundamental resource for teaching and learning. However, most teachers, especially veteran teachers, have limited skills and knowledge for applying and utilising technological tools during teaching and learning. This greatly affects the performance of learners, especially when they are writing standardised tests that are set outside the school environment, such as the mathematics Olympiads, ANA and NBT tests, because such standardised tests are of a high standard, moderated and set by mathematics specialists. To mitigate the current status in South Africa, the Department of Basic Education must develop the PCK of the facilitators and they must be adequately prepared to use technology resources so that it will be easy for them to utilise technological teaching and learning resources. They must lead by example as they are the curriculum leaders.

- The role of the facilitators is to manage, support and lead teachers regarding the curriculum, but the talk show is over; now they must promote hands-on tasks and demonstrations in workshops.
- Teachers must be actively involved in the process of curriculum development as contributors and creators, not as recipients of the curriculum, because they have daily, direct contact with learners and know the learning needs of the learners and the contextual shortfalls of their schools.
- Because the curriculum has been transforming very fast, moving from outcomes-based education to the national curriculum statement and finally CAPS, teachers must be prepared to effectively respond to these curriculum changes. It does not yield any positive outcome to decorate and transform the curriculum while teachers have no idea of how to implement the curriculum during teaching and learning.
- PD initiatives must provide ample time for teachers to reflect on what they learnt during workshops and put their learning into practice during teaching and learning to thoroughly observe and reflect (Joubert et al., 2009).

- Moreover, these initiatives must address the inability and incompetency of teachers with regard to the curriculum and curriculum differentiation, using various teaching and learning resources and classroom management, because the current millennium generation of learners is entirely different due to their technological exposure. The PD initiatives must assist in mitigating the current situation in education (Steyn, 2008).

- Teachers need to keep abreast of various learning theories so that they can be more effective and knowledgeable about paradigm shifts and can apply the relevant learning theories. This will create optimum learning during teaching and learning (Sandars et al., 2015). However, this can only be achieved if facilitators can emphasise these learning theories during workshops and implement them in the curriculum.
- Teachers must be considered as partners in decision-making in any improvements or changes about any matters pertaining to education, such as educational policies, curriculum matters, teaching methods and resources. In this way, teachers would effectively and efficiently comply with and integrate any changes agreed upon because they were involved during the decision-making process (Milondzo & Gumbi, 2011).
- School principals, together with their SMTs, HoDs, SGBs and grade leaders, as the management of the schools, should encourage teachers to upskill and engage in PD initiatives. School principals must provide time for CLPs among teachers and ensure that teachers attend workshops and share the information acquired.
- The SMT must identify the learning and teaching needs of the school together with the teachers through a participatory approach and every teacher must be consulted. Thereafter, the SGB must ensure that they fully participate for the success of the process of identifying and ordering the school's needs.
- Schools must have School Improvement Plan (SIP) meetings at least once per quarter, and during the SIP meetings they must also share good teaching practices, resources and methods so that they can learn from each other. Whatever is discussed in the SIP meetings must be implemented; the meetings must not be just a talk show. For every decision they agree upon, there must be

a time frame when it must be completed and achieved and who must complete it. SMTs, HoDs and grade leaders must monitor, guide, support and lead their subordinates to achieve their plans.

- Schools must have departmental or phase meetings more often where they share their progress and shortfalls as a department and together develop their plan of action, and they must put their action plans into practice.
- Veteran teachers and beginner teachers must work together and engage in peer mentoring where they share their teaching methods, resources, classroom management skills and teaching experiences that can lead to the development of the school and learner achievement. Teachers must collectively practise and implement what they learn in their CLPs with their learners.
- Teachers must take charge of their own PD by engaging in self-directed learning. Teachers should identify areas where they lack knowledge and engage in a personal professional plan where they can engage and share information with knowledgeable colleagues, attend PLC meetings, workshops or enrol for short courses that will upskill their PCK.
- Self-reflection is an essential tool for teachers; it is the greatest mechanism that one can implement to assess and analyse the progress of self-directed learning and CPD, yielding positive output to the teaching and learning progress by determining areas of weakness and acting upon them.

5.4 FUTURE RESEARCH

This research study focused on the know-how of the Mathletics programme during teaching and learning by veteran mathematics teachers in primary schools. This research has shown that most schools lack basic teaching and learning resources, such as textbooks. Learners are still sharing textbooks and have not progressed to technological teaching and learning resources. However, we know that technological teaching and learning resources are building blocks for ensuring that twenty-first century education takes place effectively by making sure that required programmes such as Mathletics and any other online programmes are effectively implemented. Based on the constructivist and connectivist learning theories, twenty-first century teachers must be effective facilitators of learning with the ability to integrate different

technological teaching and learning methods, resources and programmes. The aim should be to empower learners to become actively engaged, reflect during the learning process, be willing to learn more by asking questions. They should be prepared for the workplaces of the Fourth Industrial Revolution (Day & Gu, 2009). Further research should be carried out to find out what can be done to implement Mathletics and other online teaching and learning programmes for mathematics as a subject in primary schools where technological teaching and learning resources are scarce and teachers' knowledge and skills are limited. Further research should also look at:

- How veteran mathematics teachers can acquire an interest in technology to participate effectively in the digital world of teaching and learning.
- How veteran mathematics teachers can restore their professional identity and confidence in twenty-first century classrooms.
- How curriculum developers can involve teachers in curriculum matters such as the development and restructuring of the curriculum.
- What can be done by the DBE to ensure that CPD for mathematics teachers promotes active learning and collective participation of the teachers and that it becomes technologically based.
- How to develop and improve the PCK of teachers to improve the quality of teaching and learning in South African schools.
- How to ensure that CLP become functional and yield positive outcomes to the teaching practice of the teachers by encouraging teachers to support, guide and monitor each other in their CLP.

5.5 CONCLUSION

South Africa is one of the richest countries In Africa in terms of infrastructure, including educational infrastructures. Most of the higher-ranking institutions of learning, like the University of Pretoria, University of Johannesburg, University of Cape Town and the University of the Witwatersrand attract international students, because they have sufficient teaching and learning resources. However, in secondary and primary schools, particularly in public institutions, we have limited teaching and learning resources. It is evident that the DBE is trying to improve teaching and learning

resources, particularly in Gauteng. The MEC of education in Gauteng opened a school in Nigel where hard copies of lesson notes and books are no longer used, only e-textbooks, interactive boards and projectors. However, the quality of education remains poor due to teachers' inadequate pedagogical readiness for implementing those technological resources. In South Africa, we are still experiencing a huge gap in basic teaching and learning resources in pubic schools. As a result, most of the schools where I collected data use their computer centres to store feeding scheme stocks rather than computers; they simply do not have computers. On the other side, some schools have so few computers that they decided not to use them during teaching and learning. In their overcrowded classrooms, there are not enough computers for learners, even if they try to share. The participants in the study also admitted that even if they did have computers, they were not knowledgeable enough to use them during teaching and learning. Research shows that although South Africa is trying to meet the challenges in education, the decline in mathematics performance has remained a tremendous challenge over the past decade. It is exacerbated by the rigid curriculum and the GPLMS that is used as the daily guideline for teaching and learning and provides lesson plans and activities (De Clercq, 2014).

From the collected data, it can be seen that behind this poor performance in mathematics lie numerous challenges that are often not considered or taken seriously; for example, overcrowded classrooms, lack of parental involvement, unruly learners, households headed by learners, learners from informal settlements where there is no discipline, learners who are already gang members, lack of role models in their communities, learners not interested in their education and schools that are no longer safe for either learners or teachers. It obviously affects the progress of teaching and learning, because teachers spend more time disciplining learners and doing other tasks instead of teaching. Participants have found that workshop facilitators focused on theory rather than practice and that there is minimal support, guidance, monitoring and mentoring for teachers. Teachers have minimal teaching and learning time because they are overburdened by paperwork, such as marking informal and formal tasks, preparing educators' portfolios, writing lesson plans and engaging in extra-mural activities. This is often done with minimal support from colleagues and minimal teaching and learning resources, including technological teaching resources. This

remains a challenge in public schools. Moreover, rapid curriculum transformations have left veteran teachers behind, without adequate support or assistance.

A worrying finding from the collected data shows that the majority of the participating veteran teachers were not fully prepared in terms of skills, resources and methods to effectively respond to all these recent technological transformations in the classroom. Therefore, this clearly shows that more PD initiatives for veteran primary school mathematics teachers should be harnessed to ensure that active learning and collective participation of teachers is maximal. Again, the coherence and content of the subject matter must be aligned with a realistic time allocation for teachers to master the content (Mohyuddin & Khalil, 2016). PD initiatives should blend theory and practice. Thus, more practical tasks, hands-on learning, clear assessments and learning resources must be afforded to teachers. For PD to be successful, these resources should be accessible anytime and anywhere. Integrating technology into workshops and in PLCs is therefore critical.

From the collected data, it is clear that the majority of veteran primary school mathematics teachers prefer PLCs as the best mode of CPD to enhance the professional status of veteran primary school mathematics teachers. This will further assist them to acquire the relevant and contemporary skills of using Mathletics during teaching and learning (Tam, 2015). The concept of a PLC has become key in the government's national policy agenda for teachers' PD (Epstein et al., 2018). In Gauteng, PLCs have been introduced in some districts, including the Tshwane South and the Tshwane North districts. Facilitators are working tirelessly to ensure that PLCs become functional and serve their purpose. PLCs consist of teachers working together in subject-based groups, focusing on a grade or phase, to share experiences, knowledge, techniques and insights. This could improve teaching practices, learner achievement and teachers' readiness in the subject that they teach (Jensen, Sonnemann, Roberts-Hull & Hunter, 2016). These communities are intended to improve the professional status of in-service teachers by addressing the challenges that they face in the classroom. These include collaborative teaching, methodology, assessment and CK. Focused and effective implementation of a PLC can bring veteran and beginner teachers together to share their classroom management skills while learning about the new media-driven approaches that appeal to twenty-first

century learners. As a result, both groups of teachers will benefit from PLCs (R & Goldman, 2016).

LIST OF REFERENCES

Adler, J. (2017). Mathematics in mathematics education. *South African Journal of Science, 113*(3-4), 1-3.

Aina, J. K., & Philip, Y. J. (2013). Imperative of environment in science learning. *Open Science Journal of Education, 1*(1), 1-6.

Amineh, R. J., & Asl, H. D. (2015). Review of constructivism and social constructivism. *Journal of Social Sciences, Literature and Languages, 1*(1), 9-16.

Anderson, T. (2016). Theories for learning with emerging technologies. *Emergence and innovation in digital learning: Foundations and applications*, 35-50.

Anney, V. N. (2014). Ensuring the quality of the findings of qualitative research: Looking at trustworthiness criteria. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS)*, *5*(2), 272-281.

Archibald, S., Coggshall, J. G., Croft, A., & Goe, L. (2011). High-quality professional development for all Teachers: Effectively allocating resources. Research and policy brief. National Comprehensive Center for Teacher Quality. *Washington, DC 20007.*

Attard, C. (2016). Research evaluation of matific mathematics learning resources. Project report. Western Sydney University. Penrith, N.S.W.

Attwell, G., & Hughes, J. (2010). Pedagogic approaches to using technology for learning: Literature review. *Lifelong Learning UK*.

Back, J., Hirst, C., De Geest, E., Joubert, M., & Suterland, R. (2009). researching effective CPD in mathematics education (RECME).

Bada, S. O., & Olusegun, S. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research and Method in Education, 5*(6), 66-70.

Barak, M. (2017). Science teacher education in the twenty-first century: A pedagogical framework for technology-integrated social constructivism. *Research in Science Education, 47*(2), 283-303.

Bate, F. (2010). A bridge too far? Explaining beginning teachers' use of ICT in Australian schools. *Australasian Journal of Educational Technology, 26*(7), 1042-1061.

Bell, F. (2011). Connectivism: Its place in theory-informed research and innovation in technology-enabled learning. *The International Review of Research in Open and Distributed Learning, 12*(3), 98-118.

Gumus, E., & Bellibas, M. S. (2016). The effects of professional development activities on principals' perceived instructional leadership practices: Multi-country data analysis using TALIS 2013. *Educational Studies*, *42*(3), 287-301.

Berger, R. (2015). Now I see it, now I don't: Researcher's position and reflexivity in qualitative research. *Qualitative Research, 15*(2), 219-234.

Berry, M. D. (2016). *The Effect of the Mathletics.com Technology on Basic Multiplication Fact Fluency*: Wilkes University.ProQuest Dissertations Publishing.

Bietenbeck, J., Piopiunik, M., & Wiederhold, S. (2018). Africa's skill tragedy: Does teachers' lack of knowledge lead to low student performance? *Journal of Human Resources, 53*(3), 553-578.

Blake, B. (2015). Developmental psychology: Incorporating Piaget's and Vygotsky's theories in classrooms. *Journal of Cross-Disciplinary Perspectives in Education*,1(1), 59-67.

Bold, T., Filmer, D., Martin, G., Molinad, E., Rockmore, C., Stacy, B., Svensson, J., & Wane, W. (2017). What do teachers know and do? Does it matter? Evidence from primary schools in Africa. *World Bank Group Publications*. Policy Research Working Papers.

Boonk, L., Gijselaers, H. J., Ritzen, H., & Brand-Gruwel, S. (2018). A review of the relationship between parental involvement indicators and academic achievement. *Educational Research Review, 24,* 10-30.

Bray, A., & Tangney, B. (2016). Enhancing student engagement through the affordances of mobile technology: a twenty-first century learning perspective on Realistic Mathematics Education. *Mathematics Education Research Journal, 28*(1), 173-197.

Bricki, N., & Green, J. (2007). A guide to using qualitative research methodology. *Medecins Sans Frontieres.*

Bryant, J., & Bates, A. J. (2015). Creating a constructivist online instructional environment. *TechTrends, 59*(2), 17-22.

Bryceson, K. (2007). The online learning environment – a new model using social constructivism and the concept of ‘Ba’as a theoretical framework. *Learning Environments Research*, *10*(3), 189-206.

Bryman, A. (2017). Quantitative and qualitative research: Further reflections on their integration. *Mixing methods: Qualitative and Quantitative Research* (pp. 57-78): Routledge.

Budd, C. J. (2015). Promoting maths to the general public. *The Oxford Handbook of Numerical Cognition*, 1, 3-16.

Burghes, D. (2011). International comparative study in mathematics teacher training. *Reading: CfBT Education Trust*.

Bush, T., Joubert, R., Kiggundu, E., & Van Rooyen, J. (2010). Managing teaching and learning in South African schools. *International Journal of Educational Development, 30*(2), 162-168.

Carnoy, M., Chisholm, L., & Baloyi, H. (2008). Uprooting bad mathematical performance: Pilot study into roots of problems. *Human Sciences Research Council*, 6(2), 13-14.

Carrillo, C., & Flores, M. A. (2018). Veteran teachers’ identity: What does the research literature tell us? *Cambridge Journal of Education, 48*(5), 639-656.

Chai, C. S., Koh, J. H. L., Tsai, C. C., & Tan, L. L. W. (2011). Modeling primary school pre-service teachers’ Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers and Education, 57*(1), 1184-1193.

Cobb, P. (1994). Where is the mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher*, *23*(7), 13-20.

Coghlan, D., & Brannick, T. (2014). Understanding action research. *Doing action research in your own organization*, 43-62.

Collins, A., & Halverson, R. (2018). *Rethinking Education in the Age of Technology: The Digital Revolution and Schooling in America. Columbia University:* Teachers College Press.

Colvin, J. W., & Ashman, M. (2010). Roles, risks, and benefits of peer mentoring relationships in higher education. *Mentoring and Tutoring: Partnership in Learning*, *18*(2), 121-134.

Condie, R., & Livingston, K. (2007). Blending online learning with traditional approaches: changing practices. *British Journal of Educational Technology, 38*(2), 337-348.

Connelly, L. M. (2016). Trustworthiness in qualitative research. *Medsurg Nursing, 25*(6), 435-437.

Cooper, J., & Arcavi, A. (2018). Mathematicians and primary school teachers learning from each other. *EMS Newsletter, 3*(107), 46-51.

Cross, D. I. (2009). Alignment, cohesion and change: Examining mathematics teachers' belief structures and their influence on instructional practices. *Journal of Mathematics Teacher Education, 12*(5), 325-346.

Dabner, N., Davis, N., & Zaka, P. (2012). Authentic project-based design of professional development for teachers studying online and blended teaching. *Contemporary Issues in Technology and Teacher Education, 12*(1), 71-114.

Dale, M. (2016). *The Acquisition of the Language of Mathematics.* Pretoria: University of Pretoria.

Darling-Hammond, L., Amrein-Beardsley, A., Haertel, E., & Rothstein, J. (2012). Evaluating teacher evaluation. *Phi Delta Kappan, 93*(6), 8-15.

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). Effective teacher professional development. Palo Alto, CA: Learning Policy Institute.

Darling-Hammond, L., & McLaughlin, M. W. (2011). Policies that support professional development in an era of reform. *Phi delta Kappan, 92*(6), 81-92.

Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional Learning in the Learning Profession.* Washington, DC: National Staff Development Council, 12.

Davids, N. (2017). On the un-becoming of measurement in education. *Educational Philosophy and Theory, 49*(4), 422-433.

Day, C., & Gu, Q. (2009). Veteran teachers: Commitment, resilience and quality retention. *Teachers and Teaching: Theory and Practice, 15*(4), 441-457.

De Clercq, F. (2014). Improving teachers' practice in poorly performing primary schools: The trial of the GPLMS intervention in Gauteng. *Education as Change, 18*(2), 303-318.

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

Desimone, L. M., & Pak, K. (2017). Instructional coaching as high-quality professional development. *Theory into Practice, 56*(1), 3-12.

Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S., & Birman, B. F. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis, 24*(2), 81-112.

DiPaola, M., & Wagner, C. A. (2018). *Improving Instruction through Supervision, Evaluation and Professional Development. 2nd ed*. Information Age Publishing, Charlotte North Carolina.1- 405.

Dole, S., Bloom, L., & Kowalske, K. (2016). Transforming pedagogy: Changing perspectives from teacher-centred to learner-centred. *Interdisciplinary Journal of Problem-Based Learning, 10*(1), 1.

Dunaway, M. (2011). Connectivism: Learning theory and pedagogical practice for networked information landscapes. *Reference Services Review, 39*(4), 675-685.

Du Toit, P. H. (2012). Using action research as process for sustaining knowledge production: A case study of a higher education qualification for academics. *South African Journal of Higher Education, 26*(6), 1216-1233.

Du Toit, P. H. (2013). Social transformation starts with the self: An autobiographical perspective on the thinking style preferences of an educator. *South African Journal of Education, 33*(4), 1-12.

Du Toit, P. H. (2014). An auto-ethnographic lens on lecturer professional development. *Good Practice in Culture-rich Classrooms: Research-informed Perspectives*, 254-279.

Du Toit, P. (2018a). A meta-reflection on my emerging as a scholar of action research. *South African Journal of Higher Education, 32*(6), 425-439.

Du Toit, P. (2018b). Self-enquiry as an intrapersonal means to promoting scholarship of professional development: Our quest for new meaning making. *South African Journal of Higher Education, 32*(6), 422-424.

Du Toit, P.H., Bothma, T., & De Boer, A.-L. (2015). Activating Whole Brain® innovation: A means of nourishing multiple intelligence in higher education. *TD: The Journal for Transdisciplinary Research in Southern Africa, 11*(2), 55-72.

Dunn, J., Gray, C., Moffett, P., & Mitchell, D. (2018). 'It's more fun than doing work': children's perspectives on using tablet computers in the early years of school. *Early Child Development and Care, 188*(6), 819-831.

Education, GDE. (2012). GPLMS coaches manual: GDE Johannesburg.

Eickelmann, B., Drossel, K., Wendt, H., & Bos, W. (2012). *ICT-use in primary schools and children's mathematics achievement – a multi-level approach to compare educational systems through an international lens with TIMSS data.* Paper presented at the Joint AARE APERA International Conference, WERA focal meeting, Sydney.

Epstein, J., Sanders, M., Sheldon, S., Simon, B., Salinas, K., Jansorn, N. Van Voorhis, F, Martin, S., Thomas, B., Marsha, D., Greenfeld, M., Hutchins, D., & Williams, K., (2018). *School, Family, and Community Partnerships: Your Handbook for Action.* Routledge: Corwin Press.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education, 42*(3), 255-284.

Esau, O. (2015). Developing academic and community research participation in a South African township and rural Community. *Educational Research for Social Change, 4*(1), 68.

Fletcher, M. A., Zuber-Skerritt, O., Bartlett, B., Albertyn, R., & Kearney, J. (2010). Meta-action research on a leadership development program: A process model for life-long learning. *Systemic Practice and Action Research, 23*(6), 487-507.

Frederiksen, L. L. (2015). Group Mentoring: A Way to Retain ""High-Risk" Teachers on the Job. *Journal of the European Teacher Education Network, 10*, 110-119.

Friedman, V. J., & Rogers, T. (2009). There is nothing so theoretical as good action research. *Action Research*, *7*(1), 31-47.

Gajjar, D. (2013). Ethical consideration in research. *Education, 2*(7).

Gasser, K. W. (2011). Five ideas for twenty-first century math classrooms. *American Secondary Education*, 39(3), 108-116.

Geary, D. C. (2011). Consequences, characteristics, and causes of mathematical learning disabilities and persistent low achievement in mathematics. *Journal of Developmental and Behavioral Paediatrics: JDBP, 32*(3), 250-263.

Geldenhuys, J. L., & Oosthuizen, L. C. (2015). Challenges influencing teachers' involvement in continuous professional development: A South African perspective. *Teaching and Teacher Education, 51*, 203-212.

Genlott, A. A., & Grönlund, Å. (2016). Closing the gaps – Improving literacy and mathematics by ICT-enhanced collaboration. *Computers an Education, 99*, 68-80.

Gibbs, G. R. (2018). *Analyzing Qualitative Data* (Vol. 6): City: Sage.

Gilakjani, A. P. (2012). A match or mismatch between learning styles of the learners and teaching styles of the teachers. *International Journal of Modern Education and Computer Science, 4*(11), 51-60.

Goldie, J. G. S. (2016). Connectivism: A knowledge learning theory for the digital age? *Medical Teacher, 38*(10), 1064-1069.

Goos, M. (2010). *Using Technology to support effective mathematics teaching and learning: What counts? Research paper.*

Green, J., & Thorogood, N. (2018). *Qualitative Methods for Health Research*: Sage.

Green, L., & Condy, J. (2016). Philosophical enquiry as a pedagogical tool to implement the CAPS curriculum: Final-year pre-service teachers' perceptions. *South African Journal of Education, 36*(1), 1-8.

Greenhow, C., & Lewin, C. (2016). Social media and education: Reconceptualizing the boundaries of formal and informal learning. *Learning, Media and Technology, 41*(1), 6-30.

Hallam, P. R., Smith, H. R., Hite, J. M., Hite, S. J., & Wilcox, B. R. (2015). Trust and collaboration in PLC teams: Teacher relationships, principal support, and collaborative benefits. *NASSP Bulletin, 99*(3), 193-216.

Haylock, D., & Manning, R. (2014). *Mathematics Explained for Primary Teachers.* Sage.

Henriksen, D., Mishra, P., & Fisser, P. (2016). Infusing creativity and technology in twenty-first century education: A systemic view for change. *Journal of Educational Technology and Society, 19*(3), 27-37.

Hien, T. T. T. (2016). Why is action research suitable for education? *VNU Journal of Science: Foreign Studies, 25*(2), 97-106.

Hilton, A. (2018). Engaging Primary School Students in Mathematics: Can iPads Make a Difference? *International Journal of Science and Mathematics Education, 16*(1), 145-165.

Hoyles, C., & Lagrange, J.-B. (2010). *Mathematics Education and Technology: Rethinking the Terrain. New York NY*: Springer.

Hunkins, F. P., & Ornstein, A. C. (2016). *Curriculum: Foundations, principles, and issues*. Pearson Education.

Hwang, G.-J., Lai, C.-L., & Wang, S.-Y. (2015). Seamless flipped learning: A mobile technology-enhanced flipped classroom with effective learning strategies. *Journal of Computers in Education, 2*(4), 449-473.

Inan, F. A., & Lowther, D. L. (2010). Factors affecting technology integration in K-12 classrooms: A path model. *Educational Technology Research and Development, 58*(2), 137-154.

IstenicStarčič, A., Cotic, M., Solomonides, I., & Volk, M. (2016). Engaging preservice primary and pre-primary school teachers in digital storytelling for the teaching and learning of mathematics. *British Journal of Educational Technology, 47*(1), 29-50.

Jacob, S. A., & Furgerson, S. P. (2012). Writing interview protocols and conducting interviews: Tips for students new to the field of qualitative research. *The Qualitative Report, 17*(42), 1-10.

Jensen, B., Roberts-Hull, K., Magee, J., & Ginnivan, L. (2016). *Not So Elementary: Primary School Teacher Quality in Top-Performing Systems*. National Center on Education and the Economy.

Jensen, B., Sonnemann, J., Roberts-Hull, K., & Hunter, A. (2016). *Beyond PD: Teacher Professional Learning in High-Performing Systems. Teacher Quality Systems in Top Performing Countries*. National Center on Education and the Economy.

Jorgensen, D. L. (2015). Participant observation. *Emerging trends in the social and behavioral sciences: An interdisciplinary, searchable, and linkable resource*, 1-15.

Jorgensen, R., & Dole, S. (2011). *Teaching mathematics in primary schools.* Crow's Nest, NSW: Allen & Unwin.

Kafyulilo, A., Fisser, P., & Voogt, J. (2016). Teacher design in teams as a professional development arrangement for developing technology integration knowledge and skills of science teachers in Tanzania. *Education and Information Technologies, 21*(2), 301-318.

Kariuki, C. (2009). Professional development for twenty-first century teachers: Effective classroom management. *Online Submission*.

Kassa, M., & Mulugeta, A. (2015). In-service science and mathematics teachers' perceptions on continuous professional development.

Kegan, R. (2018). What “form” transforms? A constructive-developmental approach to transformative learning. *Contemporary Theories of Learning* (pp. 29-45). Routledge.

Kelly, J., & Cherkowski, S. (2017). Collaboration, collegiality, and collective reflection: A case study of professional development for teachers. *Canadian Journal of Educational Administration and Policy* (169),1-27.

Kennedy, M. M. (2016). How does professional development improve teaching? *Review of Educational Research, 86*(4), 945-980.

Ker, H. (2013). Trend analysis on mathematics achievements: a comparative study using TIMSS data. *Universal Journal of Educational Research, 1*(3), 200-203.

Kereluik, K., Mishra, P., Fahnoe, C., & Terry, L. (2013). What knowledge is of most worth: Teacher knowledge for twenty-first century learning. *Journal of Digital Learning in Teacher Education, 29*(4), 127-140.

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

Khan, A., Ahmad, R., Hamdan, A. R., & Mustaffa, M. S. (2014). Educational encouragement, parenting styles, gender and ethnicity as predictors of academic achievement among special education students. *International Education Studies, 7*(2), 18-24.

Klinger, C. M. (2011). "Connectivism" – A new paradigm for the mathematics anxiety challenge? *Adults Learning Mathematics, 6*(1), 7-19.

Knight, J. (2018). *Coaching: Approaches and Perspectives*. Corwin Press.

Konstantinou-Katzi, P., Tsolaki, E., Meletiou-Mavrotheris, M., & Koutselini, M. (2013). Differentiation of teaching and learning mathematics: An action research study in tertiary education. *International Journal of Mathematical Education in Science and Technology, 44*(3), 332-349.

Kopcha, T. J. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers and Education, 59*(4), 1109-1121.

Körkkö, M., Kyrö-Ämmälä, O., & Turunen, T. (2016). Professional development through reflection in teacher education. *Teaching and Teacher Education, 55*, 198-206.

Korthagen, F. (2017). Inconvenient truths about teacher learning: Towards professional development 3.0. *Teachers and Teaching, 23*(4), 387-405.

Kriek, J., & Grayson, D. (2009). A holistic professional development model for South African physical science teachers. *South African Journal of Education, 29*(2), 185-203.

Lareau, A. (2018). *Journeys through ethnography: Realistic accounts of fieldwork. New York*: Routledge.

Laurillard, D. (2016). The educational problem that MOOCs could solve: Professional development for teachers of disadvantaged students. *Research in Learning Technology, 24*.

Lawless, K. A., & Pellegrino, J. W. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns and ways to pursue better questions and answers. *Review of Educational Research, 77*(4), 575-614.

Letsatsi, S. (2010). *School leadership and teacher professional development in Lesotho: A case study of two secondary schools in Leribe District.*

Letwinsky, K. M., & Berry, M. D. (2017). Technology integration and the effect on mathematics fact fluency in the Middle East. *Journal of International Education and Leadership, 7*(1), n1-14.

Li, L., Worch, E., Zhou, Y., & Aguiton, R. (2015). How and why digital generation teachers use technology in the classroom: An explanatory sequential mixed methods study. *International Journal for the Scholarship of Teaching and Learning, 9*(2), 1-9.

Linder, S. M. (2011). The facilitator's role in elementary mathematics professional development. *Mathematics Teacher Education and Development, 13*(2), 44-66.

Liu, R.-D., Zhen, R., Ding, Y., Liu, Y., Wang, J., Jiang, R., & Xu, L. (2018). Teacher support and math engagement: Roles of academic self-efficacy and positive emotions. *Educational Psychology, 38*(1), 3-16.

Long, C., & Dunne, T. (2014). Approaches to teaching primary level mathematics. *South African Journal of Childhood Education, 4*(2), 134-153.

Lowrie, T., & Jorgensen, R. (2012). Teaching mathematics remotely: Changed practices in distance education. *Mathematics Education Research Journal, 24*(3), 371-383.

Macan, T. (2009). The employment interview: A review of current studies and directions for future research. *Human Resource Management Review, 19*(3), 203-218.

MacDonald, C. (2012). Understanding participatory action research: A qualitative research methodology option. *The Canadian Journal of Action Research, 13*(2), 34-50.

MacManus, S. (2018). *Young v. old: Generational combat in the twenty-first century.* Routledge.Westview Press.

Malone, M. J., & O'Shea, J. (2014). 7 e-Learning and mathematics. *Teaching and Learning with ICT in the Primary School*, 80.

Mansour, N., Heba, E.-D., Alshamrani, S., & Aldahmash, A. (2014). Rethinking the theory and practice of continuing professional development: Science teachers' perspectives. *Research in Science Education, 44*(6), 949-973.

Maree, K. (2007). *First steps in research*. Pretoria: Van Schaik Publishers.

Marton, F. (2018). Towards a pedagogical theory of learning *Deep Active Learning* (pp. 59-77). Springer, Singapore.

Mattar, J. (2018). Constructivism and connectivism in education technology: Active, situated, authentic, experiential, and anchored learning/El constructivismo y el conectivismoentecnologíaeducativa: El aprendizajeactivo, situado, auténtico, experiencial y anclado. *RIED. RevistaIberoamericana de Educación a Distancia, 21*(2).

Matthews, K. E., Cook-Sather, A., & Healey, M. (2018). Connecting learning, teaching, and research through student–staff partnerships: Toward universities as egalitarian learning communities.*Shaping Higher Education with Students: Ways to Connect Research and Teaching*. London, United Kingdom: UCL Press, 23-29.

McCarthy, J., & Oliphant, R. (2013). Mathematics outcomes in South African schools. What are the facts? What should be done. *CDE Insight*, 3-16.

McCombs, J. S., Whitaker, A., & Yoo, P. (2017). *The Value of Out-of-school Time Programs.* RAND Corporation. Santa Monica, CA.

McIntyre, J., & Hobson, A. J. (2016). Supporting beginner teacher identity development: External mentors and the third space. *Research Papers in Education, 31*(2), 133-158.

McKeown, S. (2015). How Mathletics spurs them on to work harder. *Primary Teacher Update, 2015*(46), 52-53.

McNiff, J. (2016). *You and your action research project.* New York: Routledge.

Meletiou-Mavrotheris, M., & Mavrotheris, E. (2012). Game-enhanced mathematics learning for pre-service primary school teachers. *ICICTE Proceedings*, 455-465.

Merchie, E., Tuytens, M., Devos, G., & Vanderlinde, R. (2018). Evaluating teachers' professional development initiatives: Towards an extended evaluative framework. *Research Papers in Education, 33*(2), 143-168.

Mertler, C. (2016). Should I stay or should I go? Understanding teacher motivation, job satisfaction, and perceptions of retention among Arizona teachers. *International Research in Higher Education*, *1*(2), 34-45.

Mewborn, D., & Huberty, P. (2004). A site-based model for professional development in mathematics at the elementary school level. *Pythagoras*, *2004*(59), 2-7.

Mezirow, J. (2018). Transformative learning theory. In *Contemporary Theories of Learning* , Routledge. 114-128.

Milner, G., Chimuzu, T., Mulera, D., Chimombo, J. P. G., Kunje, D. & Matale, E. (2008). *Southern and Eastern Africa Consortium for Monitoring Education Quality: Malawi SACMEQ III National Report*. Ministry of Education Science & Technology.

Milondzo, K. S., & Gumbi, D. (2011). Teacher education and training for Africa in the twenty-first century: What form should it take? *Educational Research and Reviews, 6*(1), 1-16.

Mishra, P. & Koehler, M. J. (2008, March). Introducing technological pedagogical content knowledge. In *annual meeting of the American Educational Research Association* (pp. 1-16).

Mishra, P., & Mehta, R. (2017). What we educators get wrong about twenty-first century learning: Results of a survey. *Journal of Digital Learning in Teacher Education, 33*(1), 6-19.

Modisaotsile, B. M. (2012). The failing standard of basic education in South Africa. *Policy Brief, 72*, 1-7.

Mohyuddin, R. G., & Khalil, U. (2016). Misconceptions of students in learning mathematics at primary level: Bulletin of education and research June 2016.

Moser, A., & Korstjens, I. (2018). Series: Practical guidance to qualitative research. Part 3: Sampling, data collection and analysis. *European Journal of General Practice, 24*(1), 9-18.

Mouton, N., Louw, G., & Strydom, G. (2012). A historical analysis of the post-apartheid dispensation education in South Africa (1994-2011). *The International Business and Economics Research Journal (Online), 11*(11), 1211.

Muir, T. (2014). Google, Mathletics and Khan Academy: Students' self-initiated use of online mathematical resources. *Mathematics Education Research Journal, 26*(4), 833-852.

Muir, T., Livy, S., Herbert, S., & Callingham, R. (2018a). School leaders' identification of school level and teacher practices that influence school improvement in national numeracy testing outcomes. *The Australian Educational Researcher, 45*(3), 297-313.

Mullis, I. V., Martin, M. O., Minnich, C. A., Stanco, G. M., Arora, A., Centurino, V. A., & Castle, C. E. (2012). *TIMSS 2011 Encyclopedia: Education Policy and Curriculum in Mathematics and Science. Volume 1: AK*. International Association for the Evaluation of Educational Achievement. Herengracht 487, Amsterdam, 1017 BT, The Netherlands.

Muschla, J. A., Muschla, G. R., & Muschla, E. (2010). *Math Teacher's Survival Guide: Practical Strategies, Management Techniques, and Reproducibles for New and Experienced Teachers, Grades 5-12* (Vol. 165). New Jersey: John Wiley & Sons.

Nansen, B., Chakraborty, K., Gibbs, L., Vetere, F., & MacDougall, C. (2012). "You do the math": Mathletics and the play of online learning. *New Media and Society, 14*(7), 1216-1235.

Ngulube, P. (2015). Qualitative data analysis and interpretation: Systematic search for meaning. *Addressing research challenges: Making headway for developing researchers*. Mosala-Masedi Publishers & Booksellers cc: Noordywk, 131-156.

Nkambule, G., & Amsterdam, C. (2018). The realities of educator support in a South African school district. *South African Journal of Education, 38*(1), 1-11.

No, S. A. S. A. of 1996. *Government Gazette, 29474*.

Noble, H., & Smith, J. (2015). Issues of validity and reliability in qualitative research. *Evidence-based nursing*, *18*(2), 34-35.

Northcote, M. (2011). Teaching with Technology: Step back and hand over the cameras! Using digital cameras to facilitate mathematics learning with young children in K-2 Classrooms. *Australian Primary Mathematics Classroom, 16*(3), 29-32.

Ntseto, R. M. (2015). *The role of school management teams (SMTs) in rendering learning support in public primary schools* (Doctoral Dissertation, University of the Free State).

Ono, Y., & Ferreira, J. (2010b). A case study of continuing teacher professional development through lesson study in South Africa. *South African Journal of Education, 30*(1), 59-74.

Orland-Barak, L., & Hasin, R. (2010). Exemplary mentors' perspectives towards mentoring across mentoring contexts: Lessons from collective case studies. *Teaching and Teacher Education, 26*(3), 427-437.

Orlando, J. (2014). Veteran teachers and technology: Change fatigue and knowledge insecurity influence practice. *Teachers and Teaching, 20*(4), 427-439.

Orlando, J., & Attard, C. (2016). Digital natives come of age: The reality of today's early career teachers using mobile devices to teach mathematics. *Mathematics Education Research Journal, 28*(1), 107-121.

Palauan's, E. C., Sanchez, M. C., Molintas, M., Visitacion, P., & Caricativo, R. D. (2017b). Reflexivity in qualitative research: A journey of learning. *The Qualitative Report, 22*(2), 426-438.

Palys, T. (2008). Purposive sampling. *The Sage Encyclopedia of Qualitative Research Methods*, *2*(1), 697-8.

Passey, D. (2012, July). Educational transformation with open and social technologies in the non-formal school curriculum. In *IFIP WG 3.4 International Conference on Open and Social Technologies for Networked Learning* (pp. 149-159). Springer, Berlin, Heidelberg

Perkins, D. N. (2010). *Making learning whole: How seven principles of teaching can transform education*: John Wiley & Sons.

Phillips, K. J., Desimone, L., & Smith, T. M. (2011). Teacher participation in content-focused professional development and the role of state policy. *Teachers College Record, 113*(11), 2586-2621.

Pilgrim, J., Bledsoe, C., & Reily, S. (2012). New technologies in the classroom. *Delta Kappa Gamma Bulletin, 78*(4), 16-22.

Plair, S. K. (2008). Revamping professional development for technology integration and fluency. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *82*(2), 70-74.

Popp, J. S., & Goldman, S. R. (2016). Knowledge building in teacher professional learning communities: Focus of meeting matters. *Teaching and Teacher Education, 59*, 347-359.

Powell, K. C., & Kalina, C. J. (2009). Cognitive and social constructivism: Developing tools for an effective classroom. *Education, 130*(2), 241-251.

Pyrko, I., Dörfler, V., & Eden, C. (2017). Thinking together: What makes communities of practice work? *Human Relations, 70*(4), 389-409.

Qian, M., & Clark, K. R. (2016). Game-based learning and twenty-first century skills: A review of recent research. *Computers in Human Behavior, 63*, 50-58.

Reddy, V., Zuze, T. L., Visser, M., Winnaar, L., Juan, A., Prinsloo, C., Arends, F., & Rogers, S. (2015). *Beyond Benchmarks: What Twenty Years of TIMSS Data Tell us about South African Education.* Cape Town: HSRC Press.

Republic of South Africa, D. o. B. E. (2011). National Policy Pertaining to the Programme and Promotion Requirements of the National Curriculum Statement Grades R-12. Pretoria: Government Printer.

Revans, R. W. (1982). *The origins and growth of action learning*. Studentlitteratur.

Roschelle, J., Shechtman, N., Tatar, D., Hegedus, S., Hopkins, B., Empson, S.,Knudsen, J., & Gallagher, L. (2010). Integration of technology, curriculum and professional development for advancing middle school mathematics: Three large-scale studies. *American Educational Research Journal, 47*(4), 833-878.

Ryan, T., & Bagley, G. (2015). Nurturing the integration of technology in education. *Journal of Theory and Practice in Education (JTPE), 11*(1).

Saavedra, A. R., & Opfer, V. D. (2012). Learning twenty-first century skills requires twenty-first century teaching. *Phi Delta Kappan, 94*(2), 8-13.

Samuelsson, J. (2007). *How students interact when working with mathematics in an ICT context.* Paper presented at the Seminar Net (Vol.3, No.2). Media, Technology & Life-Long Learning.

Sánchez, B., Pinkston, K. D., Cooper, A. C., Luna, C., & Wyatt, S. T. (2018). One falls, we all fall: How boys of color develop close peer mentoring relationships. *Applied Developmental Science, 22*(1), 14-28.

Sandars, J., Patel, R. S., Goh, P. S., Kokatailo, P. K., & Lafferty, N. (2015). The importance of educational theories for facilitating learning when using technology in medical education. *Medical Teacher, 37*(11), 1039-1042.

Schön, D. A. (1987). Educating the reflective practitioner.

Schweisfurth, M. (2011). Learner-centred education in developing country contexts: From solution to problem? *International Journal of Educational Development, 31*(5), 425-432.

Scott, D., & Hargreaves, E. (Eds). (2015). *The SAGE handbook of learning*. Sage.

Semerci, Ç., & Batdi, V. (2015). A meta-analysis of constructivist learning approach on learners' academic achievements, retention and attitudes. *Journal of Education and Training Studies, 3*(2), 171-180.

Serdyukov, P., & Serdyukov, P. (2017). Innovation in education: What works, what doesn't, and what to do about it? *Journal of Research in Innovative Teaching and Learning, 10*(1), 4-33.

Shabani, K., Khatib, M., & Ebadi, S. (2010). Vygotsky's Zone of Proximal Development: Instructional implications and teachers' professional development. *English Language Teaching, 3*(4), 237-248.

Shaffer, L., & Thomas-Brown, K. (2015). Enhancing teacher competency through co-teaching and embedded professional development. *Journal of Education and Training Studies, 3*(3), 117-125.

Shin, N., Sutherland, L. M., Norris, C. A., & Soloway, E. (2012). Effects of game technology on elementary student learning in mathematics. *British Journal of Educational Technology, 43*(4), 540-560.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-23.

Siddiq, F., Scherer, R., & Tondeur, J. (2016). Teachers' emphasis on developing students' digital information and communication skills (TEDDICS): A new

construct in twenty-first century education. *Computers and Education, 92*, 1-14.

Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning, 2*(1), 3-10.

Siemens, G. (2014). Connectivism: A learning theory for the digital age (2004). *Online: http://www. elearnspace. org/Articles/connectivism. htm (accessed October 2012)*.

Sivesind, K., Van den Akker, J., & Rosenmund, M. (2012). *The European curriculum: Restructuring and renewal*, 11(3),320-327.

Slabbert, J. A., De Kock, D. M., & Hattingh, A. (2009). *The Brave "new" World of Education: Creating a Unique Professionalism. Cape Town :*Juta and Company Ltd.

Smit, T., & Du Toit, P. H. (2016). Transforming beginner teacher mentoring interventions for social reform. *South African Journal of Education, 36*(3), 1-12.

Smith, I. (2005). Achieving readiness for organisational change. *Library management*.

Soffel, J. (2016). What are the twenty-first century skills every student needs. In *World Economic Forum* (Vol. 10).

Spaull, N. (2013). *South Africa's education crisis: The quality of education in South Africa 1994-2011*. Johannesburg: Centre for Development and Enterprise, 1-65.

Spaull, N., & Kotze, J. (2015). Starting behind and staying behind in South Africa: The case of insurmountable learning deficits in mathematics. *International Journal of Educational Development, 41*, 13-24.

Spaull, N., van der Berg, S., Wills, G., Gustafsson, M. & Kotzé, J. (2016). Laying firm foundations: Getting reading right. *Report to the PSPPD. University of Stellenbosch*.

Stephan, K. P. (2017). *Does Mathletics, a supplementary digital math tool, improve student learning and teaching methods at three private catholic schools in Florida? - A mixed methods study* (Doctoral Dissertation, Creighton University).

Steyn, G. (2008). Continuing professional development for teachers in South Africa and social learning systems: Conflicting conceptual frameworks of learning. *Koers, 73*(1), 15-31.

Strang, R. J. (2017). Year 7 Transition and Junior Secondary Mathematics Teachers.

Strauss, A. L. (1987). *Qualitative Analysis for Social Scientists.* Cambridge University Press.

Stronge, J. H. (2018). *Qualities of effective teachers.* ASCD.

Symonds, W. C., Schwartz, R., & Ferguson, R. F. (2011). Pathways to prosperity: Meeting the challenge of preparing young Americans for the twenty-first century. Cambridge, MA: Pathways to Prosperity Project, Harvard University Graduate School of Education.

Tack, H., Valcke, M., Rots, I., Struyven, K., & Vanderlinde, R. (2018). Uncovering a hidden professional agenda for teacher educators: A mixed method study on Flemish teacher educators and their professional development. *European Journal of Teacher Education, 41*(1), 86-104.

Tam, A. C. F. (2015). The role of a professional learning community in teacher change: A perspective from beliefs and practices. *Teachers and Teaching, 21*(1), 22-43.

Taylor, N., Fleisch, B., & Shindler, J. (2019). Education scenarios for 2019. *Key Driving Forces Scenarios*, 11-12.

Taylor, S., Bogdan, R., & DeVault, M. (2015). *Introduction to qualitative research methods: A guidebook and resource.* John Wiley & Sons.

Tekin, K., & Kotaman, H. (2013). The epistemological perspectives on action research. *Journal of Educational and Social Research, 3*(1), 81-91.

Tella, A. (2017). Teacher variables as predictors of academic achievement of primary school pupils' mathematics. *International Electronic Journal of Elementary Education, 1*(1), 16-33.

Tezci, E. (2011). Factors that influence pre-service teachers' ICT usage in education. *European Journal of Teacher Education, 34*(4), 483-499.

Tienken, C. H., & Stonaker, L. (2007). When every day is Professional Development Day. *Journal of Staff Development, 28*(2), 24-29.

Tondeur, J., Van Braak, J., Sang, G., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers and Education, 59*(1), 134-144.

Trorey, G., & Cullingford, C. (2017). *Professional Development and Institutional Needs*. Routledge.

TsaiTsai, C. C., & Chai, C. S. (2012). The third-order barrier for technology-integration instruction: Implications for teacher education. *Australasian Journal of Educational Technology*, *28*(6),1057-1060.

Tshabalala, T., & Ncube, A. C. (2016). Causes of poor performance of ordinary level pupils in mathematics in rural secondary schools in Nkayi district: Learners' attributions. *Nova Journal of Medical and Biological Sciences, 1*(1).

Turner III, D. W. (2010). Qualitative interview design: A practical guide for novice investigators. *The Qualitative Report, 15*(3), 754-760.

Twining, P., Heller, R. S., Nussbaum, M., & Tsai, C.-C. (2017). *Some Guidance on Conducting and Reporting Qualitative Studies*, 106, 1-9.

Ültanır, E. (2012). An epistemological glance at the constructivist approach: Constructivist learning in Dewey, Piaget and Montessori. *International Journal of Instruction*, *5*(2), 196-212.

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing and Health Sciences, 15*(3), 398-405.

Vale, C., Davies, A., Weaven, M. & Hooley, N. (2010). Student-centred approaches: Teachers' learning and practice. *Mathematics Education Research Group of Australasia* ,571-578.

Van Driel, J. H., & Berry, A. (2012). Teacher professional development focusing on pedagogical content knowledge. *Educational Researcher, 41*(1), 26-28.

Van Laar, E., Van Deursen, A. J., Van Dijk, J. A., & De Haan, J. (2017). The relation between twenty-first century skills and digital skills: A systematic literature review. *Computers in Human Behavior, 72*, 577-588.

Van Niekerk, M. P. (2018). *Principals' influences on teacher professional development for the integration of information and communication technologies in schools.* Pretoria: University of Pretoria.

Veletsianos, G. (2016). *Emergence and innovation in digital learning: Foundations and applications.* Athabasca University Press.

Venkat, H., & Spaull, N. (2015). What do we know about primary teachers' mathematical content knowledge in South Africa? An analysis of SACMEQ 2007. *International Journal of Educational Development, 41*, 121-130.

Vivian, R., Falkner, K., & Falkner, N. (2014). Addressing the challenges of a new digital technologies curriculum: MOOCs as a scalable solution for teacher professional development. Research in Learning Technology, 22(0), 24691-1-24691-19.

Von Glasersfeld, E. (2006). *Radical constructivism in mathematics education* (Vol. 7): City: Springer Science & Business Media.

Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2013). Challenges to learning and schooling in the digital networked world of the twenty-first century. *Journal of Computer Assisted Learning, 29*(5), 403-413.

Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological pedagogical content knowledge – a review of the literature. *Journal of Computer Assisted Learning, 29*(2), 109-121.

Vorensky, S. B. (2018). Exploring teachers' self-efficacy about technology use in learning design and student performance in mathematics: A qualitative study about math anxiety. Rowan University. *Theses and Dissertations*. 2528.

Vygotsky, L. (1987). Zone of proximal development. *Mind in society: The development of higher psychological processes, 52-91*.

Vygotsky, L. S. (2012). *The collected works of L.S. Vygotsky: Scientific legacy. University of New York:* Springer Science & Business Media.

Wachira, P., & Keengwe, J. (2011). Technology integration barriers: Urban school mathematics teachers' perspectives. *Journal of Science Education and Technology, 20*(1), 17-25.

Walton, E., & Rusznyak, L. (2017). Choices in the design of inclusive education courses for pre-service teachers: The case of a South African university. *International Journal of Disability, Development and Education, 64*(3), 231-248.

Wenger, E. (1999). *Communities of Practice: Learning, Meaning, and Identity*: Cambridge University Press.

Wenger, E. (2000). Communities of practice and social learning systems. *Organization, 7*(2), 225-246.

Whitehead, J., & McNiff, J. (2006). *Action research: Living theory.* Sage.

Wolvaardt, G., & Du Toit, P. H. (2012). Action research-driven professional development: Developing transformational health care managers and creating

learning organisations. *South African Journal of Higher Education, 26*(6), 1249-1264.

Wood, L., & Zuber-Skerritt, O. (2013). PALAR as a methodology for community engagement by faculties of education. *South African Journal of Education, 33*(4), 1-15.

Zaheer, H., Breyer, Y., Dumay, J., & Enjeti, M. (2019). Straight from the horse's mouth: Founders' perspectives on achieving “traction” in digital start-ups. *Computers in Human Behavior*, *95*, 262-274.

Zain, S. F. H. S., Rasidi, F. E. M., & Abidin, I. I. Z. (2012). Student-centred learning in mathematics-constructivism in the classroom. *Journal of International Education Research, 8*(4), 319-328.

Zakharov, A., Tsheko, G., & Carnoy, M. (2016). Do “better” teachers and classroom resources improve student achievement? A causal comparative approach in Kenya, South Africa, and Swaziland. *International Journal of Educational Development, 50*, 108-124.

Zhou, M., & Brown, D. (2015). Educational learning theories: 2nd Edition. *Education Open Textbooks.1.*

Zuber-Skerritt, O. (2015). Participatory action learning and action research (PALAR) for community engagement: A theoretical framework. *Educational Research for Social Change, 4*(1), 5-25.

APPENDIX A

LETTER TO THE HEAD OFFICE

Faculty of Education

11/07/2018

The Director,

Teachers 'Human Resource and Institutional Development of Basic Education,

South Africa.

Dear Sir/Madam

REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN THE SELECTED PRIMARY SCHOOLS IN GAUTENG PROVINCE

I am a Masters' student at the University of Pretoria in the Department of Humanities Education; conducting research.The topic of my study is **A Participatory Action Research approach to the professional development of veteran primary school mathematics teachers.**

My study aims to investigate and develop the professional status of the veteran primary school mathematics teachers through participatory action research to improve their understanding of the application of Mathletics during teaching and learning.

I intend to collect data for my study via semi-structured interviews and participant observations. My participants will be veteran mathematics primary school teachers. I attach a copy of the semi-structured interview schedule and participant observation protocol for your perusal. The interview and observation will be conducted at a time

convenient for my participants and preferred venue by the participants. Time allocation for both interview and observation will be forty-five minutes and thirty minutes respectively. The normal routine of teaching and learning will not be disturbed. The interview section shall be audio tapped while I videotape the observation segment.

Teacher participation is voluntary, and they can withdraw at any time. The identity of the school and all participants will be protected, using pseudonyms. Only my supervisor and I will know which schools were used in the research and information provided by the participants shall be strictly for research purposes.

I hereby seek for permission to conduct this study in selected primary schools in Gauteng province, possibly the end product of this study will contribute to the knowledge creation in the teaching practice and learner instructional understanding and performance in mathematics through the application of Mathletics.

Kindly confirm your acceptance through a written feedback. Your cooperation is highly solicited.

Regards,

Signature of researcher

_____

Name of researcher: Caroline Mahlangu
Contact number: 063 302 4908
E-mail address: u1136996@tuks.co.za

Signature of supervisor

_____

Name of supervisor: Prof Pieter H du Toit
Contact number: 012 420 2817
E-mailaddress:pieter.dutoit@up.ac.za

APPENDIX B

LETTER TO THE SCHOOL PRINCIPALS

Faculty of Education

REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN YOUR SCHOOL

Dear Principal,

I am a Masters' student at the University of Pretoria in the Department of Humanities Education, conducting a research. The topic of my study is **A Participatory Action Research approach to the professional development of veteran primary school mathematics teachers.**

My study aims to investigate and develop the professional status of the veteran primary school mathematics teachers through participatory action research to improve their understanding of the application of Mathletics during teaching and learning.

I intend to collect data for my study via semi-structured interviews and participant observations. My participants will be veteran mathematics primary school teachers. I attach a copy of the semi-structured interview schedule and participant observation protocol for your perusal. The interview and observation will be conducted at a time convenient for the participants and preferred venue by the participants. Time allocation for both interview and observation will be forty-five minutes and thirty minutes respectively. The normal routine of teaching and learning will not be disturbed. The interview section shall be audio tapped while I videotape the observation segment.

Teacher participation is voluntary, and they can withdraw at any time. The identity of the school and all participants will be protected, using pseudonyms. Only my

supervisor and I will know which schools were involved in the research and information provided by the participants shall be strictly for research purposes.

I hereby seek for permission to conduct this study in your school, possibly the end product of this study will contribute to the knowledge creation in the teaching practice and learner instructional understanding and performance in mathematics through the application of Mathletics.

Kindly confirm your acceptance by filling out the attached consent form.
Thank you in anticipation for your cooperation.

Signature of researcher

_____

Name of researcher: Caroline Mahlangu
Contact number: 063 302 4908
E-mail address: u1136996@tuks.co.za

Signature of supervisor

_____

Name of supervisor: Prof Pieter H du Toit
Contact number 012 420 2817
E-mail address: pieter.dutoit@up.ac.za

APPENDIX C

LETTER TO THE PARTICIPANTS

Faculty of Education

REQUEST FOR YOUR PARTICIPATION IN THE STUDY

Dear Mathematics Teacher,

I am a Masters' student at the University of Pretoria in the Department of Humanities Education, conducting a research. The topic of my study is **A Participatory Action Research approach to the professional development of veteran primary school mathematics teachers.**

My study aims to investigate and develop the professional status of the veteran primary school mathematics teachers through participatory action research to improve their understanding of the application of Mathletics during teaching and learning.

I intend to collect data for my study via semi-structured interviews and participant observations. My participants will be veteran mathematics primary school teachers. I attach a copy of the semi-structured interview schedule and participant observation protocol for your perusal. The interview and observation will be conducted at a convenient time and preferred venue by the participants. Time allocation for both interview and observation will be forty-five minutes and thirty minutes respectively. The normal routine of teaching and learning will not be disturbed. The interview section shall be audio tapped while I videotape the observation segment.

Teacher participation is voluntary, and they can withdraw at any time. The identity of the school and all participants will be protected, using pseudonyms. Only my supervisor and I will know which schools participated in the research and information provided by the participants shall be strictly for research purposes.

I hereby seek for your permission to participate in this study in your school, possibly the end product of this study will contribute to the knowledge creation in teaching practice and learner instructional understanding and performance in mathematics through the application of Mathletics.

Kindly confirm your acceptance by filling out the attached consent form.
Thank you in anticipation for your cooperation.

Signature of researcher

_____

Name of researcher: Caroline Mahlangu
Contact number 063 302 4908
E-mail address: u1136996@tuks.co.za

Signature of supervisor

_____

Name of supervisor: Prof Pieter H du Toit
Contact number 012 420 2817
E-mail address: pieter.dutoit@up.ac.za

APPENDIX D

LETTER OF INFORMED CONSENT TO THE PARTCICIPANTS

CONSENT FORM

You are invited to participate in the research project: **A Participatory Action Research approach to the professional development of veteran primary school mathematics teachers.**

My study aims to investigate and develop the professional status of the veteran primary school mathematics teachers through participatory action research to improve their understanding of the application of Mathletics during teaching and learning. If you agree to participate you will be requested to engage in a semi-structured interview (thirty minutes) and participant observation (forty five minutes) respectively.

Your identity will be protected to the best of the investigator's ability, all gathered will be kept confidential and your identity will not be disclosed in the final report. Your participation in this project is completelty voluntary and the information recorded during this study will be kept in a locked file that will be accessed by me or my supervisor. You may choose to withdraw and not to participate at anytime without penalty. For more information about the rsearch process, feel free to contact the researcher, Caroline Mahlangu on 063 302 4908 or Prof Pieter Du Toit my supervisor on 012 420 2817.

I have read the consent form and volunteer to participate in this study .

Signature :_____

Date :_____

APPENDIX E

APPROVAL LETTER FROM GAUTENG DEPARTMENT OF EDUCATION

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

CHAPTER 6 GDE RESEARCH APPROVAL LETTER

Date:	20 July 2018
Validity of Research Approval:	05 February 2018 — 28 September 2018 2018/187
Name of Researcher:	Mahlangu C. N
Address of Researcher:	Mamelodi East
	35115 Moretlwa Street Ext 6
	Rethabile, 0122
Telephone Number:	063 302 4908
Email address:	u11362996@tuks.co.za
Research Topic:	A participatory action research approach to the professional development of veteran primary school mathematics teachers
Type of qualification	Masters
Number and type of schools:	Eight Primary Schools
District/HO	Tshwane South.

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the

District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

24/07/2018

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (01 1) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

1. The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.
2. The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.
3. A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.
4. A letter/ document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.
5. The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.
6. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.
7. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.
8. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.
9. It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.
10. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.

11. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.

12 On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.

13. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.

14 Should the researcher have been involved with research at a school and/or a district/head office level, the Director conceded must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

Mr GumaniMukatuni
Acting CES: Education Research and Knowledge Management

DATE: 24/07/2018

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalata@gauteng.gov.za
Website: www.education.gpg.gov.za

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

Enquiries: Lucky Rapudi
Tel: (012) 401 6317
Fax: 0866 522 388
Email: Lucky.Rapudi@gauteng.gov.za

TO: **The Principal**
Laerskool Westpark

FROM: **Mrs. Hilda Kekana**
District Director: Tshwane South

DATE: **20th August 2018**

SUBJECT : PERMISSION TO CONDUCT RESEARCH AT AN EDUCATION INSTITUTION

Dear Sir/ Madam

Permission is hereby granted to **C.N Mahlangu** to conduct an academic research at your institution.

The researcher shall make arrangements for research with the school management. The school staff, learners and SGB are requested to co-operate with and give support to the researcher. Research findings and recommendations are critical for policy review in public education sector.

The researcher may however not disrupt the normal school programme in the course of research. The research may only take place between the months of February and September. Attached are other conditions to be observed by the researcher.

The school may request for the research outcome presentation directly from the researcher or obtain research document from Research & Knowledge Management Directorate at GDE Head Office.

Regards

Mrs H.E. Kekana
District Director: Tshwane South
Date: 20/08/2018

Making education a societal priority

Office of the District Director: Tshwane South
(Mamelodi/Eersterust/Pretoria East/Pretoria South/Atteridgeville/Laudium)
President Towers building, 265 Pretorius Street, Pretoria, 0002
Private Bag X198, Pretoria, 0001 Tel: (012) 401 6317; Fax: (012) 401 6318
Website: www.education.gpg.gov.za

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

Enquiries: Lucky Rapudi
Tel: (012) 401 6317
Fax: 0866 522 388
Email: Lucky.Rapudi@gauteng.gov.za

TO: **The Principal**
Laerskool Westpark

FROM: **Mrs. Hilda Kekana**
District Director: Tshwane South

DATE: **20th August 2018**

SUBJECT : PERMISSION TO CONDUCT RESEARCH AT AN EDUCATION INSTITUTION

Dear Sir/ Madam

Permission is hereby granted to **C.N Mahlangu** to conduct an academic research at your institution.

The researcher shall make arrangements for research with the school management. The school staff, learners and SGB are requested to co-operate with and give support to the researcher. Research findings and recommendations are critical for policy review in public education sector.

The researcher may however not disrupt the normal school programme in the course of research. The research may only take place between the months of February and September. Attached are other conditions to be observed by the researcher.

The school may request for the research outcome presentation directly from the researcher or obtain research document from Research & Knowledge Management Directorate at GDE Head Office.

Regards

Mrs H.E. Kekana
District Director: Tshwane South
Date: 20 / 08 / 2018

Making education a societal priority

Office of the District Director: Tshwane South
(Mamelodi/Eersterust/Pretoria East/Pretoria South/Atteridgeville/Laudium)
President Towers building, 265 Pretorius Street, Pretoria, 0002
Private Bag X198, Pretoria, 0001 Tel: (012) 401 6317; Fax: (012) 401 6318
Website: www.education.gpg.gov.za

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

Enquiries: Lucky Rapudi
Tel: (012) 401 6317
Fax: 0866 522 388
Email: Lucky.Rapudi@gauteng.gov.za

TO: **The Principal**
Mahlahle Primary School

FROM: **Mrs. Hilda Kekana**
District Director: Tshwane South

DATE: **20th August 2018**

SUBJECT : PERMISSION TO CONDUCT RESEARCH AT AN EDUCATION INSTITUTION

Dear Sir/ Madam

Permission is hereby granted to **C.N Mahlangu** to conduct an academic research at your institution.

The researcher shall make arrangements for research with the school management. The school staff, learners and SGB are requested to co-operate with and give support to the researcher. Research findings and recommendations are critical for policy review in public education sector.

The researcher may however not disrupt the normal school programme in the course of research. The research may only take place between the months of February and September. Attached are other conditions to be observed by the researcher.

The school may request for the research outcome presentation directly from the researcher or obtain research document from Research & Knowledge Management Directorate at GDE Head Office.

Regards

Mrs H.E. Kekana
District Director: Tshwane South
Date: 20/08/2018

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

Enquiries: Lucky Rapudi
Tel: (012) 401 6317
Fax: 0866 522 388
Email: Lucky.Rapudi@gauteng.gov.za

TO: **The Principal**
Marema Tlou Primary School

FROM: **Mrs. Hilda Kekana**
District Director: Tshwane South

DATE: **20th August 2018**

SUBJECT : PERMISSION TO CONDUCT RESEARCH AT AN EDUCATION INSTITUTION

Dear Sir/ Madam

Permission is hereby granted to **C.N Mahlangu** to conduct an academic research at your institution.

The researcher shall make arrangements for research with the school management. The school staff, learners and SGB are requested to co-operate with and give support to the researcher. Research findings and recommendations are critical for policy review in public education sector.

The researcher may however not disrupt the normal school programme in the course of research. The research may only take place between the months of February and September. Attached are other conditions to be observed by the researcher.

The school may request for the research outcome presentation directly from the researcher or obtain research document from Research & Knowledge Management Directorate at GDE Head Office.

Regards

Mrs H.E. Kekana
District Director: Tshwane South
Date: 20/08/2018

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

Enquiries: Lucky Rapudi
Tel: (012) 401 6317
Fax: 0866 522 388
Email: Lucky.Rapudi@gauteng.gov.za

TO: **The Principal**
Masizani Primary School

FROM: **Mrs. Hilda Kekana**
District Director: Tshwane South

DATE: **20th August 2018**

SUBJECT : PERMISSION TO CONDUCT RESEARCH AT AN EDUCATION INSTITUTION

Dear Sir/ Madam

Permission is hereby granted to **C.N Mahlangu** to conduct an academic research at your institution.

The researcher shall make arrangements for research with the school management. The school staff, learners and SGB are requested to co-operate with and give support to the researcher. Research findings and recommendations are critical for policy review in public education sector.

The researcher may however not disrupt the normal school programme in the course of research. The research may only take place between the months of February and September. Attached are other conditions to be observed by the researcher.

The school may request for the research outcome presentation directly from the researcher or obtain research document from Research & Knowledge Management Directorate at GDE Head Office.

Regards

Mrs H.E. Kekana
District Director: Tshwane South
Date: 20/08/2018

Making education a societal priority

Office of the District Director: Tshwane South
(Mamelodi/Eersterust/Pretoria East/Pretoria South/Atteridgeville/Laudium)
President Towers building, 265 Pretorius Street, Pretoria, 0002
Private Bag X198, Pretoria, 0001 Tel: (012) 401 6317; Fax: (012) 401 6318
Website: www.education.gpg.gov.za

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

Enquiries: Lucky Rapudi
Tel: (012) 401 6317
Fax: 0866 522 388
Email: Lucky.Rapudi@gauteng.gov.za

TO: **The Principal**
Phutaditshaba Primary School

FROM: **Mrs. Hilda Kekana**
District Director: Tshwane South

DATE: **20th August 2018**

SUBJECT : PERMISSION TO CONDUCT RESEARCH AT AN EDUCATION INSTITUTION

Dear Sir/ Madam

Permission is hereby granted to **C.N Mahlangu** to conduct an academic research at your institution.

The researcher shall make arrangements for research with the school management. The school staff, learners and SGB are requested to co-operate with and give support to the researcher. Research findings and recommendations are critical for policy review in public education sector.

The researcher may however not disrupt the normal school programme in the course of research. The research may only take place between the months of February and September. Attached are other conditions to be observed by the researcher.

The school may request for the research outcome presentation directly from the researcher or obtain research document from Research & Knowledge Management Directorate at GDE Head Office.

Regards

Mrs H.E. Kekana
District Director: Tshwane South
Date: 20/08/2018

Making education a societal priority

Office of the District Director: Tshwane South
(Mamelodi/Eersterust/Pretoria East/Pretoria South/Atteridgeville/Laudium)
President Towers building, 265 Pretorius Street, Pretoria, 0002
Private Bag X198, Pretoria, 0001 Tel: (012) 401 6317; Fax: (012) 401 6318
Website: www.education.gpg.gov.za

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

Enquiries: Lucky Rapudi
Tel: (012) 401 6317
Fax: 0866 522 388
Email: Lucky.Rapudi@gauteng.gov.za

TO: **The Principal**
Matseke Primary School

FROM: **Mrs. Hilda Kekana**
District Director: Tshwane South

DATE: **20th August 2018**

SUBJECT : PERMISSION TO CONDUCT RESEARCH AT AN EDUCATION INSTITUTION

Dear Sir/ Madam

Permission is hereby granted to **C.N Mahlangu** to conduct an academic research at your institution.

The researcher shall make arrangements for research with the school management. The school staff, learners and SGB are requested to co-operate with and give support to the researcher. Research findings and recommendations are critical for policy review in public education sector.

The researcher may however not disrupt the normal school programme in the course of research. The research may only take place between the months of February and September. Attached are other conditions to be observed by the researcher.

The school may request for the research outcome presentation directly from the researcher or obtain research document from Research & Knowledge Management Directorate at GDE Head Office.

Regards

Mrs H.E. Kekana
District Director: Tshwane South
Date: 20 / 08 / 2018

Making education a societal priority

Office of the District Director: Tshwane South
(Mamelodi/Eersterust/Pretoria East/Pretoria South/Atteridgeville/Laudium)
President Towers building, 265 Pretorius Street, Pretoria, 0002
Private Bag X198, Pretoria, 0001 Tel: (012) 401 6317; Fax: (012) 401 6318
Website: www.education.gpg.gov.za

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

Enquiries: Lucky Rapudi
Tel: (012) 401 6317
Fax: 0866 522 388
Email: Lucky.Rapudi@gauteng.gov.za

TO: **The Principal**
Patogeng Primary School

FROM: **Mrs. Hilda Kekana**
District Director: Tshwane South

DATE: **20th August 2018**

SUBJECT : PERMISSION TO CONDUCT RESEARCH AT AN EDUCATION INSTITUTION

Dear Sir/ Madam

Permission is hereby granted to **C.N Mahlangu** to conduct an academic research at your institution.

The researcher shall make arrangements for research with the school management. The school staff, learners and SGB are requested to co-operate with and give support to the researcher. Research findings and recommendations are critical for policy review in public education sector.

The researcher may however not disrupt the normal school programme in the course of research. The research may only take place between the months of February and September. Attached are other conditions to be observed by the researcher.

The school may request for the research outcome presentation directly from the researcher or obtain research document from Research & Knowledge Management Directorate at GDE Head Office.

Regards

Mrs H.E. Kekana
District Director: Tshwane South
Date: 20/08/2018

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

Ethics Committee

10 July 2018

Ms Caroline Mahlangu

Dear Ms Mahlangu

REFERENCE: HU 18/04/01

We received proof that you have met the conditions outlined. Your application is thus **approved**, and you may start with your fieldwork. The decision covers the entire research process, until completion of the study report, and not only the days that data will be collected. The approval is valid for two years for a Masters and three for Doctorate.

The approval by the Ethics Committee is subject to the following conditions being met:

1. The research will be conducted as stipulated on the application form submitted to the Ethics Committee with the supporting documents.
2. Proof of how you adhered to the Department of Basic Education (DBE) policy for research must be submitted where relevant.
3. In the event that the research protocol changed for whatever reason the Ethics Committee must be notified thereof by submitting an amendment to the application (Section E), together with all the supporting documentation that will be used for data collection namely; questionnaires, interview schedules and observation schedules, for further approval before data can be collected. Non-compliance implies that the Committee's approval is null and void. The changes may include the following but are not limited to:
    - Change of investigator,
    - Research methods any other aspect therefore and,
    - Participants.

The Ethics Committee of the Faculty of Education does not accept any liability for research misconduct, of whatsoever nature, committed by the researcher(s) in the implementation of the approved protocol.

Upon completion of your research you will need to submit the following documentations to the Ethics Committee for your

Clearance Certificate:

- Integrated Declaration Form (Form D08),
- Initial Ethics Approval letter and,
- Approval of Title.

Please quote the reference number **HU 18/04/01** in any communication with the Ethics Committee.

Best wishes

Prof Liesel Ebersöhn
Chair: Ethics Committee
Faculty of Education

Room 3-3, Level 3, Building 10
University of Pretoria, Private Bag X20
Hatfield 0028, South Africa
Tel +27 (0)12 420 1234
Fax +27 (0)12 420 5656
Email marisa.leask@up.ac.za
www.up.ac.za

APPENDIX E

SAMPLE OF INTERVIEW TRANSCRIPT

The teacher interviews

A Participatory Action Research Approach to the professional development of veteran primary school mathematics teachers

Time of interview: _____ _____Duration: _____

Date: _____

Place: _____

Interviewer:_____**Caroline Mahlangu**_____

Interviewee: _____pseudonyms:_____

Male / Female: _____

Interviewee's age: _____

Interviewer's supervisor **Prof Pieter H Du Toit**_____

This study aims to investigate and develop the professional status of the veteran primary school mathematics teachers through participatory action research to improve their understanding in the application of Mathletics during teaching and learning.

Pseudonyms will be used in the interviews, data analysis and the findings. The data collected in this study will serve in research purposes only and treated as confidential. Access to the data will be granted to the researcher and the supervisor only. Please sign the consent form at the back of this document. Thank you for your participation.

Questions	
1. What challenges do you encounter as a Maths teacher and how do you overcome them?	
2. What challenges do you encounter as a Maths teacher and how do you overcome them?	
3. What challenges do you encounter as a Maths teacher	

and how do you overcome them?	
4. What do you enjoy about being a Maths teacher?	
5. How would you encourage the practical application of mathematical thinking in everyday life?	
6. Describe your teaching methods how do they help learners to improve their understanding and application of mathematical concepts ?	
7. Do you use technology(s) in Maths lesson(s)? If yes give examples of technological tool(s) that you use?	
8. Did the above-mentioned technological tools improve your teaching practice? Briefly explain why you are of this opinion?	
9. Have you attended any workshops on Mathletics?	
10. Explain by whom was it facilitated?	
11. How often do you use Mathletics in your teaching practice?	
12. Are workshops giving enough support and guidance the application of Mathletics	
13. If you have used Mathletics before–how was learners engaged?	
14. What is your perception about Mathletics?	
15. How do you ensure that continuing professional development takes place in your community of learning practice (school)?	
16. What is your perception based on the Mathletics workshop you attended with me? Was it	

helpful can you effectively integrate it during teaching and learning?	

APPENDIX F

PARTICIPANT OBSERVATION TEMPLATE

Participant Observation

Topic of study: **A Participatory Action Research Approach to the professional development of veteran primary school mathematics teachers**

Classroom no: _____ pseudonyms: _____

Name of observer: **Caroline Mahlangu**

Role of observer: **To observe, monitor and guide while veteran teachers are teaching using Mathletics to see their strength, weaknesses and challenges that they encounter in Mathletics.**

Time of observation: _____

Length of observation: _____

Observer's supervisor: **Prof Pieter H Du Toit**

Descriptive field notes	Reflective field notes
○ checklist; ✓ **Availability of technological tools,** ✓ **Teacher preparation files are in order,** ✓ **Lesson plans are aligned with the mathematics CAPS document,** ✓ **Learner Activities are varied to meet the needs of all learners,** ✓ **Teachers are proactive and willing to learn and assist each other,** ✓ **Teachers are having their mathematics policy (CAPS) documents with them,**	
○ **Lesson observed** ○ **Creating passwords and usernames for teachers who do not have.** ○ **I will present a lesson using Mathletics and I will give teachers an opportunity to complete given tasks.**	
○ **Reflect on the challenges that teachers were facing and correcting the mistakes/misconceptions that teachers were having**	

○ **Activities! Activities! activities** ○ **Attach examples of activities**	
○ **Concluding comments, remarks and date for the next visit.**	